DIGITAL COMBAT SIMULATOR

AH-64D

Early Access Guide

Updated 12 July 2025

EAGLE DYNAMICS

INTRODUCTION

Thank you for your purchase of DCS: AH-64D!

DCS: AH-64D brings one of the most legendary attack helicopters in modern history to Digital Combat Simulator. This module features the most realistic PC simulation of the AH-64D, which includes accurately simulated flight dynamics, avionics, sensors, and weapon systems. Although the AH-64D has existed in many configurations in its history, this module simulates the AH-64D as it existed in United States Army service between the years 2005 and 2010.

The AH-64D was the first U.S. attack helicopter designed to fight and survive on the 21st century "digital" battlefield, with a significant increase in lethality over the original AH-64A. Known for its night-fighting capability, long endurance times, and its highly accurate Hellfire missiles and helmet-steerable 30mm gun, the AH-64D has seen significant use during combat operations in Iraq, Afghanistan, Libya, Mali, and Syria. When pinned down and in a tight spot, the AH-64 is the ground force commander's best friend.

Own the night!

Key features:

- Two detailed, fully-clickable, 6DOF cockpits along with a highly detailed external model.
- Detailed pilot models with new animations that can be seen from both interior and exterior views.
- "George" AI crewmember, complete with voice-overs, to assist with cockpit tasks.
- Revised, up-turned engine exhaust assemblies initially fielded in 2007.
- Integrated Helmet And Designation Sighting System (IHADSS), Modernized TADS (M-TADS/PNVS), and mast-mounted APG-78 Fire Control Radar (FCR).
- Laser- and radar-guided AGM-114 missiles, unguided rockets, and 30mm gun turret.
- Datalink modem, enabling multiple aircraft to share targeting data amongst the flight.
- Radar, laser, and missile warning defensive systems.
- Fly missions in the Black Sea region or one of the many DLC maps like the Persian Gulf, Syria, and more.
- Multiplayer cooperative and head-to-head gameplay, to include cooperative multi-crew in the same aircraft.
- Feature-rich Mission and Campaign editors facilitate user-created content.
- Huge array of land, air, and sea units to fight alongside and against.

Sincerely,
The DCS: AH-64D Team
17 March 2022

Disclaimers

The manufacturers and intellectual property right owners of the vehicles, weapons, sensors, and other systems represented within Digital Combat Simulator (DCS) in no way endorse, sponsor or are otherwise involved in the development of DCS and its modules.

This software is for entertainment purposes only.

The appearance of U.S. Department of Defense (DoD) visual information does not imply or constitute DoD endorsement.

TABLE OF CONTENTS

Introduction 2
Table of Contents 3
Latest Changes 12
DCS FUNDAMENTALS 13
Health Warning! 14
Installation and Launch 15
Configure Your Game 16
Force Trim in DCS 23
Fly a Mission 24
Mission Editor Options 25
Flight Control 27
Changing Airspeed 29
Changing Altitude 29
Changing Heading 30
HELICOPTER FUNDAMENTALS OF FLIGHT 31
Fundamentals of Flight 32
Vectors 33
Aerodynamic Lift 33
Aerodynamic Forces 34
Engine Power and Torque 37
Helicopter Control 39
Phase Lag 40
Helicopter Aerodynamics 42
Translating Tendency 42
Ground Effect 43
Transverse Flow Effect 44
Translational Lift 45
Dissymmetry of Lift 46
Retreating Blade Stall 48
Vortex Ring State 49
Autorotation 50
Power Management 51
Environmental Effects 52
Rotor Droop 55

Settling With Power 56
Limited Power Approach 57
Multi-Engine Drive Train Limitations 58
Height-Velocity Avoid Region 60
THE AH-64D 61
Aircraft History 62
Advanced Aerial Fire Support System 62
Advanced Attack Helicopter Program 63
AH-64A 63
AH-64A+, AH-64B, and other upgrade proposals 66
Aviation Restructure Initiative (ARI) 67
AH-64D 68
Aircraft Overview 71
Cockpit 71
Fuselage 72
Fire Protection System 72
Engines 72
Auxiliary Power Unit (APU) 74
Drive Train 74
Rotors 75
Flight Controls 76
Landing Gear 77
Fuel System 78
Electrical System 79
Hydraulic System 79
Integrated Pressurized Air System (IPAS) 80
Environmental Control System (ECS) 81
Lighting System 82
Avionics 83
Sensor and Sighting Systems 86
Weapons & Munitions 88
M139 Area Weapon System (AWS) 88
Aerial Rocket Sub-System (ARS) 88
Hellfire Modular Missile System (HMMS) 90
Auxiliary Fuel Systems (IAFS & ERFS) 90
Pilot Cockpit Overview 91

Instrument Panel 92
Keyboard Unit 100
Left Console 102
Right Console 108
Copilot/Gunner Cockpit Overview 110
Instrument Panel 111
Keyboard Unit 112
Left Console 112
Right Console 114
TADS Electronic Display And Control (TEDAC) 115
Cyclic & Collective Hand Controls 123
Cyclic Grip 123
Collective Flight Grip 125
Collective Mission Grip 127
Integrated Helmet And Display Sighting System (IHADSS) 129
Flight Symbology 129
Night Vision System (NVS) 139
Enhanced Up-Front Display (EUFD) 142
Multi-Purpose Displays (MPD) 151
Menu (M) Page 156
Engine (ENG) Page 157
Flight (FLT) Page 165
Fuel (FUEL) Page 171
Performance (PERF) Page 176
Utility (UTIL) Page 180
Tactical Situation Display (TSD) Page 182
Video (VID) Page 208
Video Cassette Recorder (VCR) Page 210
Data Management System (DMS) Page 211
Flight Management Computer (FMC) 216
Stability Augmentation System 217
Command Augmentation System 218
Force Trim & "Breakout" Values 219
Hold Modes 219
Flight Control Advisories 232
PROCEDURES 233

Aircraft Start 235
Prior to Starting APU 235
APU Start 238
Engine Start 243
Taxi & Before Takeoff 244
Before Taxi 244
Ground Taxi 245
Before Takeoff 246
Hovering Flight 247
Performing a Hover 248
Hover Power Check 249
Takeoff 250
VMC Takeoff 251
VMC Level Acceleration Takeoff 252
VMC Minimum Power Takeoff 253
Rolling Takeoff 254
Landing 255
Before Landing 255
VMC Approach 256
Roll-on Landing 257
Autorotation Landing 258
Aircraft Shutdown 259
After Landing Check 259
Aircraft Shutdown 260
Refueling/Rearming 261
Rapid Refueling/Rearming 263
NAVIGATION 264
Navigation 265
Points 266
TSD Point (POINT) Sub-page 272
Adding a Point 275
Editing a Point 279
Deleting a Point 283
Storing a Point 285
Routes 289
TSD Route (RTE) Sub-page 291

Creating a Route using the Mission Editor 294
Creating a Route using the Route (RTE) sub-page 295
Creating a Direct Route using the Route (RTE) sub-page 297
Editing a Route using the Route (RTE) sub-page 298
Selecting a Route using the Route Menu (RTM) sub-page 300
Deleting a Route using the Route Menu (RTM) sub-page 301
Radio Navigation in Low-Visibility Conditions 302
TSD Instruments (INST) Sub-page 303
Tuning the ADF to an NDB Frequency 306
Editing an ADF Preset 307
RADIO COMMUNICATIONS 308
Radio Communications 309
Communications Architecture 310
Communications Controls 311
Communications (COM) Page 312
Tuning a Radio to a Preset 314
Editing a Preset 317
Manually Tuning a Radio 321
Radio Hand & Foot Controls 324
TACTICAL EMPLOYMENT 325
Attack Helicopters in Combat 326
Mobility, Standoff, and Planning 328
Masking/Un-Masking and Terrain Flight 330
AH-64 Tactical Employment 331
Team Maneuvering 331
Terrain Flight Modes 333
Weapon Delivery Techniques 334
Sights and Sensors 335
Sight Selection Logic 336
Acquisition (ACQ) Sources 337
ACQ Selection Logic 338
Night Vision Goggles (NVG) 340
HELMET-MOUNTED DISPLAY (HMD) 341
Helmet-Mounted Display (HMD) 342
IHADSS Boresight 344
HMD High Action Display 346

HMD Acquisition and Ranging 350
HMD Hand Controls 357
TARGET ACQUISITION DESIGNATION SIGHT (TADS) 358
AN/ASQ-170 Modernized Target Acquisition Designation Sight 359
TADS Weapon Symbology 362
TADS Targeting Modes 367
Linear Motion Compensation (LMC) 367
Image Auto-Track (IAT) 368
Laser Spot Track (LST) 372
TADS Acquisition and Ranging 373
TADS Hand Controls 382
FIRE CONTROL RADAR (FCR) 383
AN/APG-78 Fire Control Radar 384
Fire Control Radar (FCR) Page 393
FCR Modes 402
Ground Targeting Mode (GTM) 402
Radar Map Mode (RMAP) 406
Air Targeting Mode (ATM) 409
FCR Acquisition and Ranging 413
Sight LINK 416
FCR Hand Controls 419
DATALINK (DL) 420
Datalink Communications 421
Secure Modem Datalink (SMDL) Network 422
Datalink Controls 424
Team Messages 434
COM Message Send (MSG SEND) Sub-Page 434
Sending Text Messages 435
Sending Mission Files 437
Receiving Text Messages & Mission Files 439
TSD Points 441
Transmitting a Point 441
Receiving a Point 443
Tactical Reports 444
TSD Report (RPT) Sub-page 445
Sending Tactical Reports 450

Requesting Tactical Reports 451
Receiving Tactical Reports 452
Reviewing Tactical Reports 453
Battle Area Management 457
TSD Battle Area Management (BAM) Sub-page 458
Drawing Fire Zones 462
Assigning Priority Fire Zones 465
Sending Fire Zones 466
Receiving Fire Zones 467
Radar Target Handovers 468
FCR page RF Handover (RFHO) Selection Menu 469
Sending an RF Handover 470
Receiving an RF Handover 471
WEAPONS EMPLOYMENT 472
Weapons Employment 474
Weapon employment tips and recommendations 478
Weapon (WPN) Page 480
Area Weapon System (AWS) 489
M230E1 30mm Automatic Gun 490
Gun Engagement using TADS (NORM Mode) 495
Gun Engagement using FCR (NORM Mode) 497
Gun Engagement using HMD (NORM Mode) 498
Gun Engagement using HMD (FXD Mode) 499
Aerial Rocket Sub-system (ARS) 500
Hydra-70 2.75-inch Unguided Rockets 501
Rocket Engagement using TADS (Direct Fire in COOP Mode) 510
Rocket Engagement using TADS (Indirect Fire in COOP Mode) 512
Rocket Engagement using FCR (Direct Fire or Indirect Fire) 514
Rocket Engagement using HMD (Direct Fire) 516
Hellfire Modular Missile System (HMMS) 518
AGM-114K Semi-Active Laser-homing (SAL) Missile 519
Laser-guided Hellfire Engagement (LOBL) 532
Laser-guided Hellfire Engagement (LOAL, DIR Trajectory) 534
Laser-guided Hellfire Engagement (Rapid Fire) 536
Laser-guided Hellfire Engagement (Remote Fire, LO or HI Trajectory) 539
Laser-guided Hellfire Engagement (Ripple Fire) 541

AGM-114L Radio Frequency (RF) Missile 544
Radar-guided Hellfire Engagement (FCR, Ground Targeting Mode) 555
Radar-guided Hellfire Engagement (FCR, Air Targeting Mode) 557
Radar-guided Hellfire Engagement (TADS) 559
Radar-guided Hellfire Engagement (RF Handover) 562
Weapon Hand Controls 564
AIRCRAFT SURVIVABILITY EQUIPMENT (ASE) 565
Aircraft Survivability Equipment 566
Aircraft Survivability Equipment (ASE) Page 567
Radar & Laser Signal Detecting Sets 571
Common Missile Warning System 572
Countermeasures Dispensers 574
Chaff Dispenser 574
Flare Dispensers 575
ASE Hand Controls 576
"GEORGE" AI 577
"George" AI 578
AH-64D AI Overview 579
AH-64D AI Controls Structure 580
Player-as-Pilot "George" AI Controls 582
Search Tasks 584
Combat Identification (CID) 592
Target Acquisition 594
Target Tracking & Engagement 597
Start-Up & Shutdown 601
Player-as-Pilot AI Helper Commands 602
Player-as-Pilot AI Helper Controls 603
Player-as-CPG "George" AI Controls 604
Additional "George" AI Features 608
AI Mission Editor Options 608
AI Helper Controls 609
APPENDICES 610
Appendix A - Abbreviated Checklists 611
Procedures 612
Navigation 617
Radio Communications 624

Datalink Communications 626
Combat Employment 637
Appendix B - ASE Threat Symbols 640
Air Defense Radar Systems 640
Airborne Radar Systems 641
Other Threat Symbols 642
Appendix C - ABR Page Point Tables 643
Waypoints (WPTHZ) 643
Hazards (WPTHZ) 643
General Control Measures (CTRLM) 643
Friendly Control Measures (CTRLM) 644
Enemy Control Measures (CTRLM) 645
Target (TGT/THRT) 646
Threats (TGT/THRT) 646
Appendix D - Frequently Asked Questions (FAQ) 649
Appendix E - Glossary of Terms 653
Appendix F - Formulas 664

LATEST CHANGES

Significant changes to the guide will be noted on this page.

- **15 July 2022** – Corrected typos/errors from initial release. Revised/updated AH-64 History and Aircraft Overview. Added Force Trim in DCS sub-section. Added Flight Management Computer section (describes FMC, SCAS and Hold mode functionality/logic). Added appendices for Glossary of Acronyms and Abbreviations, and Frequently Asked Questions (FAQ).
- **12 Aug 2023** – Updated manual to new formatting and structure. Revised all chapters for more thorough and improved explanations. Notable chapters that have received significant improvements are The AH-64D chapter's cockpit panel and MPD diagrams along with refined Flight Management Computer explanations, a much more detailed Procedures chapter with more detailed explanations and figures of maneuvers, and a more detailed Weapon Employment chapter. Added Helmet-Mounted Display (HMD) and Target Acquisition Designation Sight (TADS) chapters; and added ASE Threat Symbols appendix.
- **11 Sep 2023** – Updated Radio Communications chapter for the addition of radio presets and related functions. Added explanation of Controls Indicator to DCS Fundamentals chapter.
- **07 Dec 2023** – Updated Aircraft Survivability Equipment chapter for the addition of the laser warning component of RLWR. Added Datalink chapter for addition of datalink messaging, which includes explanations of all datalink-related MPD pages and functions (COM pages: ORIG ID, NET, MODEM, MSG-SEND, MSG-REC. TSD pages: POINT-XMIT, RPT, FARM, BAM).
- **07 Mar 2024** – Updated Aircraft History and Cyclic & Collective Hand Controls sections. Added Fire Control Radar (FCR) chapter. Added Radar Target Handovers to Datalink chapter. Added FCR engagements to Weapons Employment chapter. Added Datalink Communications checklists to Appendix A. Updated first page of Appendix A with hyperlinks to all checklists for more efficient use on electronic devices such as tablets.
- **29 Apr 2024** – Updated Fire Control Radar (FCR) chapter with descriptions of ZOOM format, C-Scope, and LINK functions. Updated TEDAC Right Handgrip and Collective Mission Grip descriptions for ZOOM, C-SCOPE and LINK functions.
- **29 Jul 2024** – Updated Fire Control Radar (FCR) chapter with description of Radar Map (RMAP) mode. Updated TEDAC Left Handgrip and Collective Mission Grip descriptions for additional FCR modes. Added "Return to Checklist index" shortcut to each page of Appendix A for more efficient use on electronic devices such as tablets.
- **06 Oct 2024 –** Updated Fire Control Radar (FCR) chapter with description of Air Targeting Mode (ATM) and more detailed descriptions of FCR Priority Schemes. Added Radar-guided Hellfire Engagement (FCR, Air Targeting Mode) to the Weapons Employment chapter.
- **29 Jun 2025 –** Added Helicopter Fundamentals of Flight chapter. Added more detailed explanation of automatic route sequencing and MGRS coordinates and required input format. Added WCA table to EUFD section. Added Autorotation Landing and Refueling/Rearming to Procedures chapter. Updated Player-as-Pilot section of George AI chapter. Added Rapid Refueling/Rearming and Editing a Communications Preset checklists to Appendix A.

DCS FUNDAMENTALS

US Army photo
by SFC Jeff Troth

HEALTH WARNING!

Please read before using this computer game or allowing your children to use it.

A very small proportion of people may experience a seizure or loss of consciousness when exposed to certain visual images, including flashing lights or light patterns that can occur in computer games. This may happen even with people who have no medical history of seizures, epilepsy, or "photosensitive epileptic seizures" while playing computer games.

These seizures have a variety of symptoms, including light-headedness, dizziness, disorientation, blurred vision, eye or face twitching, loss of consciousness or awareness even if momentarily.

Immediately stop playing and consult your doctor if you or your children experience any of the above symptoms.

The risk of seizures can be reduced if the following precautions are taken, (as well as a general health advice for playing computer games):

- Do not play when you are drowsy or tired.
- Play in a well-lit room.
- Rest for at least 10 minutes per hour when playing the computer game.

INSTALLATION AND LAUNCH

To install DCS and the DCS: AH-64D module, you will need to be logged into Windows with Administrator rights.

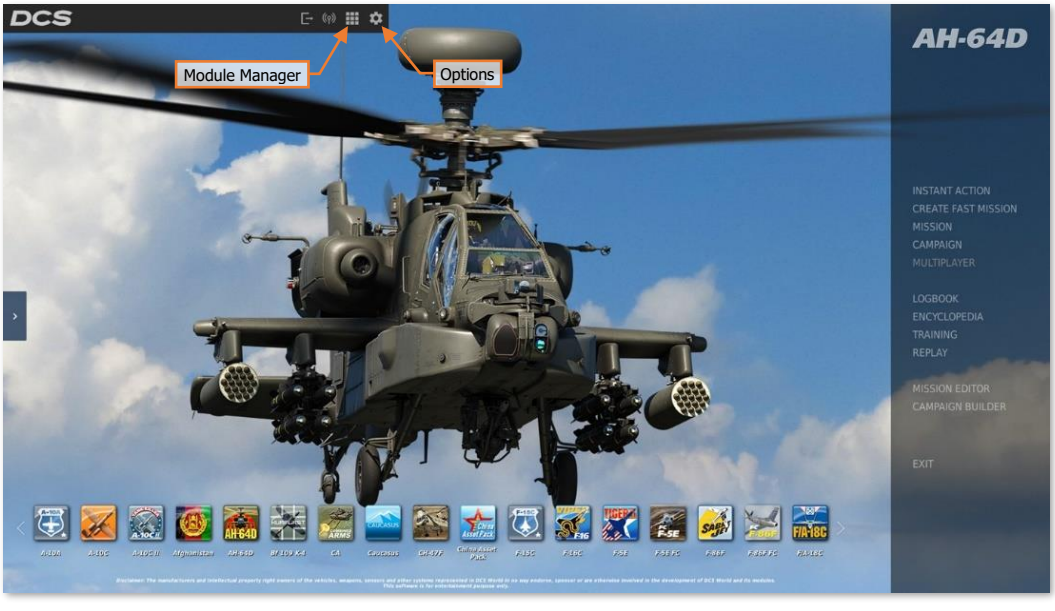
DCS is the PC simulation environment that the DCS: AH-64D simulation operates within. When DCS is launched, you in turn launch DCS: AH-64D.

As part of DCS, a map of the Caucasus region, the Su-25T "Frogfoot" attack aircraft, and TF-51 training aircraft are also included for free.

After purchasing DCS: AH-64D from our e-Shop, start DCS by executing the icon on your desktop. Upon initialization, the DCS Main Menu page is opened. From the Main Menu, you can read DCS news, change your wallpaper by selecting any of the icons at the bottom of the page, or select any of the options along the right side of the page.

Select the Module Manager icon at the top of the Main Menu. Upon initial entry into the Module Manager, a pop-up window titled Install Modules should automatically display, listing any DCS products that you have purchased and have yet to install. Ensure DCS: AH-64D is checked, and then click OK. Alternatively, you can select the Modules tab, scroll down until you locate the DCS: AH-64D entry, and click Install. In either case, DCS will close and automatically proceed with an update to download and install the necessary files. After the download and installation is complete, DCS will automatically restart.

To get started quickly, you can select Instant Action and play any of the missions listed for the AH-64D.



Configure Your Game

Before jumping into the cockpit, the first thing we suggest is to configure your game. To do so, select the Options button at the top of the Main Menu screen. You can read a detailed description of all Options in the DCS User Manual. For this Early Access Guide, we will just cover the basics.

SYSTEM Tab

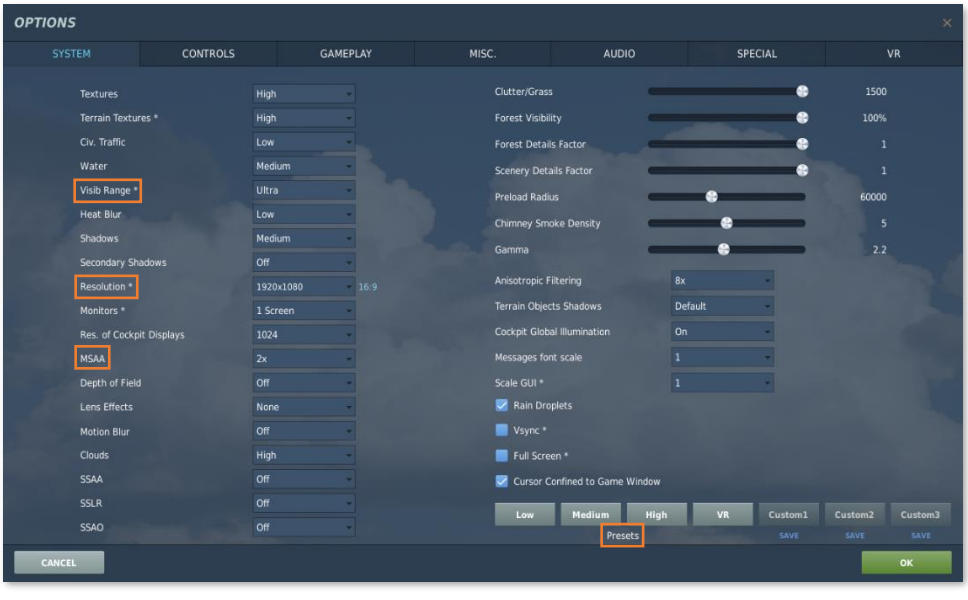
This tab allows you to configure your graphics options to best balance aesthetics with performance.

There are Presets options along the bottom of the page, but you can further adjust your graphics settings to best suit your computer. If you have lower performance, we suggest selecting the "Low" button and then increase graphics options to find your best balance.

Items that most affect performance include Visibility Range, Resolution, and MSAA. If you wish to improve performance, you may wish to first adjust these system options.

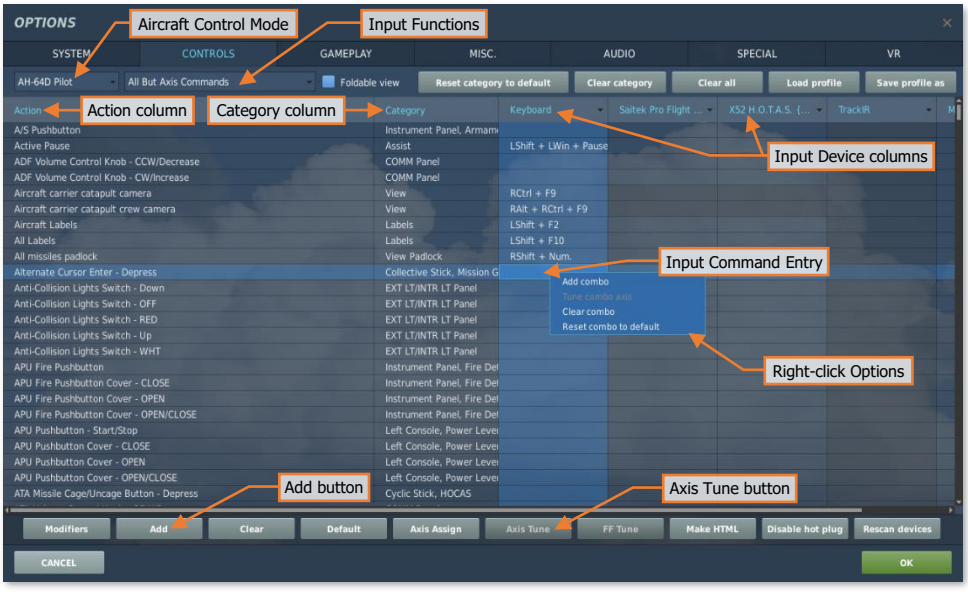
Items that have an asterisk (*) displayed next to them will require a restart of DCS to take effect.

Note that some missions may enforce different Civ. Traffic settings that override the individual user selection on this tab. This may result in higher or lower levels of expected civilian traffic scenery, or none at all.



CONTROLS Tab

This tab provides an interface to set up your controls and functional bindings.



Aircraft Control Mode. From this drop-down menu, select "AH-64D Pilot" or "AH-64D CP/G". The default seating position when starting a mission in the DCS AH-64D will always be the Pilot seat; unless joining another player's aircraft in multiplayer, in which case the seating position will be in the CP/G seat. Both cockpits have separate control input command lists, so changing an input command in one seat will not affect the other.

Input Functions. This displays various categories of input functions, such as axis devices, views, cockpit functions, etc. Additionally, "Search…" can be selected from the Input Functions drop-down to manually filter the Action column according to keyword matches.

Action column. This column along the left side of the screen displays the action associated with the corresponding input command entries.

Category column. This column to the right of the Action column displays the function group or cockpit panel each Action is grouped within.

Input Device columns. These columns display which input devices have been detected, including your keyboard, mouse, joysticks, throttles, or rudder pedals, and which input commands from the respective input devices will perform the corresponding Action.

Add button. To assign an input command to an Action, left-click the input command entry that corresponds with the desired Action under the desired input device column, then press the Add button along the bottom row. Alternatively, a double left-click on the desired command entry using mouse can be used, or right-clicking on the command entry and selecting "Add combo". Any of these methods will display the ASSIGNMENT PANEL.

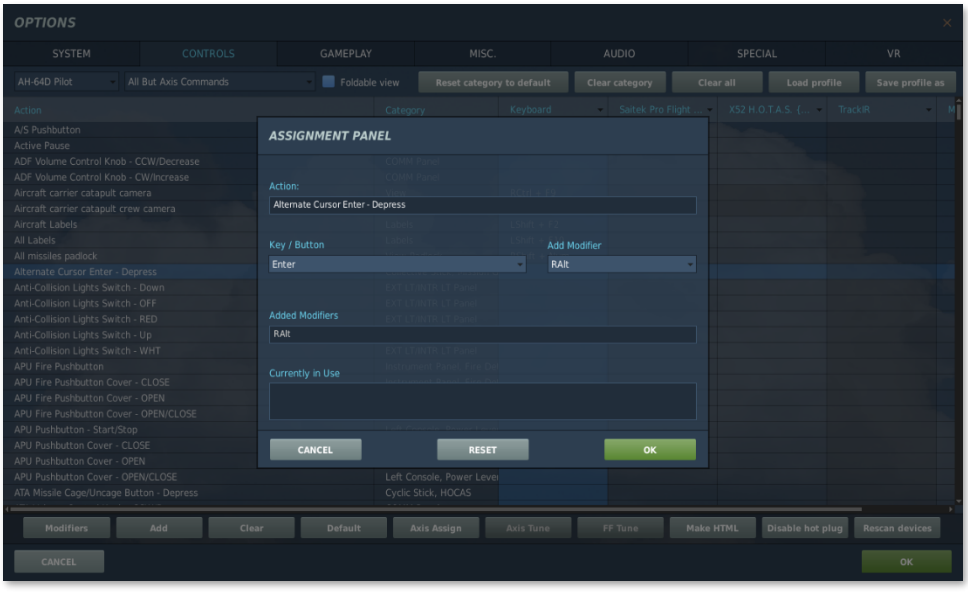
Default button. After assigning a command to an Action, you may revert to the default command assignment for that command entry by clicking on the corresponding entry to highlight, and then clicking the Default button. This can also be accomplished by right-clicking on the command entry and selecting "Reset combo to default".

Clear button. If you wish to remove all commands from an input device for that Action, click on the corresponding command entry to highlight, and then click the Clear button. This can also be accomplished by right-clicking on the command entry and selecting "Clear combo".

Axis Tune button. This button becomes available if an axis command entry is highlighted. When this button is clicked, the AXIS TUNE PANEL is displayed. This can also be accomplished by right-clicking on the command entry and selecting "Tune combo axis".

ASSIGNMENT PANEL

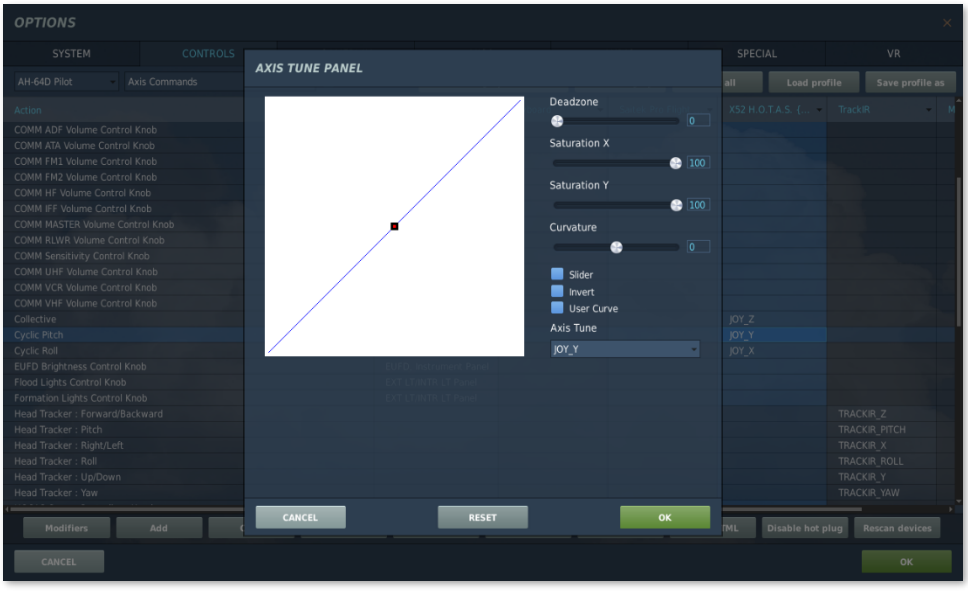
When this panel is displayed, simply press the button (or combination of buttons) or move the axis of the device to assign it to that Action.



- **Example 1:** If setting a pitch axis for a joystick, first select **Axis Commands** from the Input Functions drop down. Find the box where your Joystick input device and the "Pitch" Action intersect and double-click the left mouse button in the box. In the ASSIGNMENT PANEL, move your joystick forward and back to assign the axis. Press OK when finished.
- **Example 2:** If setting a keyboard or controller device button, first select **All But Axis Commands** as the Input Function category, or the category that contains the desired Action you wish to edit. Find the box where your input device and the Action intersect, and double-click the left mouse button in the box. In the ASSIGNMENT PANEL, press the keyboard or controller device button you wish to assign to the Action. Press OK when finished.
- If you make a mistake during the assignment process, press the RESET button and try again.
- If another Action is already assigned to that button or button combination, that Action will be shown under Currently In Use.

AXIS TUNE PANEL

When this panel is displayed, the selected axis can be assigned a dead zone, different response curves, and other tuning.



GAMEPLAY Tab

This tab primarily allows you to adjust the game to be as realistic or casual as you want it to be. Choose from various difficulty settings like labels, tooltips, unlimited fuel and weapons, etc. You can also set your preferred language and units of measurement.

Turning Mirrors off can assist with improving performance.

Note that some missions may enforce different gameplay settings that override the individual user selection on this tab. This may result different gameplay behavior than the user expects, such as enforcing no labels or restricting information on the F10 map.

MISC Tab

This tab contains miscellaneous features to further tune the game to your preference.

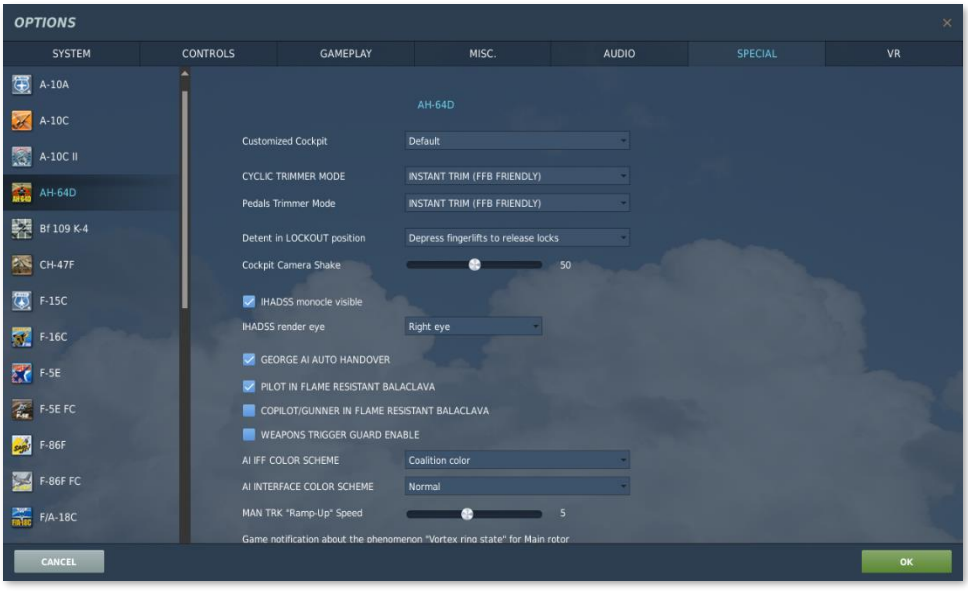
Note that some missions may enforce different gameplay settings that override the individual user selection on this tab. This may result different gameplay behavior than the user expects, such as enforcing no external views or Battle Damage Assessment overlays.

AUDIO Tab

Use this tab to adjust the audio levels within the game, enable/disable various audio effects, or manage your Voice Chat settings.

SPECIAL Tab

Use this tab to modify module-specific options by selecting the AH-64D from the module list along the left side of the screen.



Customized Cockpit. Only one option is available at this time, set to "Default".

Cyclic Trimmer Mode. This selection provides options for simulating force trim functions for various types of input devices.

- Instant Trim (FFB Friendly) – As soon as the Force Trim Release button (trimmer) is released, the new trimmed position of the player's stick will be applied immediately.
- Central Position Trimmer Mode – After the Force Trim Release button (trimmer) is released, the new trimmed position of the player's stick will be applied immediately; however any further control inputs will only be applied in each axis after the stick is returned to the neutral position in that axis (pitch and roll axes are monitored separately).
- Joystick Without Springs and FFB – This option is used for joysticks lacking any spring resistance or Force-Feedback (FFB).

Pedals Trimmer Mode. This selection provides the same trimming options as the Cyclic Trimmer Mode but applied to the Rudder axis.

Detent in LOCKOUT position. This selection determines when the engine power levers will be permitted to advance beyond the FLY position and into LOCKOUT.

- Automatically Jump Over – This option will move the engine power levers past the FLY position and into LOCKOUT without any detents applied. Recommended for player throttles equipped with physical detents.
- Depress Finger Lifts to Release Locks – This option will move the engine power levers past the FLY position and into LOCKOUT only when the Power Lever Finger Lift detent commands are used. Recommended for player throttles that lack physical detents.

Cockpit Camera Shake. Adjusts the intensity of physics applied to moveable cockpit elements.

IHADSS monocle visible. If enabled, a "ghost HDU" outline around the IHADSS symbology will be displayed to simulate the physical obstruction of the HDU monocle. If disabled, only the IHADSS symbology itself will be displayed.

IHADSS render eye. May be set to "Right eye", "Left eye" or "Both eyes." When using a VR headset, this will determine which eyepiece(s) render the IHADSS symbology and video.

George AI Auto Handover. If enabled, when the player switches position to the front (CPG) seat, George AI will automatically take control of the helicopter flight controls. If disabled, the player will still retain flight control of the helicopter when switching to the CPG seat and will need to command George AI to take the flight controls. The player will always retain the flight controls when switching to the Pilot seat.

Pilot in Flame Resistant Balaclava. If enabled, the 3D model of the Pilot will wear a flame-resistant balaclava.

Copilot/Gunner in Flame Resistant Balaclava. If enabled, the 3D model of the Copilot/Gunner will wear a flame-resistant balaclava.

Weapons Trigger Guard Enable. If enabled, the cyclic trigger guard key commands must be used prior to pulling the trigger. Any time the trigger guards are in the closed position, the cyclic triggers will not respond to key commands. If disabled, the trigger guard positions are ignored, allowing the player to fire an actioned weapon without a requirement to open the trigger guard prior to pulling the trigger.

AI IFF Color Scheme. This selection determines the color palette that is used to display units within the George AI Interface Target List when the player is occupying the Pilot seat and relying on George AI to perform Copilot/Gunner duties.

- NATO – Targets will be colored based on their hostility status, regardless of their coalition color.
  - Unit belongs to Hostile Coalition
  - Unit belongs to Friendly Coalition
  - Unit belongs to Neutral Coalition
  - Coalition affiliation is unknown.
- Coalition color – The Target List will display all targets in accordance with their assigned coalition.
  - Unit belongs to Red Coalition
  - Unit belongs to Blue Coalition
  - Unit belongs to Neutral Coalition
  - Coalition affiliation is unknown.

AI Interface Color Scheme. This selection determines the color palette that is used by the George AI Interface and provides options for players that are affected by forms of colorblindness.

- Normal – AI Interface text is displayed using normal, default colors.
- Colorblind Safe – AI Interface text is displayed using altered red and green colors.
- Monochrome White – AI Interface text is displayed using a uniform white color.
- Monochrome Yellow – AI Interface text is displayed using a uniform yellow color.

NOTE: Setting the AI Interface Color Scheme option to Monochrome White or Monochrome Yellow will override the AI IFF Color Scheme setting. All targets within the George AI Target List will be displayed in the same monochrome color as the remainder of the AI Interface, regardless of coalition affiliation.

MAN TRK "Ramp-Up" Speed. Adjusts the rate that the Sight Manual Tracker on the CPG Right TEDAC Grip increases, or "ramps up", input magnitude over time. Setting this slider to the right will reduce the time to reach full input magnitude and setting the slider to the left will increase the time to reach full input magnitude. This option allows players that are using a multi-directional hat switch in lieu of an analog input axis to control sight slew rates based on their preferences.

Game notification about the phenomenon "Vortex ring state" for Main rotor. If enabled, the player will receive artificial visual and/or audio warnings regarding the conditions, development, and onset of vortex ring state (VRS) conditions within the main rotor.

- **Audio notification.** Audio tones will be heard to warn of VRS conditions.
- **Visual notification (on controls indicator).** If the Controls Indicator overlay is enabled, visual symbols will be displayed to warn of VRS conditions.

Aerodynamic conditions are approaching those in which the main rotor may enter a vortex ring state.

Audio tone

● ● ● ● ● ●

Aerodynamic conditions have been met in which the main rotor is entering a vortex ring state.

Audio tone

● ● ● ● ● ● ● ● ●

Aerodynamic conditions have been met in which the main rotor has entered a vortex ring state.

Audio tone

● — ● — ● —

VR Tab

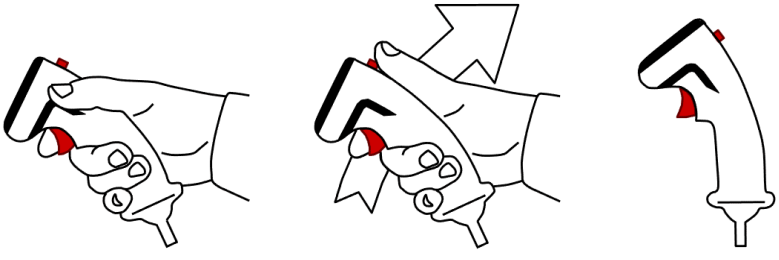
This tab allows you to enable support for a wide variety of VR Headsets and adjust their functionality. When using VR, be particularly aware of the Pixel Density setting as it can have a dramatic effect on game performance.

Force Trim in DCS

Most helicopters are rarely flown with either the cyclic or the pedals in the neutral position. Many helicopters feature a "force trim" system to reduce pilot workload. Such systems produce a force gradient which maintains the position of the cyclic (and pedals in some cases) using springs or magnetic brakes. The pilot can apply pressure against this force gradient if desired, or they can release the pressure entirely by pressing a button on the cyclic. When this button is no longer pressed, the force gradient is re-applied and holds the controls at their new position(s). This button is often called the "force trim release" or "force trim interrupt" button since it releases or interrupts the force gradient holding the controls in place (the term "Trimmer" is also used to describe this button).

The closest simulation of real-world force trim functionality is facilitated through the use of force-feedback gaming sticks. However, since most flight simulation enthusiasts use more conventional spring-centered joysticks, a special trim function is available in the simulation, with several options available to the player. These options are set using the Cyclic Trimmer Mode and Pedals Trimmer Mode drop-down selections (described on the previous pages), but the underlying logic is based around establishing a new "center point" for the cyclic and pedals.

To trim the controls in their current position, press and release the "Trimmer" button, then immediately return the gaming joystick and pedals to their neutral positions. It is recommended that players unfamiliar with this force trim simulation spend some time in the cockpit on Active Pause **[LShift + Lwin + Pause]** or while sitting on the ground and observe the behavior of the simulated controls within the cockpit relative to their physical controls in their hands.



1) Establish a stable flight attitude

2) Press and release the trimmer button, return the stick to neutral

3) The helicopter will continue to fly in the trimmed attitude

Trimming Procedure

Another means to observe this simulated trimming procedure is to display the Controls Indicator overlay while in game by pressing **[RCtrl + Enter]**. You can reset trim at any time by pressing **[LCtrl + T]**, which will re-synchronize the simulated controls within DCS with your physical joystick and/or pedals.

Author's Note regarding Trimmer options in DCS: AH-64D

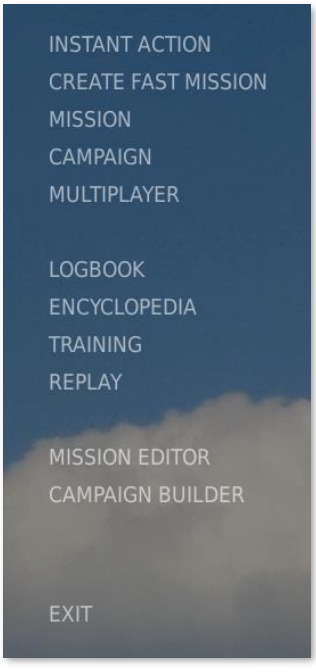
Due to the nature of the AH-64D Flight Management Computer and its associated breakout values and hold mode logic (described in the Force Trim & "Breakout" Values and Hold Modes sections), the Trimmer options that are most conducive to interacting with the hold modes are the "Central Position Trimmer Modes". However, during fast-paced action while performing low altitude flight maneuvers or evading enemy fire, it can become mentally counter-intuitive to reposition the stick to the neutral state when instinctive action dictates that you make an input in the opposite direction away from center.

For these reasons, when using a spring-centered cyclic stick and rudder pedals, the author recommends using "Instant Trim (FFB Friendly)" for the Cyclic option, but "Central Position Trimmer Mode" for the Pedal option; since many individuals lack the same physical dexterity and control precision in their feet as compared to their hands. Regardless, it is encouraged that each player tries the different options to assess which Trimmer modes best suit their personal preferences and specific input devices.

Fly a Mission

Now that you have configured your game, let's get to why you purchased DCS: AH-64D, to fly some missions! You have several options to fly a single or multi-player mission.

On the Main Menu page, you have the options to fly the AH-64D in an INSTANT ACTION mission, CREATE FAST MISSION, load a MISSION, play a CAMPAIGN, go through a TRAINING lesson, or create a mission in the MISSION EDITOR. You also have the option to jump online and fly with others in MULTIPLAYER.



INSTANT ACTION. Simple missions that place you in the task of your choice. These missions are grouped according to which map they take place in, so selecting a different map from the list along the right side of the Instant Action mission list may provide additional missions to choose from.

CREATE FAST MISSION. Set various mission criteria to allow a mission to be created for you.

MISSION. More in-depth, stand-alone combat missions.

CAMPAIGN. Linked missions to create a campaign narrative.

MULTIPLAYER. Create your own multiplayer session or join a multiplayer session already in progress.

TRAINING. Lessons that provide step-by-step instructions in tasks such as starting the AH-64D, takeoff and landing, navigation, or employing weapons.

MISSION EDITOR. Use this very powerful tool to create your own missions.

To get started, we suggest one of the "Free Flight" INSTANT ACTION missions. Later, you can also use these missions to practice starting up the aircraft, takeoffs, landings, navigation, and sensor / weapon employment.

Game Problems

If you encounter a problem, particularly with controls, we suggest you back up and then delete the **Saved Games\DCS\Config** folder in your home directory, which is created by DCS on your operating system drive at first launch. Restart the game and this folder will be rebuilt automatically with default settings, including all the controller input profiles.

If problems persist, we suggest consulting our online technical support forums.

Useful Links

- Digital Combat Simulator homepage
- DCS: AH-64D Forum

Note about this manual

(N/I). This denotes a system or function within this manual that is not implemented in DCS: AH-64D.

Mission Editor Options

Whether you are creating a mission for yourself and a friend to play online, or creating a large-scale mission for many players in many aircraft, there are a few important options regarding the DCS: AH-64D that should be properly configured within the Mission Editor.

Each DCS aircraft will have several tabs displayed on their Airplane Group or Helicopter Group panes, with each having a specific purpose in preparing the aircraft for the mission.

Route. Allows the mission creator to program a series of waypoints that the aircraft should fly during the mission. If the aircraft is to be controlled by AI during the mission (Skill option is set to any level except Player or Client), advanced waypoint actions may be added to any waypoint which may dictate specific actions that the AI should perform.

Payload. Allows the mission creator to specify the fuel, weapons, and munitions that should be carried by the aircraft during the mission.

Triggered Actions. Allows the mission creator to program AI tasks that will be performed when/if triggered within the mission. These will only apply if the aircraft is being controlled by AI.

Summary. Allows the mission creator to review a route summary of the flight plan programmed on the Route tab.

Failures (Player only). Allows the mission creator to program any number of emergency conditions or component failures that may occur during the mission.

Radio Settings (Player/Client only). Allows the mission creator to configure the preset radio frequencies used by the aircraft radios, if such capability exists for that aircraft.

Aircraft Additional Properties. Allows the mission creator to configure any remaining properties that are unique to the aircraft type.

- **FCR/RFI removed.** When checked, the mast-mounted Fire Control Radar assembly will be removed.
- **Allow Plt NVG.** When checked, the Pilot in the rear cockpit will be equipped with night vision goggles. If un-checked, night vision goggles will not be available during the mission.
- **Allow Cpg NVG.** When checked, the Copilot/Gunner in the front cockpit will be equipped with night vision goggles. If un-checked, night vision goggles will not be available during the mission.
- **Flare Burst Count/Interval, Salvo Count/Interval, Delay btw. Programs.** Pre-configures the flare dispenser program prior to the mission, since this can only be performed by ground crews via an external access panel. These options may also be configured via the player kneeboard while the main engines are off and the rotor is not spinning. (See Flare Dispensers in the Aircraft Survivability Equipment (ASE) chapter for more information.)
- **AI IFF Detection Mode.** See AI Mission Editor Options for more information.
- **Track Air Targets.** See AI Mission Editor Options for more information.

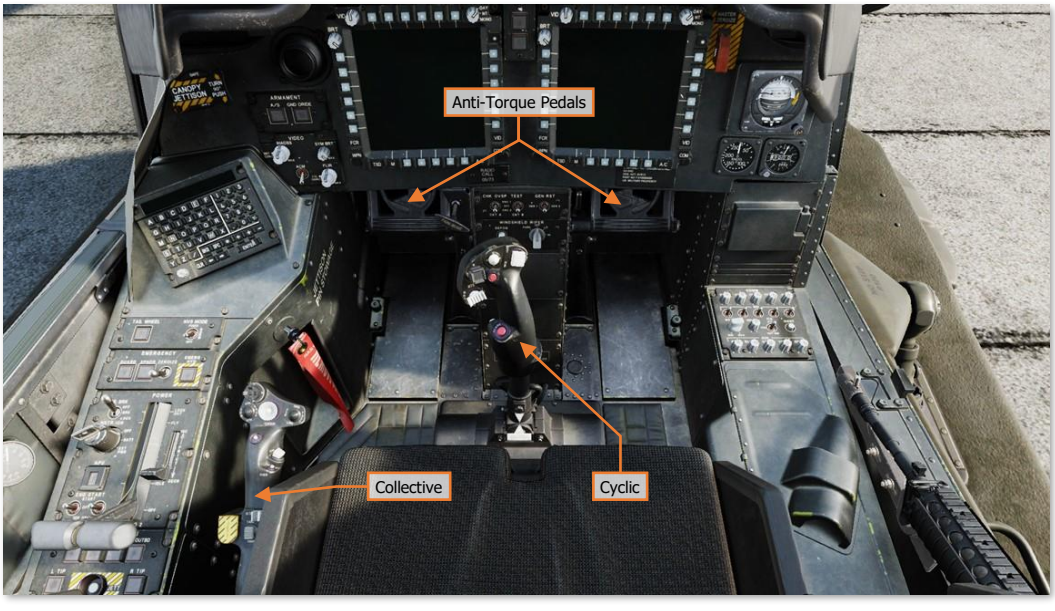
- **Aircraft Control Priority.** Configures the "multicrew" control handover logic when two players are occupying the same AH-64D during a multiplayer session. As the pilot-in-command, the Pilot will always have initial control of the aircraft.
  - **Pilot.** The Pilot has priority control of the aircraft.
    - The CPG must request control from the Pilot, after which the Pilot may grant or deny the request to transfer the flight controls.
    - The Pilot can take control from the CPG at any time but cannot give control to the CPG without a transfer request from the CPG.
  - **CPG.** The CPG has priority control of the aircraft.
    - The Pilot may request control from the CPG, after which the CPG may grant or deny the request to transfer the flight controls.
    - The CPG can take control from the Pilot at any time and can give control to the Pilot at any time.
  - **Ask Always.** Neither crewmember has priority control of the aircraft.
    - The crewmember that does not have control must request control. The crewmember that has control may grant or deny the request to transfer the flight controls.
  - **Equally Responsible.** Neither crewmember has priority control of the aircraft.
    - The crewmember that does not have control may take control at any time.
    - The CPG may give control to the Pilot at any time, but the Pilot cannot give control to the CPG.
- **AI Disabled.** When checked, "George" AI will be disabled within the aircraft. If the AH-64D is occupied by only one player, they will need to switch between each crewstation to perform the tasks of both crewmembers. (See AI Mission Editor Options for more Information.)
- **Disable Multicrew.** When checked, only one player may occupy the AH-64D during multiplayer gameplay. Only one crewmember position will be available to join from the "Multiplayer – Select role" screen. The player will need to switch between each crewstation to perform the tasks of both crewmembers or rely on "George" AI to assist with the operation of the aircraft (if **AI Disabled** is not checked as well).
- **Datalink Originator ID.** See Datalink Mission Editor Options for more information.
- **Ownship CallSign.** See Datalink Mission Editor Options for more information.

Datalinks. Allows the mission creator to configure communication preset and datalink settings for the aircraft. (See the Datalink chapter for more information.)

FLIGHT CONTROL

The primary helicopter flight controls include the **Cyclic**, **Collective**, and **Anti-torque Pedals**.

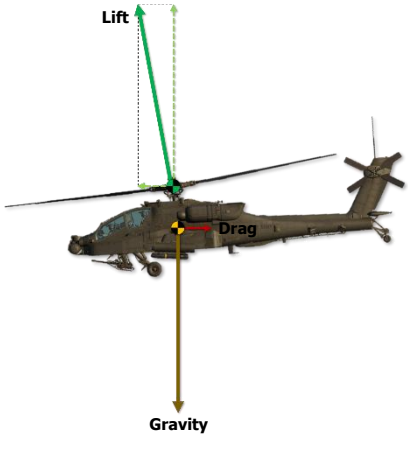
- The **Cyclic** is used to pitch the nose up and down to control airspeed, and roll the aircraft left and right to perform turns while in forward flight or to translate left and right while in a hover.
- The **Collective** is used to control the amount of lift the main rotor produces for maintaining a constant altitude or climbing and descending.
- The **Anti-torque Pedals** are used to control the amount of thrust the tail rotor produces to counter the torque produced by the main rotor and for yawing the nose left and right while in low speeds or in a hover; and on the ground to turn the nose when taxiing.



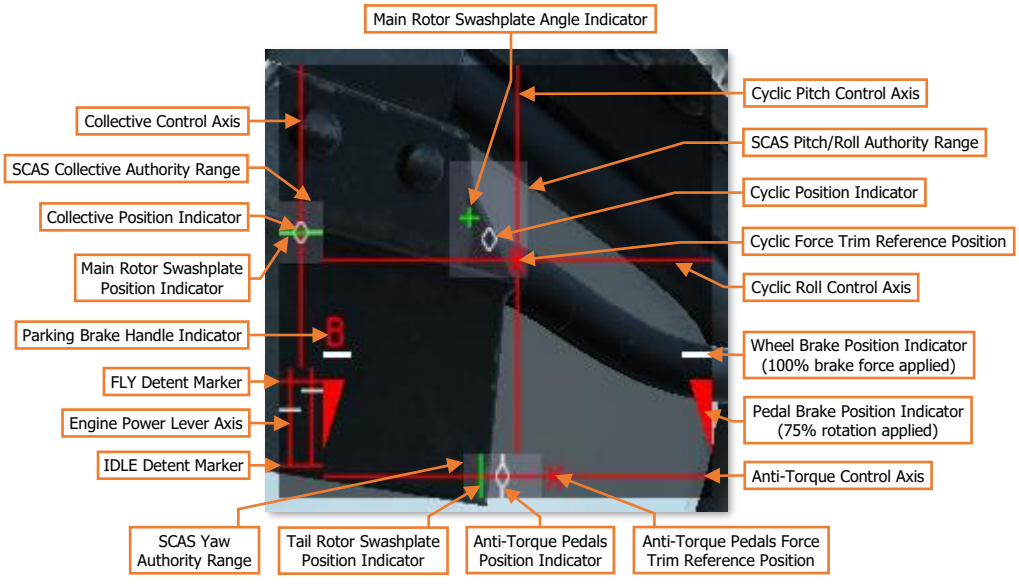
Just as fixed-wing aircraft use the physics of opposing forces to fly and maneuver through the air, helicopters also rely on opposing forces to maintain controlled flight. However, the physical forces involved in rotary-wing flight are much more difficult to maintain in a state of balance and require constant attention by the pilot to maintain controlled flight.

Although DCS: AH-64D includes keyboard commands for manipulating the flight controls, it is highly recommended that analog control devices of some form are utilized. If you do have a joystick, it may be equipped with a throttle handle for controlling the collective; and/or a twist grip, which will allow you to control the anti-torque pedals.

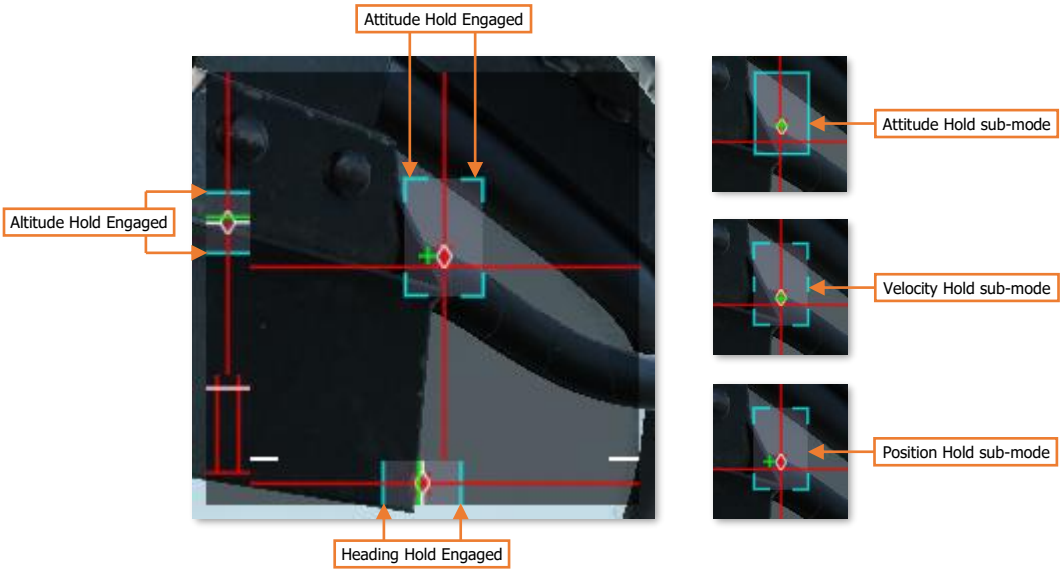
See the Helicopter Fundamentals of Flight chapter for more information.



When flying from the cockpit, the Controls Indicator may be displayed by pressing **[RCtrl]+[Enter]** to view a visual representation of the flight control positions and their behavior, as commanded by the flight computer.



If the Flight Management Computer (FMC) is automatically holding the aircraft at a specific attitude, altitude, heading, velocity, or a stationary hover, blue indicators will appear around the SCAS authority range (light-shaded regions) of the corresponding flight control axis (or axes) in which Hold mode(s) are engaged. In addition, the format of the blue indicator around the SCAS pitch/roll authority range will change depending on the specific sub-mode logic within which the Attitude Hold is operating.



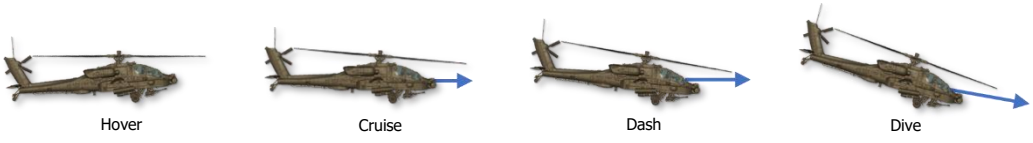
See the Flight Management Computer section in The AH-64D chapter for more information.

Changing Airspeed

A helicopter's airspeed is a function of its pitch attitude. The lower the pitch angle, the faster the helicopter will fly. However, too low of a pitch angle and the helicopter will enter a dive.

To accelerate, the nose should be pitched down to redirect the main rotor's lift forward, which will cause the helicopter to accelerate. However, since some of the main rotor's lift is now being used for propulsion and not for countering gravity, the helicopter will descend. This must be countered by pulling up on the collective to increase the lift that the main rotor is producing.

To decelerate, the nose should be pitched up to redirect the main rotor's lift aft, which will cause the helicopter to decelerate. However, this will cause the helicopter to climb and must be countered by pushing down on the collective to decrease the lift that the main rotor is producing.

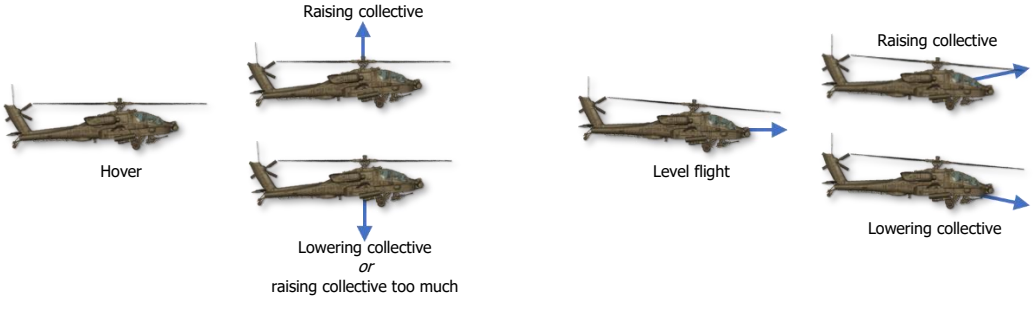


Changing Altitude

Changing the position of the collective lever can increase or decrease the helicopter altitude; or be used to maintain the current altitude as the helicopter is pitched up or down to change airspeed.

Increasing the collective pitch angle of the main rotor blades will increase the amount of lift the main rotor produces, which will cause the helicopter to climb. However, this will also increase the amount of torque that the main rotor imparts on the helicopter, which will manifest as a right yawing motion. This must be countered by applying left pedal as the collective is increased.

Decreasing the collective pitch angle of the main rotor blades will decrease the amount of lift the main rotor produces, which will cause the helicopter to descend. However, this will also decrease the amount of torque that the main rotor imparts on the helicopter, which will manifest as a left yawing motion. This must be countered by applying right pedal as the collective is decreased.



NOTE: It is possible to increase the collective beyond the capabilities of the engines to keep the rotor spinning at the correct rotational speed. As the rotor blades' angle-of-attack is increased, the blades will produce more lift *and* more drag. If the drag on the rotor system exceeds the maximum torque output from the engines, the rotational speed of the rotor will slow, also known as "rotor droop". As the rotor speed decreases, the amount of lift the rotors produce will decrease exponentially, and the helicopter will descend. The collective must be lowered to reduce the drag on the rotor system and regain rotational speed of the rotor, and the helicopter will regain lift. This principle is analogous to recovering an airplane from the effects of a stall, in which the nose of the airplane is pitched downward to gain airspeed and reduce the angle-of-attack of the wings in order to regain lift.

Changing Heading

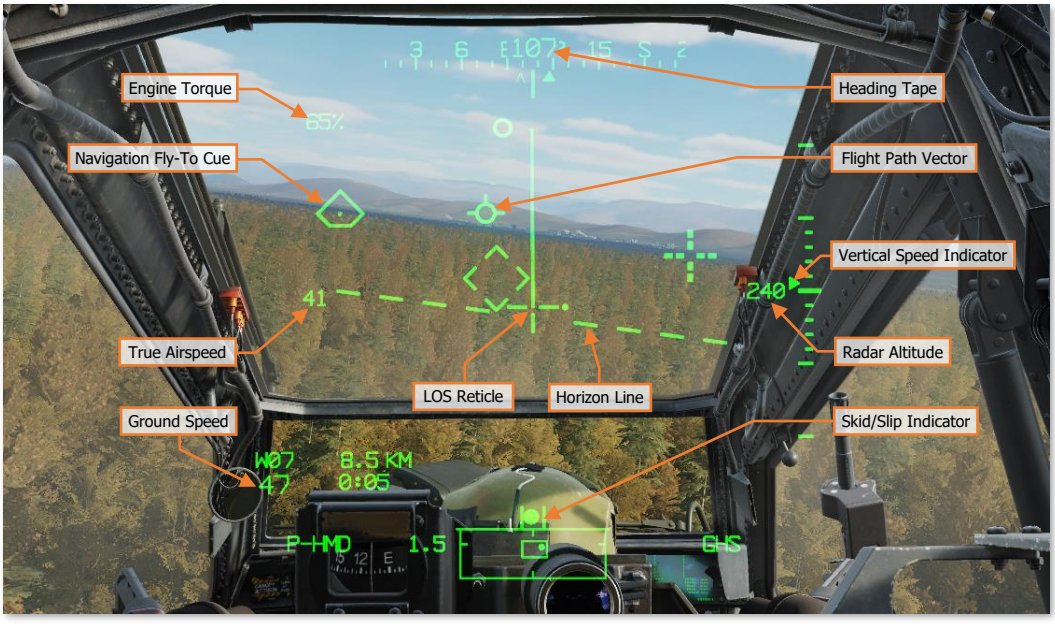
Changing the heading of the helicopter in the horizontal plane is accomplished in one of two ways, depending on whether the helicopter is in forward cruise flight or is at low airspeed or hovering.

When in forward flight, the heading of the helicopter is changed by rolling, or banking, the helicopter in the desired direction. As the bank angle is increased, the collective must be increased to maintain altitude. At steeper bank angles, pulling back on the cyclic may be required to maintain altitude or to increase the turn rate by pitching the nose in the direction of the turn. Just prior to reaching the desired heading, the cyclic should be used to roll the helicopter back to level flight, so the helicopter returns to a level attitude just as the desired heading is reached.

When at a stationary hover, the heading of the helicopter is changed by yawing the helicopter in the desired direction. As the airspeed increases, a combination of yaw and roll will be necessary to change heading when at low airspeed, until the airspeed becomes high enough that the turn may be performed using roll alone.

Note the following:

- Shallow bank angles will require a slight increase in collective to prevent altitude loss. Steep bank angles will require a combination of collective increase and cyclic pitch input to prevent altitude loss.
- During steep turns, higher pitch rates will increase the turn rate but will also cause the helicopter to slow down. If too much airspeed is lost while in a steep turn, the helicopter will rapidly lose altitude and impact the terrain. Decreasing the bank angle as the speed decreases will prevent loss of altitude.



The Heading Tape along the top of the helmet display symbology can be used to monitor heading. The chevron along the bottom of the Heading Tape shows the relative direction to your next waypoint. If you turn the aircraft toward it and then align the Flight Path Vector with the Navigation Fly-To Cue, you will be flying to your waypoint.

The Horizon Line is displayed relative to the Line-Of-Sight (LOS) Reticle, which are the crosshairs within the center of the helmet display symbology. If the Horizon Line bisects the LOS Reticle, the nose of the helicopter is on the horizon. If the LOS Reticle is above the Horizon Line, the nose of the helicopter is above the horizon.

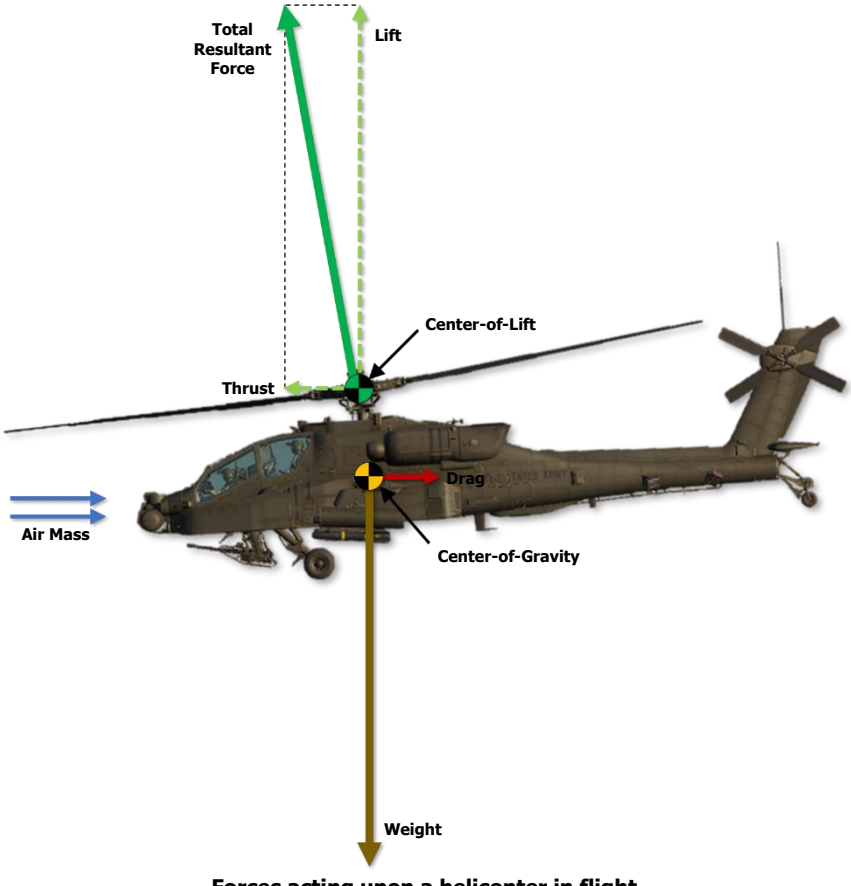
HELICOPTER FUNDAMENTALS OF FLIGHT

US Army photo
by SGT Richard Wrigley

FUNDAMENTALS OF FLIGHT

The core fundamentals of flight are the same for airplanes and helicopters. The key difference is that the airfoils of an airplane are fixed to the airplane fuselage and rely on forward motion through an air mass to generate lift, whereas the airfoils of a helicopter rotate to generate lift independently of the fuselage motion through the same air mass. This difference in how airfoils generate lift relative to the fuselage is the origination of the terms fixed-wing aircraft and rotary-wing aircraft in describing airplanes and helicopters, respectively.

All aircraft fly by precisely balancing the opposing forces of lift versus weight and thrust versus drag. However, the act of rotating the airfoils independently of the fuselage produces a very different set of aerodynamic properties and physical forces that are unique to rotary-wing aircraft. As such, these unique aerodynamic characteristics create greater instability of opposing forces acting upon the helicopter, the balance of which must be actively and continuously maintained in order to keep the helicopter in a state of controlled flight.

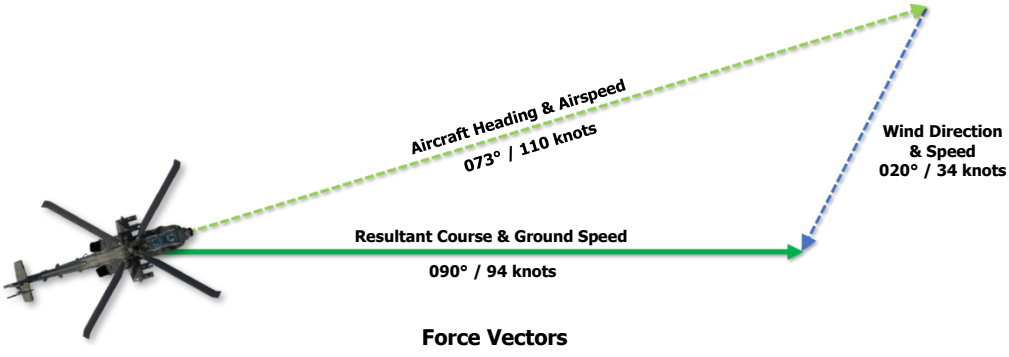


Forces acting upon a helicopter in flight

The most common type of helicopter utilizes a single main rotor to produce lift and thrust. In a very basic sense, the helicopter's main rotor does what wings and a propeller do for a fixed-wing aircraft. However, it is important to note that a helicopter's main rotor is not simply a large propellor, but an assembly of multiple airfoils that collectively produce a total force vector which is used for both vertical lift and horizontal thrust.

Vectors

Vectors are lines with arrows that can be used to depict magnitude and direction of a force or energy state, with the length of the vector representing the magnitude of the force. When several vectors are used to depict a combined effect of multiple forces, the effect of these forces is known as the *resultant*. Vectors are often used to depict aerodynamic or physical forces acting upon an airfoil or an aircraft while in flight.



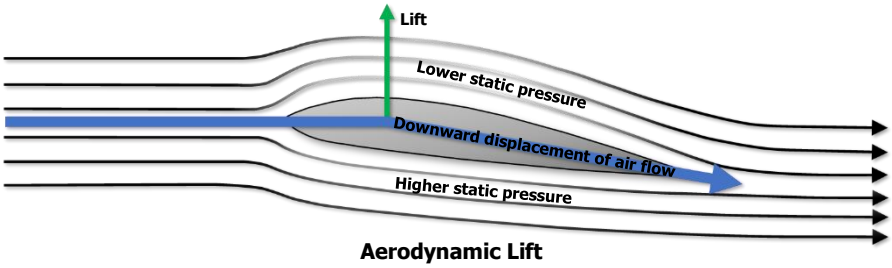
Force Vectors

Aerodynamic Lift

Airfoils generate lift by using a combination of static pressure differential across the upper and lower surfaces of the airfoil (Bernoulli's Principle) and the force imparted on the airfoil itself from the downward displacement of air (Newton's Third Law of Motion).

Aerodynamic forces are subject to the same law of conservation of energy that governs fluid dynamics. As energy cannot be created or destroyed, the same amount of energy that enters a closed system must also exit. Given a mass flow rate within a three-dimensional area, the flow rate will remain constant if the cross-sectional area that the mass is traveling within remains constant. If the cross-sectional area decreases, the flow rate will increase; and vice versa. This phenomenon is known as the Venturi effect and describes the relationship between static pressure and dynamic pressure as air flows across a curved surface.

As air flows around an airfoil, the total pressure that is exerted on the airfoil must remain constant. However, due to the Venturi effect, the velocity of the air increases as it is constricted by the curved surface of the airfoil, which converts static pressure exerted on the airfoil surface to dynamic pressure. As the upper surface of an asymmetrical airfoil has more camber compared to the lower surface, the air flowing across the upper surface will have a greater dynamic pressure and less static pressure compared to the lower surface. This static pressure differential accounts for approximately 75% of the total lift generated by the airfoil.

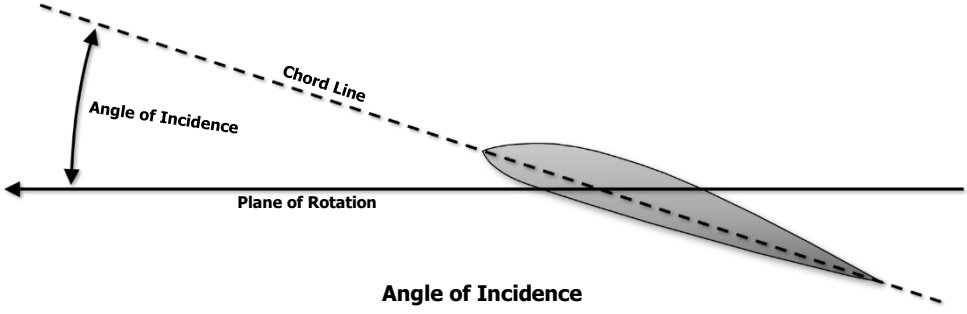


Aerodynamic Lift

The remaining 25% of the total lift generated by the airfoil is produced by the downward deflection of air as it impacts the lower surface of the airfoil, which produces an opposite reaction force against the airfoil.

Aerodynamic Forces

Helicopter rotor blades are airfoils much like the wings of an airplane; and as such, they share many characteristics. Like an airplane wing, a rotor blade airfoil's *angle of incidence* is the measured angle between the airfoil's chord line and the reference plane. However, unlike an airplane, the reference plane of a helicopter is the rotor system's plane of rotation, not the longitudinal plane of the aircraft fuselage.

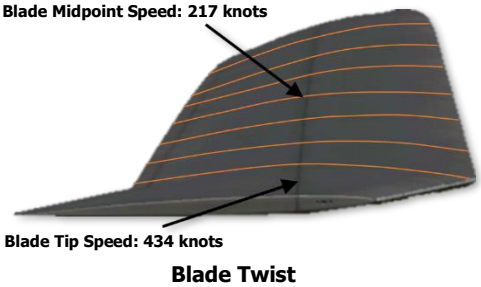


Angle of Incidence

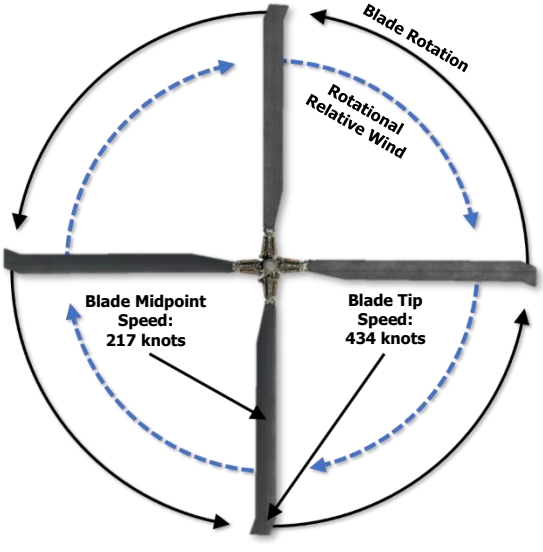
Rotational Relative Wind

The movement of any airfoil through the air generates *relative wind*. Relative wind moves in a parallel but opposite direction to the movement of the airfoil. The term used when describing rotary-wing airfoils is *rotational relative wind*.

As a rotor system spins, the rotational relative wind velocities will vary greatly between the blade root and the blade tip. To compensate, rotor blades are designed with a twist, which creates a higher angle of incidence for the inner portions of the airfoil, resulting in a more uniform distribution of lift across the length of the rotor blade. This uniform distribution of lift increases the blade loading near the inboard section and reduces stress on the internal blade structure.



Blade Twist

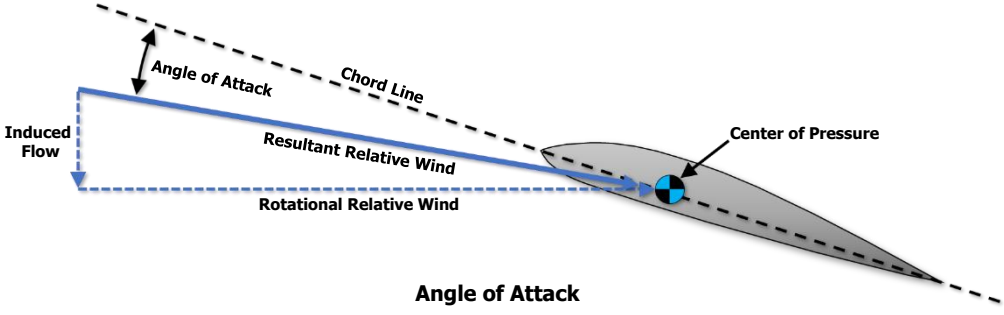


Rotational Relative Wind

Angle of Attack

When a rotor blade is set to "flat pitch", meaning that the overall angle of incidence of the blade is set to its minimum setting, little to no lift is created. As blade pitch is increased, and since each rotor blade is traveling within the same plane of rotation as the remaining rotor blades, the rotor system as a whole induces a downward flow of air. This downward flow of air is called *induced flow* (also called "downwash").

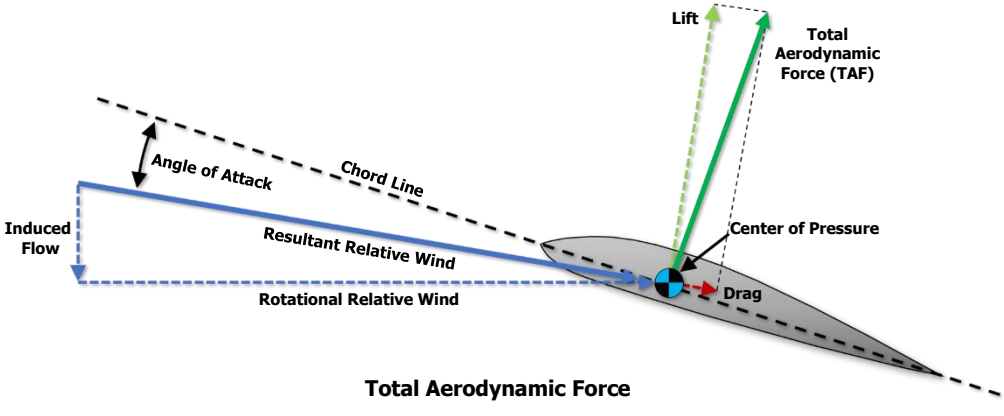
The entire rotor system operates within this descending column of air. This downward component of air from induced flow modifies the rotational relative wind vector in such a way that the air approaching the rotor blade airfoil will do so at a reduced *angle of attack* compared to the angle of incidence of rotor blades themselves. This combination of rotational relative wind modified by induced flow is known as the *resultant relative wind*. Angle of attack is the measured angle between the airfoil's chord line and the resultant relative wind.



Angle of Attack

Total Aerodynamic Force

As air flows around the airfoil, aerodynamic lift is generated at an angle perpendicular to the resultant relative wind. Simultaneously, air resistance to the movement of the airfoil against the resultant relative wind generates aerodynamic drag parallel to and in the same direction as the resultant relative wind. The combined aerodynamic forces of lift and drag acting upon the airfoil is known as the *total aerodynamic force* (TAF). The total aerodynamic force acts upon the airfoil's center of pressure.



Total Aerodynamic Force

Aerodynamic Drag

The aerodynamic drag that acts upon a helicopter in flight are categorized within three types: profile drag, induced drag, and parasite drag.

Profile Drag

Profile drag is incurred from the frictional resistance of the rotor blades passing through the air. Profile drag consists of both form drag from the shape of the rotor blade airfoil (streamlined versus blunt) and skin resistance from the surface roughness of the blade itself.

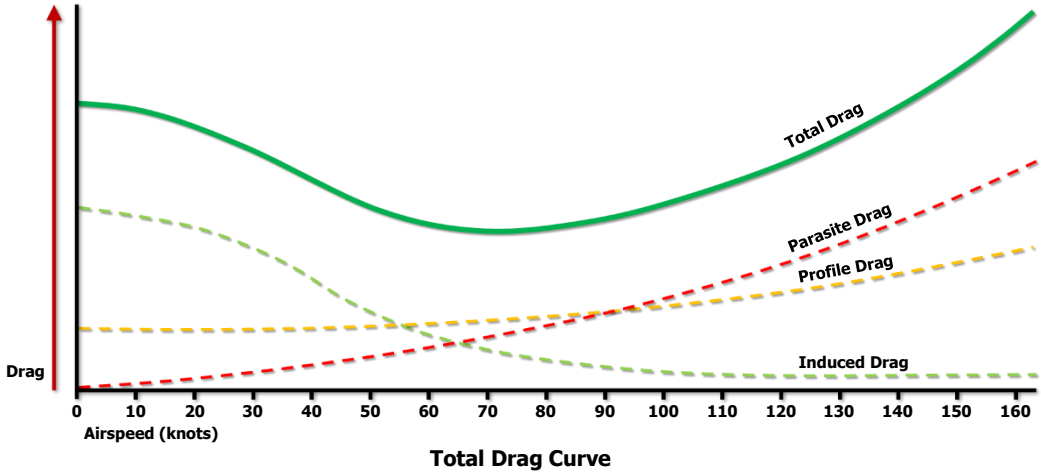
Induced Drag

Induced drag is incurred from the production of lift. As air is deflected downward by the rotor system, the velocity of the induced flow through the rotor system increases, which elevates the angle of the resultant relative wind. As lift is produced perpendicular to the resultant relative wind, this inclines the lift vector aft against the plane of rotation. This rearward component of lift acting on each blade is induced drag.

Parasite Drag

Parasite drag is incurred from non-lifting components of the aircraft. This includes the profile drag from the shape of the fuselage itself, the engine cowlings, weapon pylons, and the rotor mast and hub.

A helicopter's total drag is the sum of all three of these drag forces. As airspeed increases, profile drag increases moderately, parasite drag increases considerably, but induced drag decreases. When all three of these drag forces are combined, this results in the *total drag curve*. The total drag curve is an important factor in understanding a helicopter's performance.



Total Drag Curve

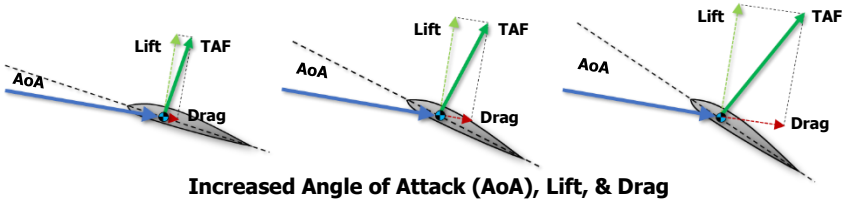
As total drag increases, more engine power is required to overcome the effects of drag and maintain airspeed, altitude, and the rotational speed of the rotor system. However, as illustrated in the graph above, understanding a helicopter's total drag curve is critical in understanding how much power is required to perform specific maneuvers under a given set of conditions of pressure altitude, air temperature, and gross weight; and how much margin exists between the power that is required to perform a maneuver and the amount of power that is available to be utilized in any contingencies that may be encountered.

During combat maneuvers, a robust power margin may be the difference between colliding with terrain or rapidly orienting the aircraft weapon systems onto a target and evading enemy fire. In some scenarios in which the environmental factors of altitude and temperature are high, a reduction in gross weight may be necessary to regain the required power margin for the mission. There may be instances in which even the method of getting airborne during takeoff is driven by the power margins that are available at that time.

Engine Power and Torque

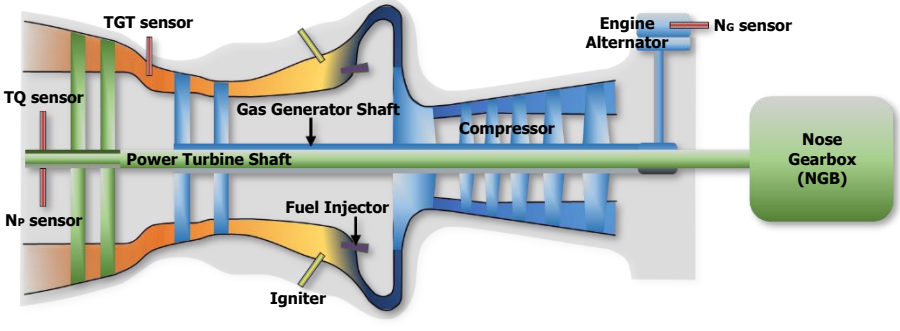
Just as an airplane requires engine thrust to generate forward motion through an air mass, and thus airflow across its airfoils to produce lift, a helicopter requires engine power of some form to maintain the high-speed rotation of its rotor systems, which in turn produce lift and thrust.

The airfoils of a helicopter's rotor systems are designed to operate within a specific range of rotational speeds that are determined to be most optimal across its flight envelope. Like all objects moving through an air mass, a helicopter's rotor blades are subject to aerodynamic drag. As the pitch of a helicopter's rotor blades are increased, the increased angle of attack results in a simultaneous increase of lift and drag. If the engine power output remains the same as the drag on the rotor system increases, the rotational speed of the rotor will decrease. Therefore, to maintain the rotational speed of the rotor system, the engine power output must be continuously adjusted to maintain a balance between the opposing forces of engine power output and aerodynamic drag.



Increased Angle of Attack (AoA), Lift, & Drag

In most modern helicopters, the power output from the engines into the drive train assembly (transmission, gearboxes, and interconnecting shafts) is adjusted automatically through mechanical or electronic control systems, or a combination of the two. As the pilot demands more lift from the helicopter, the engines will increase their power output accordingly to counter the increase in drag. Although some small helicopters are equipped with reciprocating engines, most modern helicopters leverage the efficiency and power of turboshaft engines, which are a type of gas turbine engine designed to output mechanical torque rather than direct thrust.



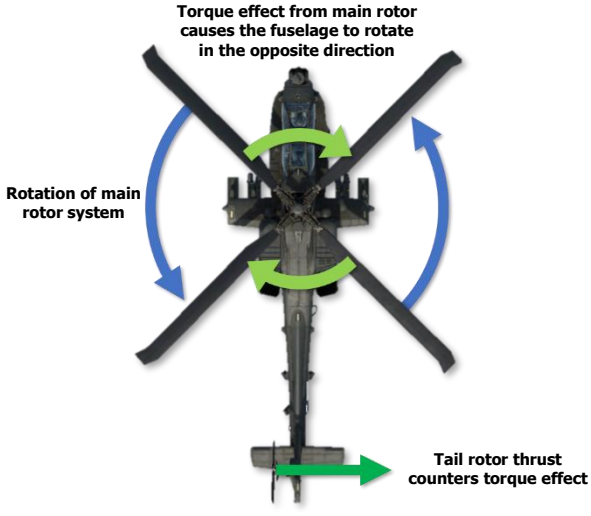
T700-series Gas Turbine Engine

In the AH-64, the amount of engine power that is currently input into the drive train system is expressed as a measurement of torque, which is any rotational force within a mechanical system. As the pilot pulls up on the collective lever within the cockpit to demand more lift, additional fuel is injected into the combustion section of the engines, which is expelled through the power turbine section. The hot expanding gases passing through the turbine blades generate additional mechanical force to turn the power turbine shaft, which in turn is input into the drive train system via the engine nose-mounted gearbox to counter the aerodynamic drag on the rotor system. The opposing forces of engine thrust and aerodynamic drag creates a twist in the power turbine shaft, which is measured by a torque (TQ) sensor in the aft section of each engine. This electrical signal is converted into an electronic value and displayed to the pilot as "Torque %", which represents the amount of rotational force being supplied to the drive train system by the engines.

Anti-Torque Thrust

As aerodynamic drag on the rotor system increases, mechanical torque is input into the drive train system by the helicopter's engine(s) to oppose the aerodynamic drag and maintain the rotational speed of the rotor system. However, due to Newton's Third Law of Motion that states for every action there is an equal and opposite reaction, the *torque effect* from the main rotor will cause the helicopter fuselage to rotate in the opposite direction.

All rotary-wing aircraft that rely on engine torque to maintain powered flight must compensate for the torque effect in some manner. Many rotary-wing designs use two equally sized main rotors that spin in opposite directions to cancel the opposing torque forces of each rotor system. However, the most common type of helicopter uses a single large main rotor for lift and thrust, and a small rotor mounted on the tail to generate lateral thrust to counter the torque effect of the main rotor in order to maintain control over yaw and heading.



Anti-torque thrust of Tail Rotor

Just as the engine power output must be adjusted to counter the opposing force of aerodynamic drag on the rotor system, so that the rotational speed of the rotors can be maintained in a state of balance, the thrust of the tail rotor must also be simultaneously adjusted to counter the opposing torque effect on the helicopter's fuselage, so the pilot can maintain control over yaw and heading. To facilitate yaw control, the pilot manipulates the anti-torque pedals in the cockpit in the same manner as the rudder pedals in a fixed-wing aircraft are manipulated to adjust the angle of a rudder. In this case, however, movement of the anti-torque pedals directly changes the amount of thrust that is produced by the tail rotor.

If a helicopter's main rotor spins in a clockwise direction, as in the case of the Mi-24 attack helicopter, the torque effect will cause the helicopter's nose to yaw to the left as torque is increased, requiring the pilot apply right pedal to counter an increase in torque. If a helicopter's main rotor spins in a counter-clockwise direction, as in the case of the AH-64 (illustrated above), the torque effect will cause the helicopter's nose to yaw to the right as torque is increased, requiring the pilot apply left pedal to counter the torque. If the amount of torque is decreased, the pedals must be adjusted accordingly to reduce the amount of anti-torque thrust the tail rotor produces.

HELICOPTER CONTROL

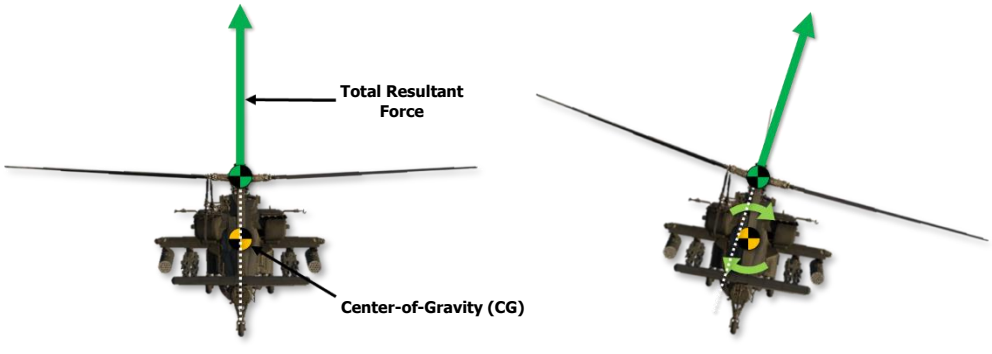
Helicopters are controlled by adjusting the pitch angle of the rotor blades cyclically and collectively. When the cyclic, collective, or anti-torque pedals in the cockpit are moved by the pilot, the corresponding flight control linkages adjust the angle and positions of the swashplates on the main and tail rotor systems. Movement of the swashplates is translated to each individual rotor blade by the pitch change links, which changes the pitch angle of that blade, also known as feathering.

Rotor Blade Feathering

Cyclic Feathering

When the pilot adjusts the position of the cyclic, the angle of the main rotor swashplate is tilted. As the blades rotate about the rotor mast, the tilted angle of the swashplate forces the pitch change links of each rotor blade to increase and decrease the pitch angle of the blades in a *cyclic* pattern within the plane of rotation. Cyclic feathering of the rotor blades results in unequal amounts of lift generated on one side of the rotor disk compared to the other. In a fully articulated rotor system like the AH-64, the rotor blades are connected to the rotor hub in a manner that permits each blade to independently flap up or down as they rotate about the rotor mast.

Blade flapping allows the plane of the rotor disk to be tilted in any direction in response to cyclic inputs by the pilot. When the rotor disk is displaced in this manner, the total resultant force from the lift generated by the main rotor is offset from the helicopter's center-of-gravity (CG). This creates a pitch and/or roll moment around the CG, permitting the pilot to control the pitch and roll attitude of the helicopter using the cyclic.



Lift vector in-line with CG (left) and offset from CG (right)

Collective Feathering

When the pilot adjusts the position of the collective, the entire swashplate translates up or down around the rotor mast. When this occurs, the pitch angles of the rotor blades are *collectively* increased or decreased, producing a change in overall lift that is generated by the entire main rotor system.

Anti-torque Feathering

Like the main rotor, the tail rotor is also equipped with a swashplate to permit the feathering of the tail rotor blades. However, the tail rotor swashplate is only equipped with a single flight control linkage to collectively increase and decrease the thrust produced by the tail rotor; it cannot cyclically feather the tail rotor blades.

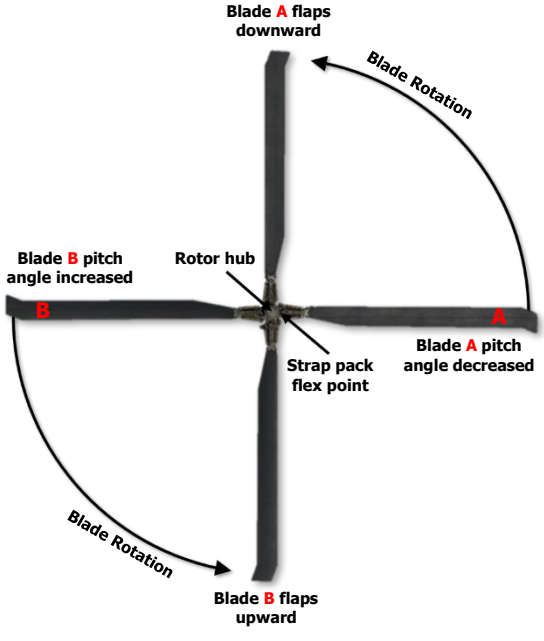
When the pilot adjusts the position of the anti-torque pedals, the entire swashplate translates left or right around the tail rotor shaft. When this occurs, the pitch angles of the tail rotor blades are collectively increased or decreased, producing a change in anti-torque thrust and permitting the pilot to control the yaw and heading of the helicopter.

Tail Rotor Feathering

Phase Lag

When a change in a rotor blade's angle of attack occurs, whether it be due to a variation in the induced flow or a mechanical adjustment to the pitch angle of the blade, the rotor blade will flap up or down relative to the plane of rotation in response to the change in lift acting on the blade itself. However, this vertical displacement of the rotor blade as it flaps up or down will manifest later within the plane of rotation from where the change in lift actually occurs. This angular difference between where the change in lifting force occurs and where the blade reaches maximum vertical displacement as a result of the change is known as *phase lag*.

Such behavior within the rotor system of a helicopter is often referred to as "gyroscopic precession", which states that any force imparted onto a rotating object will manifest precisely 90° later in the direction of rotation, however this term is not an accurate explanation as to what is truly occurring within a spinning rotor system. Although the rotor system of a helicopter does exhibit some behavior similar to that of a gyroscope, a rotor system is not a singular rotating body, but rather a collection of airfoils predominantly driven by aerodynamic forces.

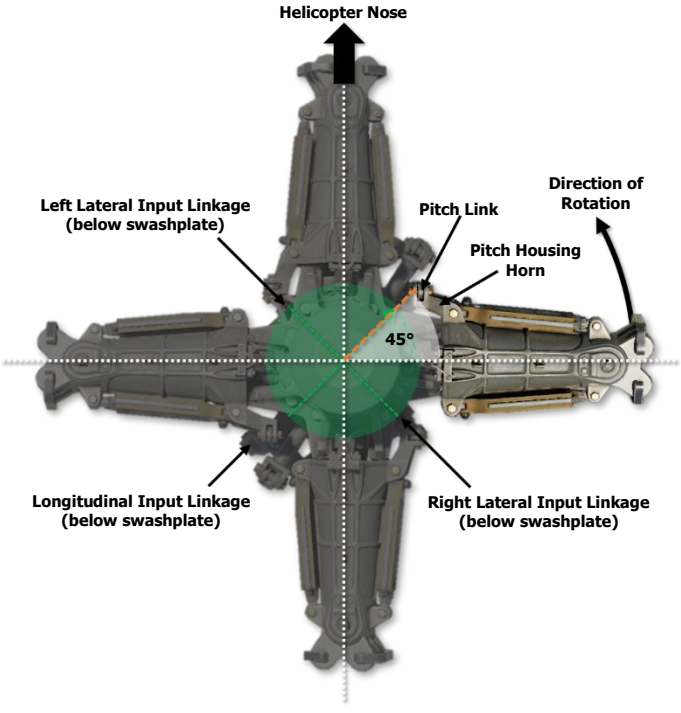


Phase Lag

Further, depending on the design of a specific rotor system, the amount of phase lag may vary, which is distinct from gyroscopic precession which strictly occurs 90° later in the direction of rotation. Coincidentally, in the case of the AH-64, in which the flap of the blades originates at the rotor hub, the phase lag of the main rotor system is essentially 90°. As such, any mechanical input into the swashplate as a result of cyclic displacement must be mechanically offset 90° prior within the plane of rotation to generate the desired displacement of the rotor disk.

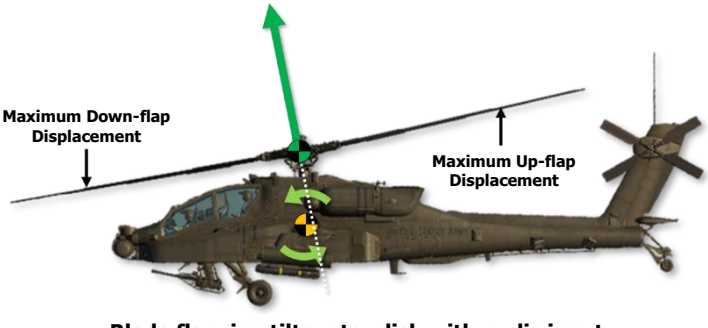
In the image to the right, the rotor head of the AH-64 is shown, with one of the four rotor blade pitch change housings highlighted. Each pitch change housing includes a pitch housing horn that that is connected to the rotating upper swashplate via a pitch link. The pitch housing horn facilitates a 45° offset between a given swashplate input and the corresponding change in pitch of each rotor blade (Dashed line).

The non-rotating lower swashplate is offset in a manner that translates cyclic inputs 45° prior to the desired effect within the axis of rotation (Shaded circle). Using the image on the right as an example, if the pilot intended to pitch the helicopter nose downward, the cyclic would be pushed forward. This action would be translated to the lower swashplate by the longitudinal input linkage, causing the swashplate to tilt down at the forward-right position and up at the aft-left position. This would in turn cause the pitch link connected to the rotor blade on the right side of the helicopter to reduce blade pitch and flap downward.



Advance angle of swashplate inputs

The result of the 45° offset in swashplate tilt in response to cyclic inputs combined with the 45° offset in pitch input by each blades' pitch housing horn facilitates a 90° mechanical advance angle to compensate for phase lag. As the cyclic is pushed forward, the pitch angles of the rotor blades are at their highest when passing over the left side of the helicopter and at their lowest when passing over the right side of the helicopter. Consequently, due to phase lag, the rotor blades reach their highest up-flap when passing over the tail and their lowest down-flap when passing over the nose, with the entire rotor disk tilted forward and causing a forward pitching motion as commanded by the pilot.



Blade flapping tilts rotor disk with cyclic input

HELICOPTER AERODYNAMICS

As described in the preceding sections of this chapter, helicopters utilize rotating airfoils to generate aerodynamic lift to counter the opposing force of gravity, and direct that lift (as thrust) to counter the opposing force of aerodynamic drag. The helicopter itself is controlled by adjusting the amount of lift generated by the individual airfoils of the helicopter's rotor systems, thereby manipulating the forces of lift and thrust to change or maintain a given attitude. However, due to the nature of aerodynamics within a spinning rotor system, rotary-wing aircraft are subject to several aerodynamic behaviors that can alter the balance of opposing forces in flight.

Under static conditions, in which the flow of air through the rotor system would be uniform and unchanging, the aerodynamic forces that act upon a helicopter would likewise be uniform and unchanging. However, the atmosphere is never static, and the nature of the local air mass within which a helicopter flies is ever-changing as a result of the helicopter's attitude and velocity through the air; the interaction of air flowing across, around, and through the fuselage and rotor systems; and environmental factors such as wind, pressure, and temperature. As a result, aerodynamic behaviors that are unique to rotary-wing aircraft, of which the helicopter pilot must be aware, will manifest under certain conditions.

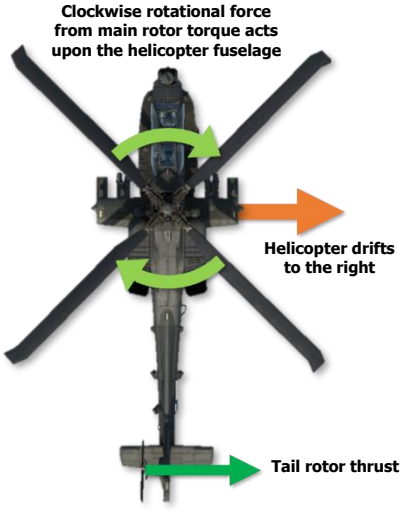
Although some of these behaviors can adversely affect the safe operation of a helicopter if they are not avoided (such as Retreating Blade Stall or Vortex Ring State), others may be leveraged by the pilot to improve the performance or safety margins of a helicopter during flight (such as Ground Effect, Translational Lift, or Autorotation). Proper understanding and awareness of these aerodynamic behaviors allow the helicopter pilot to anticipate and mitigate those that he or she wishes to avoid, while anticipating and actively utilizing those that he or she plans to leverage while in flight.

Translating Tendency

In the case of single-rotor helicopters that utilize a tail rotor to counter the torque effect generated by the main rotor, these helicopters will exhibit a *translating tendency* in the direction of the tail rotor thrust. This behavior is most noticeable while in a stationary hover, in which a helicopter with a counter-clockwise spinning main rotor, such as the AH-64, will drift to the right.

When the pilot pulls up on the collective to increase lift generated by the main rotor, the torque effect from the counter-clockwise rotation of the main rotor will cause the fuselage to spin in the opposite direction. The torque effect acting upon the fuselage is countered by applying left pedal, which subsequently results in the aircraft drifting to the right from the combined forces of the main rotor torque effect and the tail rotor thrust.

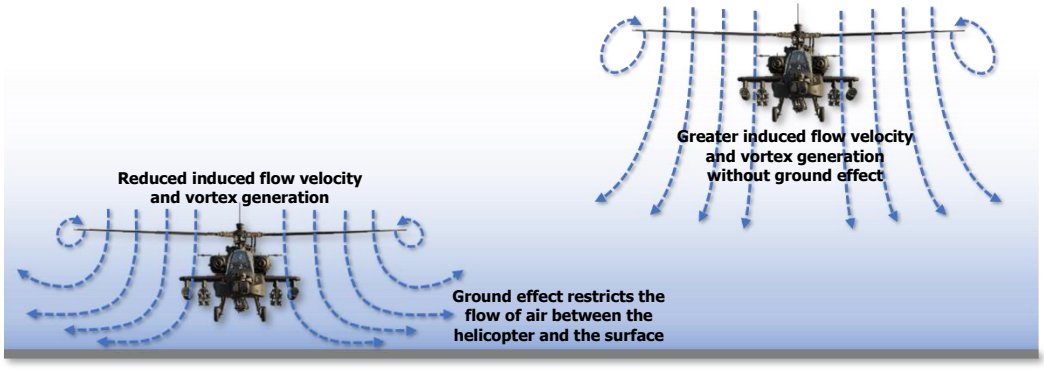
Although some helicopters, such as the Mi-24, counter translating tendency by mounting the main transmission with a slight tilt in the opposite direction of the tail rotor thrust, the translating tendency of the AH-64 must be countered by applying a slight amount of left cyclic. This will offset the lift vector of the main rotor slightly to the left, causing the helicopter to hover with a slight left bank (under conditions of calm winds).



Translating Tendency

Ground Effect

When operating near the surface, a helicopter's rotor system will exhibit an increase in overall lift efficiency due to the surface itself restricting the flow of air underneath the helicopter, a behavior known as *ground effect*. When a rotor system is in ground effect, the restriction in air flow downward through and outward from the rotor system reduces the velocity of the induced flow and the generation of vortices along the rotor tip path plane.



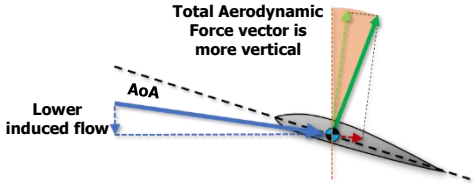
Air flow while hovering In- and Out-of-Ground Effect

Although the altitude over the surface at which ground effect will occur may be affected by winds and the nature of the surface itself (asphalt, grass, water, etc), the primary factor that determines when a helicopter is influenced by ground effect is the diameter of the helicopter's rotor system. Ground effect may begin at an altitude equal to 1.25 times the diameter of the rotor system, but the efficiency of the rotor system increases exponentially with proximity to the ground, with the most noticeable increase in rotor efficiency occurring at an altitude equal to 0.50 times the diameter of the rotor system or below.

In the case of the AH-64D with a rotor diameter of 48 feet, ground effect may influence the rotor system as high as 60 feet above the surface, but the effect will be negligible. Rather, the efficiency of the rotor system will noticeably increase at a hover altitude of 24 feet or below, with as much as a 20% increase in overall lift efficiency at a hover altitude of 5 feet.

In Ground Effect (IGE)

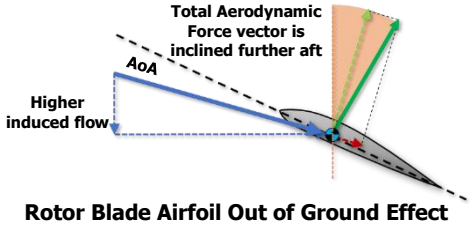
When operating in ground effect, the lower induced flow velocity lowers the angle of the resultant relative wind (Solid line). This in turn requires a lower airfoil angle of incidence to achieve a given angle of attack to produce sufficient lift to counter the weight of the helicopter. This results in a more vertical lift vector (Dashed line), less induced drag on the rotor system (Shaded Angle), and requires less torque output from the helicopter engine(s).



Rotor Blade Airfoil In Ground Effect

Out of Ground Effect (OGE)

When operating out of ground effect, the higher induced flow velocity raises the angle of the resultant relative wind (Solid line). This in turn requires a higher airfoil angle of incidence to achieve a given angle of attack to produce sufficient lift to counter the weight of the helicopter. This results in the lift vector being inclined further aft (Dashed line), increasing the induced drag on the rotor system (Shaded Angle), which requires a corresponding increase in torque output from the helicopter engine(s).



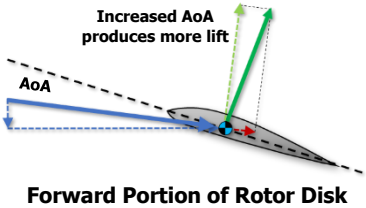
Rotor Blade Airfoil Out of Ground Effect

Transverse Flow Effect

When a helicopter begins accelerating into forward flight, the air flow through the rotor disk becomes more horizontal as the airspeed increases. However, the longer that it takes for air to travel across the rotor disk, the greater the influence the rotor system has on the air flow itself. As a result, the downward flow of air induced by the rotor system has a greater influence on the air flowing through the aft portion of the rotor disk compared to the air flowing through the forward portion. During low airspeeds, the rotor blades encounter a significantly greater induced flow velocity when passing over the tail compared to the reduced induced flow velocity when passing over the nose. This aerodynamic condition is known as *transverse flow effect* and occurs between 10 and 20 knots of airspeed.

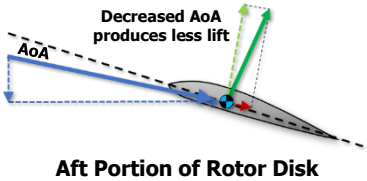
Transverse Flow Effect (10-20 knots)

As each rotor blade passes over the nose, the reduced induced flow velocity *lowers* the resultant relative wind and *increases* the angle of attack. This in turn increases the lift generated by the rotor blade.



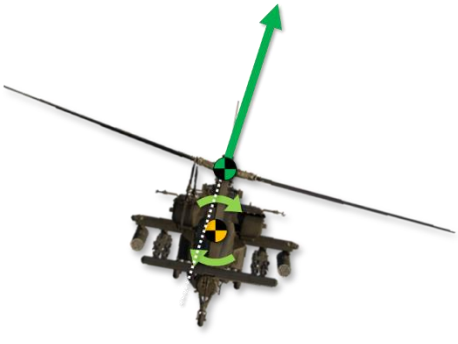
Forward Portion of Rotor Disk

As each rotor blade passes over the tail, the greater induced flow velocity *raises* the resultant relative wind and *decreases* the angle of attack. This in turn decreases the lift generated by the rotor blade.



Aft Portion of Rotor Disk

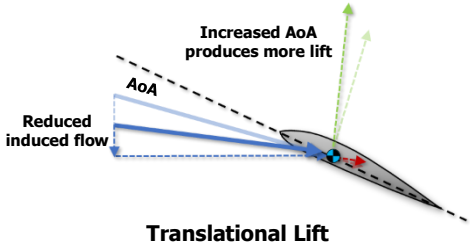
The unequal production of lift and drag between the forward and aft portions of the rotor disk generates a noticeable vibration throughout the airframe and causes the entire rotor disk to tilt. However, due to phase lag, the increased lift over the forward portion of the rotor disk will cause the blades to flap up as they pass over the left side of the helicopter (with a counter-clockwise spinning main rotor) and the decreased lift over the aft portion of the rotor disk will cause the blades to flap down as they pass over the right side of the helicopter. This results in a rolling motion to the right that must be countered by applying left cyclic.



TFE-induced roll to the right

Translational Lift

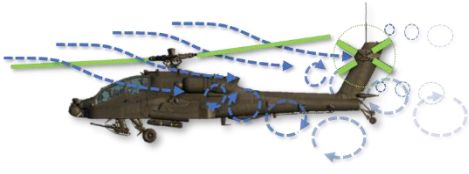
When a helicopter accelerates into directional flight, the air flow through the rotor disk becomes more horizontal as the airspeed increases, and the turbulence and rotor tip vortices that are generated during the production of lift are left behind. As the air flow becomes more horizontal, the induced flow velocity is reduced, which in turn lowers the resultant relative wind vector and increases the angle of attack, resulting in an increase in lift production for a given angle of incidence. This aerodynamic condition is known as *translational lift*.



Translational Lift

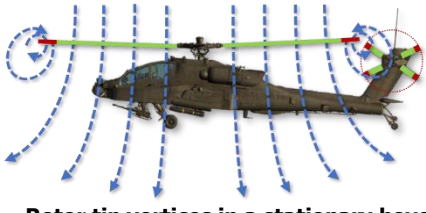
With no directional airspeed, each rotor blade passes through the vortices produced by the blade preceding it within the plane of rotation. This disruption of air interferes with the production of lift, effectively preventing the outer portion of each rotor blade from contributing to the overall lift production of the rotor system. As airspeed increases, the forward portion of the rotor system begins to operate in undisturbed air as the vortices begin trailing behind. As airspeed continues to increase, the portion of the rotor disk that is operating in undisturbed air increases as well, resulting in a greater area of the rotor disk efficiently producing lift free of turbulence and vortices. The aerodynamic condition in which the airspeed has increased to a point in which the entire rotor disk is operating in undisturbed air is known as *effective translational lift* (ETL) and occurs between 16 and 24 knots of airspeed, depending on rotor diameter, rotor blade area, and the rotational speed of the rotor system itself.

Entire rotor disks are free of turbulence and vortices



Effective Translational Lift (>24 knots)

Vortices interfere with lift generation at rotor tips



Rotor tip vortices in a stationary hover

It is important to understand that the tail rotor also benefits from translational lift and will accordingly experience an increase in thrust efficiency for a given angle of incidence. As the helicopter accelerates, the amount of thrust produced by the tail rotor will increase as a greater portion of the tail rotor is operating in undisturbed air.

When accelerating through ETL, the compounded effects of an increase in lift efficiency of the main rotor and thrust from the tail rotor will result in a noticeable increase in altitude and/or climb rate and a yaw to the left (with a counter-clockwise spinning main rotor). This must be countered by applying right pedal and, if desired, reducing collective to maintain the same altitude or climb rate, which will require even more right pedal to compensate for the corresponding decrease of main rotor torque effect.

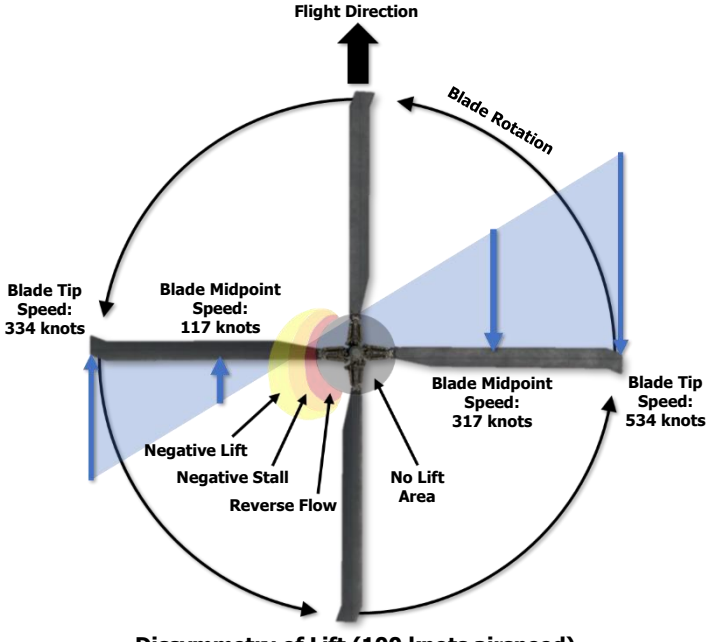
Conversely, when decelerating through ETL, the compounded effects of a decrease in lift efficiency of the main rotor and thrust from the tail rotor will result in a noticeable decrease in altitude and/or increase in descent rate and a yaw to the right (with a counter-clockwise spinning main rotor). This must be countered by applying left pedal and increasing collective to maintain the same altitude or descent rate, which will require even more left pedal to compensate for the corresponding increase in main rotor torque effect.

It is worth noting that an onset of aircraft vibrations is a common method of detecting when the aircraft is transitioning through ETL in either direction. Despite the common euphemism of describing such vibrations as the "ETL shudder", these vibrations are a result of the transverse flow effect (TFE) and are not caused by translational lift. However, since the aerodynamic conditions of TFE and ETL both directly correlate to the airspeed of the helicopter and occur approximately within the same airspeed range, using such airframe vibrations is a useful method in determining the state of lift efficiency of the rotor system independently of the helicopter's speed across the ground, which can vary with wind patterns.

Dissymmetry of Lift

In directional flight, the velocity and direction of air flowing across and around an individual rotor blade airfoil will vary depending on the rotor blade's position within the plane of rotation. As the airspeed of the helicopter itself increases, the oncoming air will increase the rotational relative wind velocity on the advancing half of the rotor disk and decrease the rotational relative wind velocity on the retreating half of the rotor disk. This difference in air flow velocity across the rotor blade airfoils produces unequal amounts of lift on each side of the rotor disk, an aerodynamic condition known as *dissymmetry of lift*.

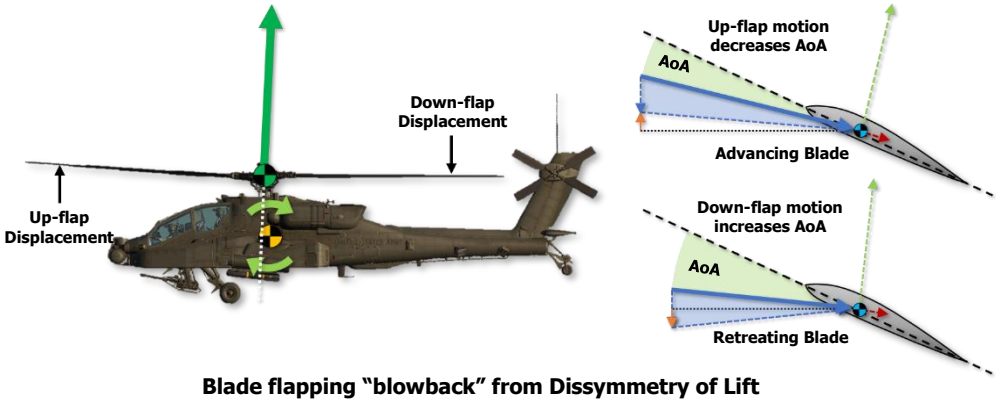
In the figure below, a rotor system is spinning in a counter-clockwise direction with a rotational speed of 434 knots at the rotor blade tips and 217 knots at the midpoint of each rotor blade. However, with a directional airspeed of 100 knots across the rotor disk itself, the rotor blade on the advancing side of the rotor disk will experience a higher relative wind velocity compared to the rotor blade on the retreating side of the rotor disk.



Dissymmetry of Lift (100 knots airspeed)

In addition, the inner sections of the rotor blades will experience a disruption of air flow caused by the oncoming air on the retreating half of the rotor system, which can create a stall region and prevent the production of positive lift. When the velocity of oncoming air exceeds the rotational speed of the inner portions of the rotor blades themselves, the airfoils can even experience a reverse flow of air on the retreating half of the disk compared to the rest of the rotor blade span.

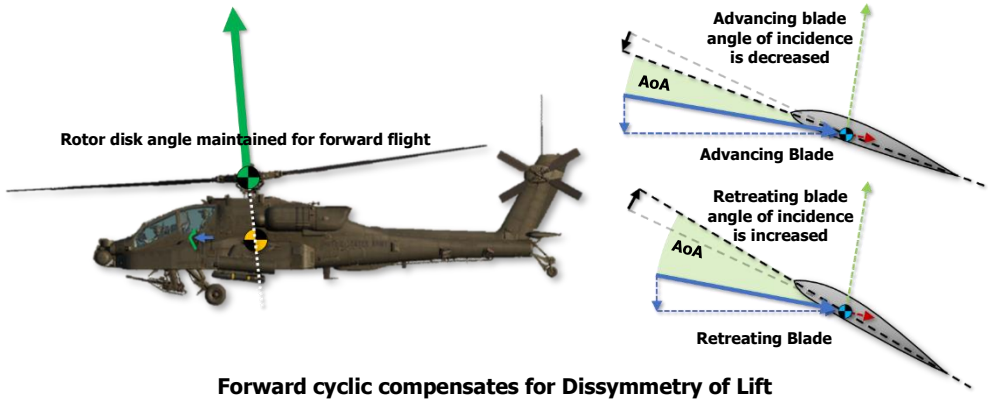
Dissymmetry of lift is inherently countered by blade flapping. As a rotor blade encounters the increased relative wind velocity on the advancing side of the rotor disk, the blade will flap upward. This up-flap motion alters the angle at which the resultant relative wind impacts the airfoil, decreasing the angle of attack and thereby reducing lift on the advancing half of the rotor disk. Conversely, as a rotor blade encounters the decreased relative wind velocity on the retreating side of the rotor disk, the blade will flap downward. This down-flap motion alters the angle at which the resultant relative wind impacts the airfoil, increasing the angle of attack and thereby increasing lift on the retreating half of the rotor disk.



Blade flapping "blowback" from Dissymmetry of Lift

Due to phase lag, the up-flap motion on the advancing side of the rotor disk will reach a maximum up-flap displacement over the nose of the helicopter, and a maximum down-flap displacement over the tail, assuming the helicopter is in forward flight. This displaces the total resultant force from the lift generated by the main rotor further aft, in turn causing the nose of the helicopter to pitch upward, an effect known as "blowblack".

To counter dissymmetry of lift and the pitch up motion from the resulting "blowback" effect, the pilot must apply forward cyclic as the helicopter accelerates into forward flight. Alternatively, if the helicopter is accelerated into sidewards flight, the "blowback" effect will cause the helicopter to roll in the opposite direction of flight, requiring the pilot to apply left cyclic to maintain left sidewards flight or right cyclic to maintain right sidewards flight. The greater the directional airspeed, the greater the magnitude of cyclic displacement that is required to counter dissymmetry of lift and maintain the current attitude.



Forward cyclic compensates for Dissymmetry of Lift

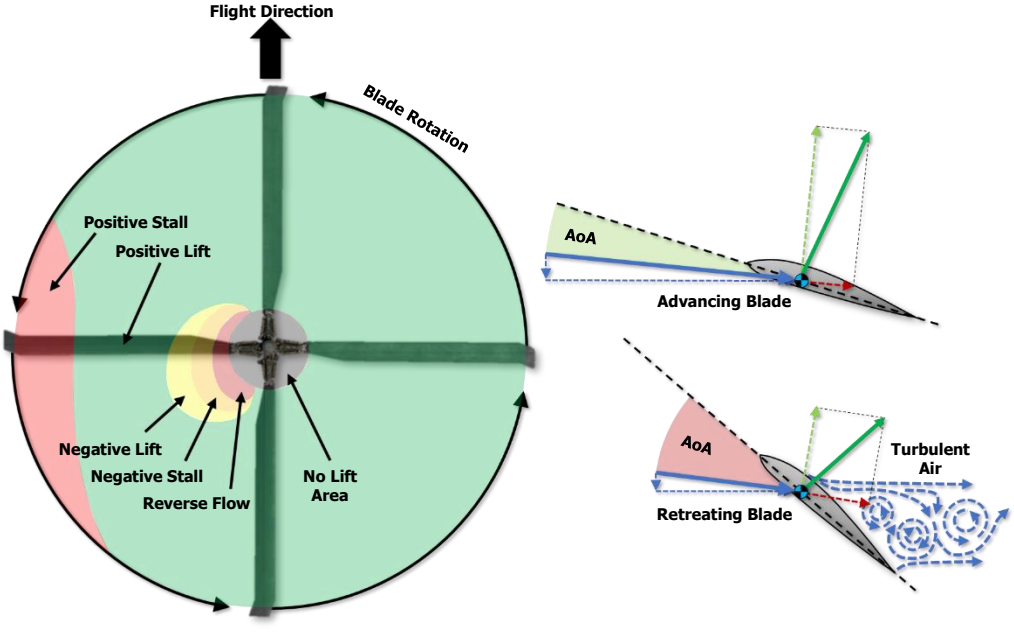
Through cyclic feathering, the angle of incidence on the advancing side of the rotor disk will be lowered, decreasing the angle of attack and thereby reducing lift on the advancing half of the rotor disk; while the angle of incidence on the retreating side of the rotor disk will be raised, increasing the angle of attack and thereby increasing lift on the retreating half of the rotor disk.

The tail rotor also experiences dissymmetry of lift, which is likewise countered by blade flapping and differential feathering. The tail rotor, using a semi-rigid teetering design in which each opposing pair of blades flap together like a see-saw, incorporates a delta-hinge that mechanically feathers the blades as blade flapping occurs. As the velocity of air flowing across the tail rotor increases, the inherent flapping tendency of the tail rotor blades will mechanically incur a differential pitch angle between each opposing pair of tail rotor blades, decreasing the angle of incidence on the advancing half of the tail rotor and increasing the angle of incidence on the retreating half.

Retreating Blade Stall

Just as the airfoils of a fixed-wing aircraft experience aerodynamic stall when exceeding a critical angle of attack, so too will the airfoils of a rotary wing aircraft. However, unlike fixed-wing aircraft, which are limited by low speeds to avoid an aerodynamic stall, rotary-wing aircraft are limited by high speeds to avoid an aerodynamic stall on the retreating half of the rotor disk.

During directional flight, the rotational relative wind velocity across the rotor blades on the retreating half of the rotor disk is greatly reduced, creating a dissymmetry of lift between the advancing and retreating halves of the rotor system. To maintain an equal distribution of lift across both halves of the rotor system, the angle of attack on the retreating side must be increased to generate more lift, in the same way that the angle of attack of a fixed-wing aircraft must be increased to maintain adequate lift at lower airspeeds. As a helicopter's airspeed increases, the regions along the inner portion of the rotor system that do not contribute to the production of positive lift will grow outward, placing an increasing demand of lift production on the outer regions of the retreating half of the rotor disk. When the rotor blades reach a critical angle of attack at a sufficiently low rotational relative wind velocity, the rotor blades will begin to stall on the retreating half of the rotor disk.



Retreating Blade Stall

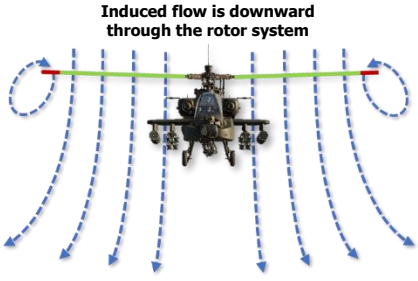
When the retreating blades begin to stall, the turbulent air encountered by the rotor blades will cause vibrations, buffeting, and the aircraft may pitch up and roll left (with a counter-clockwise spinning main rotor). To alleviate this condition, aft cyclic should be applied to reduce the angle of attack on the retreating half of the rotor disk, and/or a reduction in collective if sufficient altitude and obstacle clearance permits such an action.

The airspeed at which retreating blade stall occurs within a given rotor design will vary; but the following conditions, or combinations thereof, will increase the likelihood of encountering retreating blade stall.

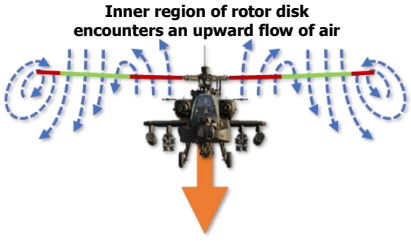
- High gross weight (increased blade loading/AoA).
- High-G maneuvers (increased blade loading).
- High altitude (lower air density).
- Low rotor RPM (lower rotational airspeed).

Vortex Ring State

As a helicopter's rotor system generates lift, air is propelled downward through the rotor system, also known as induced flow. During hovering flight, or at airspeeds below effective translational lift, a small portion of this air mass is recirculated along the outer tip region of the rotor system. As some of the downwash rejoins the air entering the top of the rotor disk, vortices are generated along the rotor tip path plane. These rotor tip vortices generate drag and degrade the overall lift efficiency of the rotor system but otherwise do not affect the operation of the helicopter as long as a sufficient power margin is available to maintain altitude while in a stationary hover out of ground effect (OGE).



Air flow in an OGE hover



Air flow in a rapid vertical descent

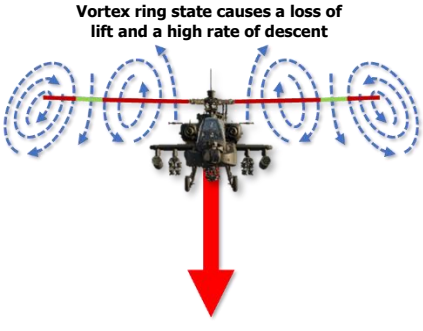
If a helicopter begins to descend vertically into its own downwash, the amount of air that is recirculated along the rotor tips will increase, causing the rotor tip vortices to enlarge. This enlarges the donut-shaped pattern of vortices around the outer region of the rotor system which interferes with lift production.

The induced flow is not uniform across the rotor disk, with the outer regions producing the highest induced flow velocities and the inner regions producing the lowest. If a helicopter descends at a rate that exceeds the induced flow velocity along the inner region of the rotor disk, the air flow will be reversed, which can further degrade the overall lift efficiency of the rotor disk.

This upward flow of air along the inner region of the rotor disk generates a secondary donut-shaped vortex ring along the inner region of the rotor system. As a result, a large portion of the rotor system will be operating in turbulent air vortices and the descent rate will increase significantly, accompanied by noticeable aircraft vibrations and shudders.

This aerodynamic phenomenon is known as *vortex ring state* (VRS) and can only occur if all of the following conditions exist.

- Directional airspeed relative to the induced flow vector is less than effective translational lift (ETL; 16-24 knots).
- Excessive rate of descent (will vary based on the blade loading of a given helicopter's rotor system).
- Sufficient power is applied to generate an induced flow.



Air flow during Vortex Ring State

In addition, the following conditions, or combinations thereof, will increase the likelihood of encountering VRS.

- High gross weight (increased blade loading).
- High altitude (lower air density).
- Steep approaches at low airspeeds.
- Approaches with tail winds.

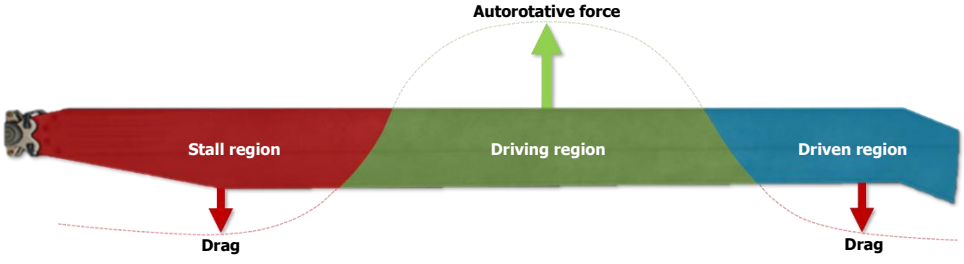
If a vortex ring state is encountered, the only way in which the condition can be exited is by gaining sufficient directional airspeed to exit the helicopter's own downwash. Simply increasing the collective will not arrest the descent and will likely exacerbate the aerodynamic phenomenon. Once the helicopter gains translational lift, the vibrations and aircraft shudders will subside, and the descent may be arrested.

NOTE: Vortex Ring State is an *aerodynamic* condition and should not be confused with Settling With Power, a condition in which the helicopter has an insufficient power margin available to arrest a descent for the current gross weight; or Rotor Droop, a condition in which drag on the rotor system has exceeded the maximum torque output of the engines, causing the rotational speed of the rotor to slow, leading to a loss of lift.

Autorotation

Under normal conditions of powered flight, engine power is used to overcome the force of drag on the rotor system, which would otherwise cause the rotor speed to decrease, resulting in a loss of lift. In the event that a helicopter suffers a loss of engine power during flight, the pilot should immediately lower the collective to simultaneously reduce the drag on the rotor system and enter a descent, thereby producing an upward flow of air through the rotor system. This upward flow of air generates an autorotative force to maintain the rotational speed of the rotor system, which allows the pilot to perform a controlled descent and safely land the helicopter.

During an autorotational descent, the forces of lift and drag acting upon the rotor blade airfoils divides the rotor disk into three regions known as the driven, driving, and stall regions.

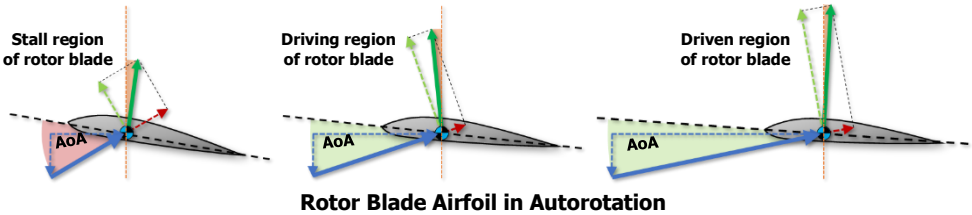


Aerodynamic forces during Autorotation

Stall region. Air flowing upward into the inner stall region impacts the airfoil at a lower rotational speed and a steep angle of attack, producing drag against the rotation of the rotor system.

Driving region. Air flowing upward into the driving region impacts the airfoil at a higher rotational speed and a lower angle of attack, which results in less drag and more lift, but with the total aerodynamic force inclined forward of the axis of rotation, thereby creating a driving force to maintain the rotation of the rotor system.

Driven region. Air flowing upward into the driven region impacts the airfoil at an even higher rotational speed, which results in more drag and more lift, but at a lower angle of attack which inclines the total aerodynamic force aft of the axis of rotation, thereby creating a lifting force to slow the rate of descent while producing drag against the rotation of the rotor system.



Rotor Blade Airfoil in Autorotation

Once autorotation is established in the descent, the pilot must maintain a constant rotor speed by adjusting the collective to balance the autorotative driving force with the drag acting on the rotor blades, which will permit a controlled rate of descent. This is referred to as a "steady-state" autorotational descent, in which the pilot maneuvers the helicopter to a suitable landing area while maintaining a controlled descent rate and descent angle, trading altitude to maintain rotor speed and lift. (See Autorotation Landing for more information.)

Just prior to touchdown, the pilot must simultaneously reduce the rate of descent and forward airspeed, which is normally initiated as the aircraft passes through the final 100 feet above ground (but may vary depending on descent rate and helicopter type). By performing a positive-pitch flare maneuver just prior to touchdown, the pilot exchanges airspeed for additional lift to reduce the rate descent, and then increases collective to arrest the descent using the remaining rotational inertia of the rotor system itself in the final moments before touchdown.

POWER MANAGEMENT

All aircraft that are capable of powered flight do so by precisely balancing the opposing forces of lift versus weight and thrust versus drag. In the case of rotary-wing aircraft, the rotor systems provide both the lift and thrust necessary for powered flight, in addition to controlling the aircraft attitude. These rotor systems require engine power to operate, namely to counteract drag acting upon the rotor systems themselves in addition to the mechanical friction within the drive system, that would otherwise cause the rotational speed of the rotors to slow and eventually come to stop. However, as with all engines that output some form of mechanical energy or thrust, there are limits as to how much engine power can be utilized by a helicopter during flight. Knowing how much power is available and how much power is required to perform a given maneuver is known as *power management*.

The key to avoiding catastrophe (a crash resulting in injury or death to the crew) is understanding whether the helicopter has sufficient power available under the current conditions to perform a maneuver prior to committing to the maneuver itself. This requires understanding the limitations of the helicopter's performance, the power requirements for a given maneuver, how the environment may negatively impact the performance of the engines or the efficiency of the rotor system, and how to budget fuel and munitions to avoid exceeding the maximum gross weight for the maneuvers that are required to be performed during the mission.

Maneuvers requiring the most power available:

- Takeoff
- Hovering
- Landing
- Combat maneuvers

Conditions that negatively impact a helicopter's performance:

- Environmental effects
- High gross weight
- Improper pilot actions
- Single-engine operation

Conditions that improve a helicopter's performance:

- Forward flight (translational lift)
- Ground effect
- Expending fuel and/or munitions (reduction of gross weight)

The following pages describe environmental effects on helicopter performance, improper pilot actions, and power considerations in multi-engine helicopters. In addition to understanding how ground effect and translational lift affects the efficiency of a helicopter's rotor system, one must also be familiar with the various types of takeoff and landing maneuvers and their application with regards to power margins, and how to interpret and utilize the Performance (PERF) page within the cockpit prior to and during a mission.

Environmental Effects

Aircraft exploit the physical properties of the Earth's atmosphere to generate lift and thrust, and any variation of pressure within the atmosphere will alter the ability of airfoils to produce lift and engines to produce thrust. Therefore, the atmospheric environment must be considered when assessing an aircraft's performance.

The two factors that affect the local atmospheric pressure around the aircraft are altitude and temperature.

Altitude. The atmosphere is pulled toward the Earth by gravity like any other mass. At sea level, the density of the atmosphere will be the greatest due to the compression of the atmosphere itself, resulting in higher air pressure in the same manner that the water pressure exerted on the body increases the deeper one dives into the ocean. As altitude increases, the density of the atmosphere decreases, resulting in lower air pressure.

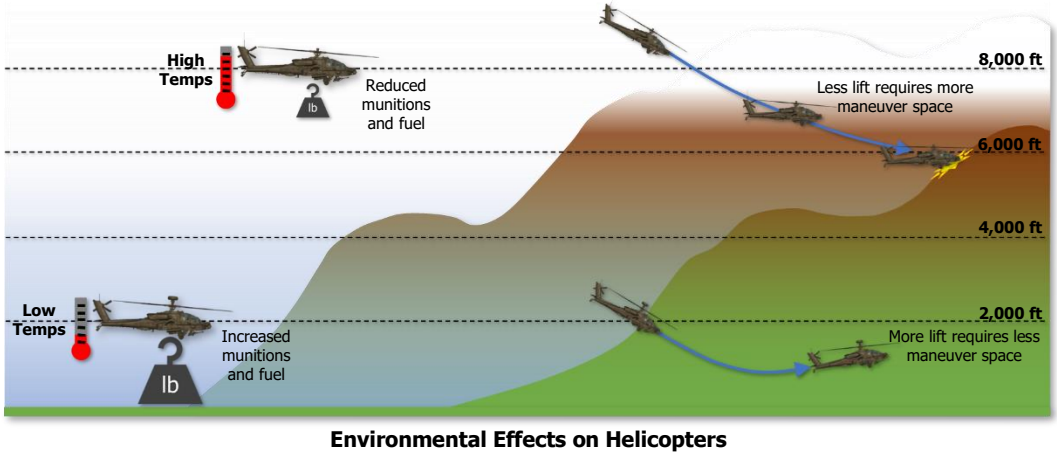
Temperature. Temperature reflects the energy state of atmospheric molecules, in that atmospheric molecules move faster and occupy more volume at higher temperatures. As the volume of an air mass expands, the density of the atmosphere decreases, resulting in lower air pressure.

As atmospheric pressure is required to generate lift and thrust, the density of the air will directly correlate to an aircraft's performance. If the air density is low, the aircraft's performance will be degraded. If the air density is high, the aircraft's performance will improve.

Environmental Effects on Helicopter Rotor Systems

Airfoils require atmospheric pressure to produce lift to counter the force of gravity, and a lower air density will result in less lift production. A helicopter's rotor system will produce less lift on a hot day compared to a cold day, and the rotor system will produce less lift at 8,000 feet compared to 2,000 feet.

When performing a mission in hot weather conditions and/or at high altitudes, particularly over high-elevation terrain such as mountains, the maximum allowable gross weight of the helicopter will be reduced. In other words, the helicopter will not be capable of carrying the same payload under such conditions compared to cold weather and/or lower altitudes.



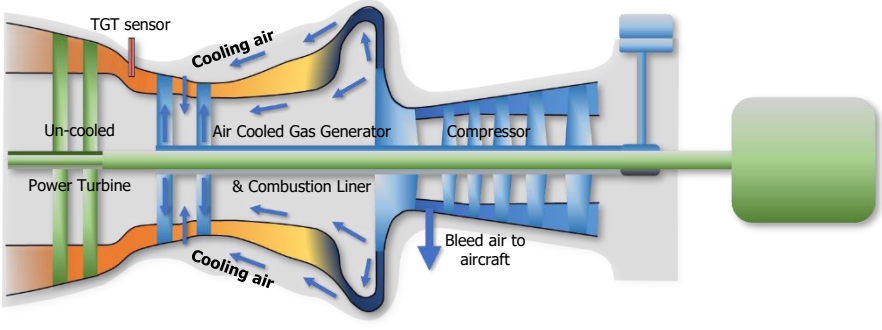
Environmental Effects on Helicopters

Further, since a helicopter directs the lift vector of its rotor system to control its attitude and alter its flight path, and the rotor system produces less lift in hot and high conditions, the responsiveness of the flight controls will be reduced and the helicopter will require more maneuver space to overcome the aircraft's inertia. The helicopter's turning radius will be larger, more altitude will be required to pull out of a dive, and larger takeoff and landing areas will be necessary to account for the additional time needed to accelerate or decelerate.

Environmental Effects on Turbine Engines

Gas turbine engines produce thrust by combusting fuel with compressed air and then expelling the high energy gas particles across a rotating turbine which drives the engine's compressor to create a self-sustaining process. As more fuel is injected into the engine, more combustion occurs, which increases the temperature of the hot gases expelled from the engine, generating a greater flow of energy over the gas generator rotor blades, accelerating the engine compressor to higher speeds to draw in more air for compression.

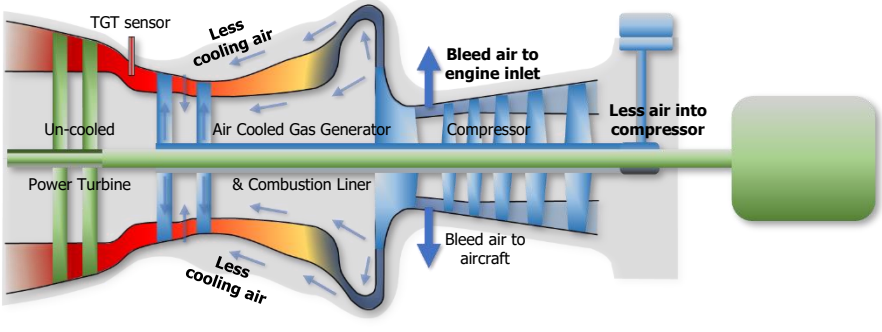
In addition to supplying pressurized air for fuel combustion, gas turbine engines bleed air from the compressor for other uses, such as engine cooling and supplying pneumatic pressure to other systems onboard the aircraft. In the case of the T700-series engine in the AH-64, air supplied by the compressor is routed through the internal engine components to provide cooling to both stages of the gas generator nozzles and rotor blades and the annular combustion liner.



T700-series Engine Cooling

Although it may seem counterintuitive to use bleed air from the compressor for engine cooling, which is typically hot enough to cause burns on exposed skin, the temperature of the hot gases expelled from the combustion section of an idling turbine engine will often exceed 500° Celsius (932° Fahrenheit), significantly hotter than the temperature of bleed air from the compressor. In fact, the majority of air consumed by gas turbines is used for engine cooling as opposed to combustion, which typically accounts for less than 25% of the total air consumption.

Despite the fact that fuel combustion requires a significantly smaller ratio of the total quantity of air drawn into the compressor compared to that used for engine cooling, the air required for complete combustion of fuel at a given throttle setting will remain relatively unchanged. However, if the total quantity of air that can supplied by the compressor is reduced, less air will be available for cooling and the turbine gas temperatures will rise. This will occur any time the atmospheric density drops due to high altitude and/or high ambient temperatures. It may also occur if additional air is bled from the compressor, as in the case of the engine inlet anti-ice being enabled.



Environmental Effects on Turbine Engines

If the turbine gas temperatures within the engine become too hot, or the speed of the rotating turbine blades gets too high, the internal engine components can become deformed or suffer a catastrophic material failure, destroying the engine. Therefore, the two principal limitations of all gas turbine engines are heat and speed. Most gas turbine engines incorporate mechanical or electronic mechanisms, or a combination of both, to limit the combustion and rotational speed of the engines within acceptable margins to prevent catastrophic failure, increase engine reliability, and extend the life of the engine.

Temperature Limitations

Thermal sensors within gas turbine engines measure the temperature of the hot expanding gases being expelled from the combustion section of the engine. Depending on the type and design of the engine, an automated limiting mechanism may be installed that prevents the pilot from exceeding the acceptable operating range of turbine gas temperatures (TGT) during flight at high altitude and/or hot ambient temperatures.

In the case of the T700-series engines on the AH-64, electronic TGT limiters are applied by the Digital Electronic Control (DEC) units installed on the engines themselves which will limit the fuel flow into the combustion section when the TGT reaches a specific value. In the event one engine fails, the DEC of the opposing engine will increase the TGT limiter to a higher value to permit the pilot to demand additional power from the remaining engine, if necessary, at the risk of reducing the life of the engine. However, even when operating the engine(s) at a power setting below the TGT limiter, many engines such as the T700 will have specified TGT ranges at high-power settings that should only be used for short durations to increase engine life and reliability.

(See The AH-64D chapter for more information.)

Speed Limitations

Tachometer sensors within gas turbine engines measure the rotational speed of the engines. Depending on the type and design of the engine, an automated limiting mechanism may be installed that prevents the pilot from exceeding the acceptable operating range of the compressor, gas generator, or power turbine rotor stages.

In the case of the T700-series engines on the AH-64, the compressor speed will be limited if the compressor blades approach supersonic speeds, also known as N_G Mach, during flight in cold ambient temperatures (typically below 0° Celsius), to prevent disruption or damage to the compressor section.

In addition, electronic overspeed protection is applied by the DEC units installed on the engines themselves if the power turbine speed (N_P) exceeds optimal parameters, and mechanical overspeed protection is engaged within the Hydromechanical Unit (HMU) if the compressor/gas generator speed (N_G) exceeds optimal parameters. In either case, the engine will flame out if the N_P or N_G overspeed protection is triggered.

Fuel Flow Limitations

Under some environmental conditions, engine power will be limited by the fuel flow, in that the amount of fuel that can be supplied through the fuel manifold into the combustion section of the engine has reached the maximum flow rate. Under these conditions, the engine may not have yet encountered a temperature or speed limitation, but is not able to provide additional power due to being physically incapable of supplying any more fuel to the combustion section.

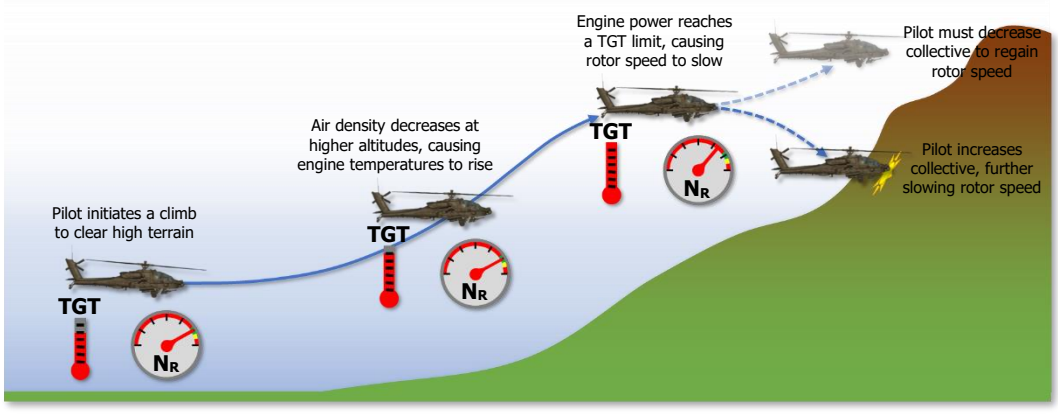
Regardless of whether the engine power is limited by temperature, speed, or fuel flow, if the pilot attempts to demand additional power from the helicopter by increasing collective, the engine(s) will be incapable of meeting the additional load demand and the rotational speed of the rotor system will begin to slow, also known as rotor droop, described on the following page.

Rotor Droop

Any time the angle of attack of an airfoil is increased, there is a simultaneous increase of lift and drag. Therefore, to maintain the rotational speed of the rotor system, the engine torque output must be continuously adjusted to maintain a balance between the opposing forces of engine torque output and aerodynamic drag. However, as mentioned in the previous section, there are limitations in how much power a helicopter's engine(s) can produce. If the drag on the rotor system exceeds the maximum power output of the engine(s), the rotor system will slow and produce less lift. This loss of rotor speed due to insufficient power is known as *rotor droop*.

Although rotor droop itself is due to insufficient power available to counter the drag on the rotor system, incurring such a condition is often a result of improper pilot actions, due to a lack of understanding of the helicopter performance limitations and/or a lack of awareness of the power requirements for a given maneuver.

In the figure below, a pilot initiates a climb to higher altitudes which, as described in the previous section, will cause the turbine gas temperatures (TGT) to rise due to lower air densities. Once the engines reach the maximum allowable TGT, the engines will not produce any more power to counter the drag on the rotor system. If the climb is maintained, the air density will continue to decrease, causing the engines to automatically reduce the fuel flow into the combustion section to prevent the TGT limit from being exceeded. The rotor speed will droop, lift will be lost, and the helicopter will stop climbing. If the pilot increases the collective to maintain the intended climb rate, the rotor speed will droop further, more lift will be lost, and the helicopter will descend.



Rotor Droop (TGT Limiting)

The key to understanding the criticality of rotor droop is examining the lift equation: $\mathbf{L = C_L \tfrac{1}{2} \rho V^2 S}$

- **L** lift force
- $\mathbf{C_L}$ lift coefficient (the efficiency of the airfoil in producing lift)
- **ρ** (rho) air density
- **V** velocity of air flowing across the airfoil
- **S** surface area of the airfoil

The pilot cannot affect the efficiency or surface area of the airfoils, nor can a pilot affect the local air density. The pilot can only affect the angle of attack and velocity of the airfoils. The typical instinctive action to prevent a loss of altitude is to increase collective, which increases the angle of attack of the rotor system. However, in a situation in which the engine(s) have encountered a limit and no more engine power is available to counter the additional load demand on the rotor, this will further aggravate the condition of rotor droop.

It is important to understand that the velocity component of the lift equation is V^2 (squared), meaning that the velocity of the airfoil has an *exponential* effect on the amount of lift produced by the airfoil. That is, for whatever amount of lift is gained by increasing the angle of attack, an exponential amount of lift is lost by incurring more drag and a loss of airfoil velocity. Therefore, rotor droop must be countered by *lowering* the collective, which will reduce drag, allowing the rotor to regain speed and produce *more* lift as airfoil velocity is increased.

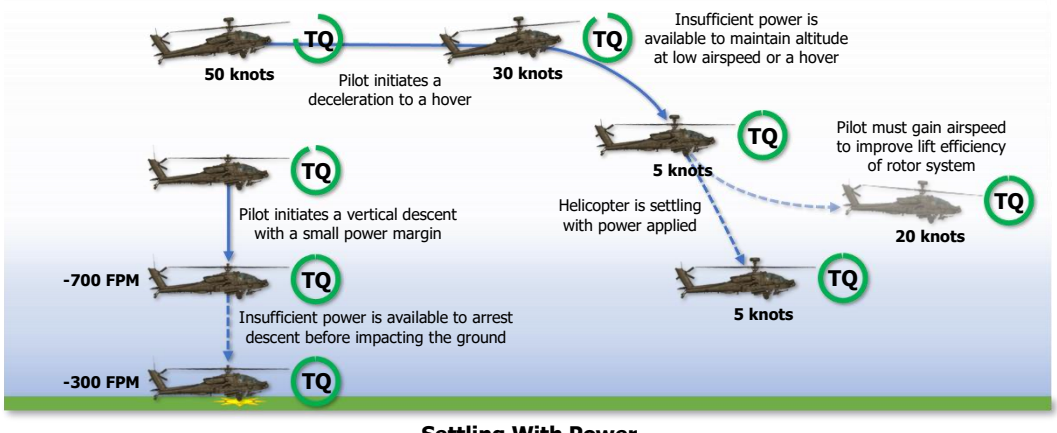
Settling With Power

If the amount of engine power that is required to sustain flight is close to a helicopter's maximum power available, the power margin for performing maneuvers will be very small. As the power margin between power required and power available narrows, there may be certain maneuvers or flight conditions that may not be possible without incurring an unintentional loss of altitude due to insufficient power available to arrest the descent, which is known as *settling with power*.

Helicopters are most susceptible to settling with power any time the helicopter is operating out of ground effect (OGE) while near or over the maximum allowable gross weight for performing an OGE hover.

- If the gross weight is below, but close to, the maximum gross weight for performing an OGE hover within the current environmental conditions, the helicopter may not have sufficient power to overcome the helicopter's inertia and arrest high rates of descent at low airspeeds before impacting the ground.
- If the gross weight exceeds the maximum gross weight for performing an OGE hover within the current environmental conditions, the helicopter will not have sufficient power to maintain altitude below a given airspeed, which is referenced as V_{SDE} (Velocity Safe Dual Engine) if under dual-engine power, or V_{SSE} (Velocity Safe Single Engine) if under single-engine power.

In the figure below, the pilot in an FCR-equipped aircraft is heavily loaded with fuel and munitions, with a gross weight that exceeds the maximum allowable gross weight for performing an OGE hover within the current environmental conditions. As the helicopter decelerates and the rotor system becomes less efficient due to a loss of translational lift, the helicopter will begin to descend even though the pilot has increased collective to the maximum torque available. This descent will continue unless the pilot accelerates to gain translational lift.



Settling With Power

In the same figure above, the pilot in a non-FCR aircraft is moderately loaded with fuel and munitions, with a gross weight that is just below the maximum allowable gross weight for performing an OGE hover within the current environmental conditions. Even though the aircraft has sufficient power to maintain an OGE hover, if the pilot allows a sufficient descent rate to accumulate, there may not be sufficient power to overcome the aircraft's inertia before impacting the ground, even if the pilot increases collective to the maximum torque available.

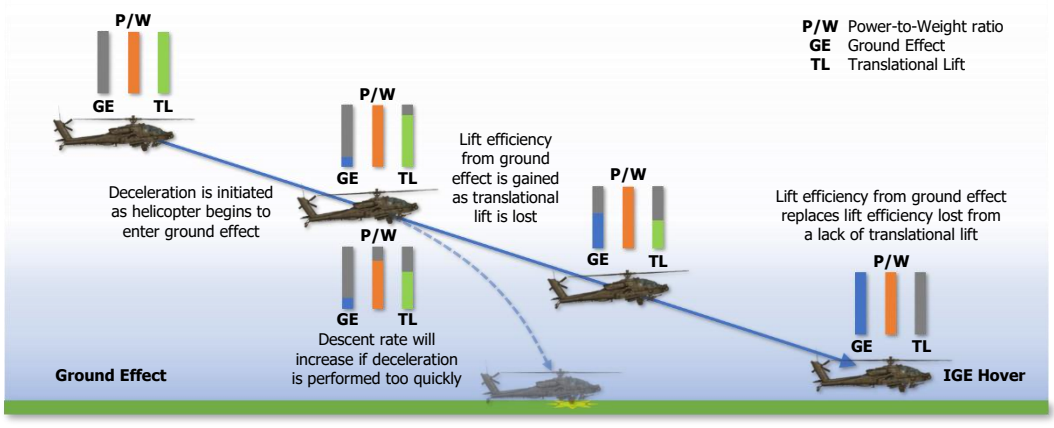
NOTE: If the pilot increases collective above the maximum torque available, the rotor will droop and lose lift, and the descent rate will *increase*. Further, if a descent rate incurred by settling with power and/or rotor droop is high enough, the rotor system may encounter the aerodynamic condition of vortex ring state. However, it is important to understand that each of these conditions (Settling With Power, Rotor Droop, and Vortex Ring State) are unique conditions that are caused by different factors, even though one condition may lead into another, depending on the power margins within the current environmental conditions and the actions taken by the pilot.

Limited Power Approach

In the event that a helicopter does not have sufficient power margins to maintain a stationary hover out of ground effect (OGE), takeoffs and landings may still be performed if there is sufficient power to maintain a stationary hover in ground effect (IGE). However, any maneuvers that require robust power margins will not be possible and some maneuvers may need to be performed in a more deliberate and conservative manner to account for the limited power margins available.

When performing a takeoff with a limited power margin, a Minimum Power Takeoff or a Rolling Takeoff (if equipped with wheeled landing gear) may be performed, in which the helicopter remains in ground effect until forward airspeed can be attained to improve the lift efficiency of the rotor system through translational lift. Once sufficient forward airspeed is attained, the helicopter climbs out of ground effect and proceeds on its mission.

When performing an approach to landing with a limited power margin, regardless of whether it is an approach to an IGE hover, an approach to the ground with no forward movement, or a Roll-On Landing, a shallow approach angle is used to leverage the improved lift efficiency from ground effect. During a limited power approach, the rate of deceleration is managed in such a way that ground effect improves the overall lift efficiency of the rotor system at the same rate that the loss of translational lift is reducing the lift efficiency. If timed correctly, the helicopter will maintain a constant approach angle to the intended point of touchdown by offsetting one source of lift efficiency for the other.



Limited Power Approach

However, if timed incorrectly in such a way that translational lift is lost too quickly, before the helicopter has sufficiently entered ground effect, the rate of descent will increase and the helicopter may enter a settling with power condition.

During the approach, if the maximum torque available has already been reached, the pilot cannot increase the collective any further without incurring rotor droop. The pilot must control the rate of descent with airspeed.

- Increasing forward airspeed will increase translational lift, which will improve lift efficiency and decrease the rate of descent.
- Decreasing forward airspeed will decrease translational lift, which will degrade lift efficiency and increase the rate of descent.

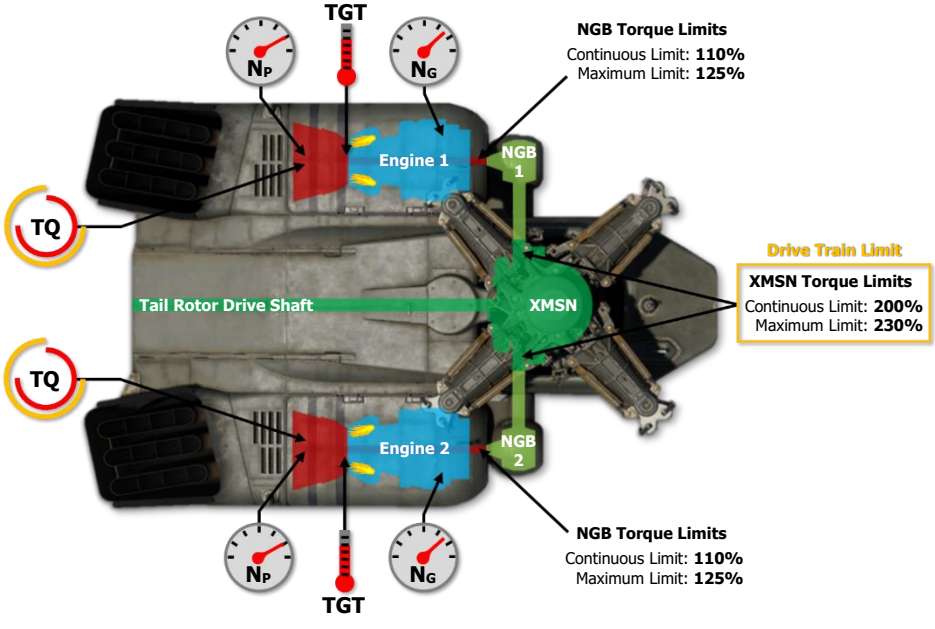
Essentially, once the maximum torque available has been reached, reduce airspeed as necessary as ground effect is entered to maintain the current approach angle and avoid shallowing, taking into account the size of the landing area and any obstacles in the approach path or in the vicinity of the landing area itself.

Multi-Engine Drive Train Limitations

Although environmental conditions may limit the efficiency of the helicopter's rotor blades in producing lift or the engines in producing thrust, the limitations of the helicopter's drive train (transmission and gearboxes) must also be considered when assessing a helicopter's gross weight for a mission. In the case of a multi-engine helicopter like the AH-64D, performance planning must take into account the possibility of losing power from one engine and the implications of such a contingency on the helicopter's performance and mission profile.

Under dual-engine power, an AH-64D is typically limited by the main transmission. When operating at low pressure altitudes and moderate temperatures, its T700 engines are capable of producing a combined torque that exceeds the maximum power for which the main transmission is rated before encountering a TGT limit, an N_G limit, or a fuel flow limit.

An illustration of the AH-64D drive train under dual-engine power is shown in the figure below. It is important to note that all primary indications within the cockpit that relate to the state of the drive train are measured within the engines themselves rather than the main transmission (XMSN) or nose gearboxes (NGB). With regard to the engines' torque output, these sensors are located within the power turbine sections of each engine. Each engines' torque output is quantified as a percentage and displayed separately on the Engine (ENG) page of the MPDs, but are combined into a single torque value on the Flight (FLT) page and in the IHADSS Flight symbology, which displays the highest torque value of the two.



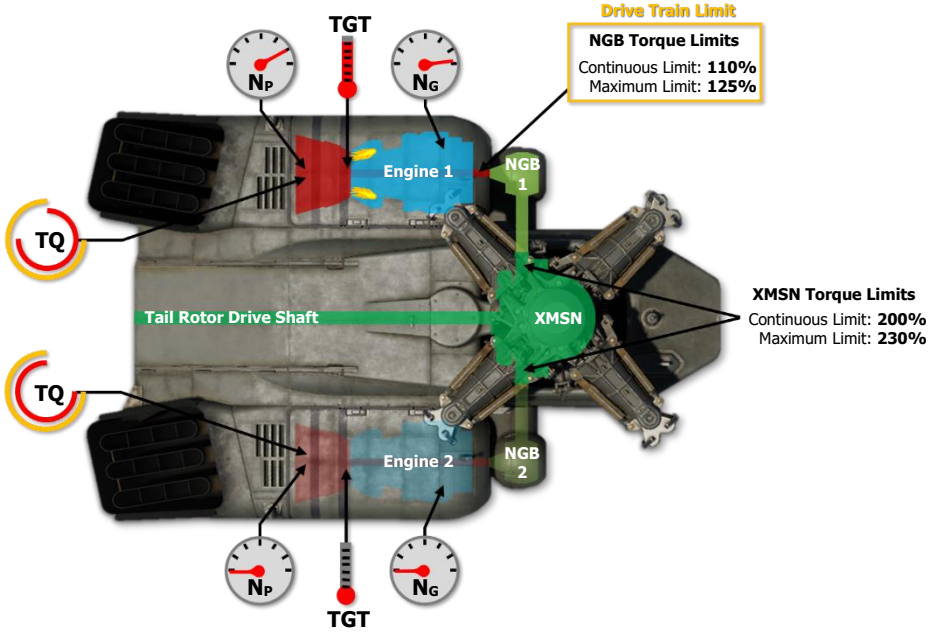
AH-64 Drive Train (Dual-Engine)

As the individual torque output of each engine is measured locally within the engines themselves, the combined torque load within the main transmission is cumulative. If both engines are individually producing a torque output of 100% each, the combined torque load on the main transmission is quantified as 200%, which is the continuous torque limit of the main transmission. The main transmission is rated up to a maximum torque limit of 230% but can only sustain a torque load between 201% and 230% for up to 6 seconds before incurring a post-flight inspection and/or possible replacement due to an over-torque condition.

Accordingly, when the rotor speed (N_R) is at flight RPMs, the continuous dual-engine torque limit is 100% and the maximum dual-engine torque limit is 115% for no more than 6 seconds, as indicated within the cockpit.

Under single-engine power, an AH-64D is typically limited by the nose gearbox of the operational engine. When operating at low pressure altitudes and moderate temperatures, a T700 engine is capable of producing enough torque to exceed the maximum power for which the nose gearbox is rated before encountering a TGT limit, an N_G limit, or a fuel flow limit.

An illustration of the AH-64D drive train under single-engine power is shown in the figure below. If the torque output from the opposite engine is less than 51%, the TGT limiter of the engine is increased to allow the healthy engine to operate in a single-engine contingency mode for up to 2.5 minutes within a higher turbine gas temperature range.



AH-64 Drive Train (Single-Engine)

The nose gearbox is rated for a continuous torque limit of 110% and a maximum torque limit of 125% but can only sustain a torque load between 123% and 125% for up to 6 seconds, or a torque load between 111% and 122% for 2.5 minutes, before incurring a post-flight inspection and/or possible replacement due to an over-torque condition.

Accordingly, when the rotor is at flight RPMs, the continuous single-engine torque limit is 110% and the maximum single-engine torque limit is 125% for no more than 6 seconds, as indicated within the cockpit. The main transmission is no longer the limiting component within the overall drive train under single-engine power, as the maximum torque limit for the nose gearbox is 125%, far below the 200% continuous torque limit of the main transmission.

However, environmental conditions may still limit the maximum torque available from the engines themselves below the torque limits of the main transmission and/or nose gearboxes.

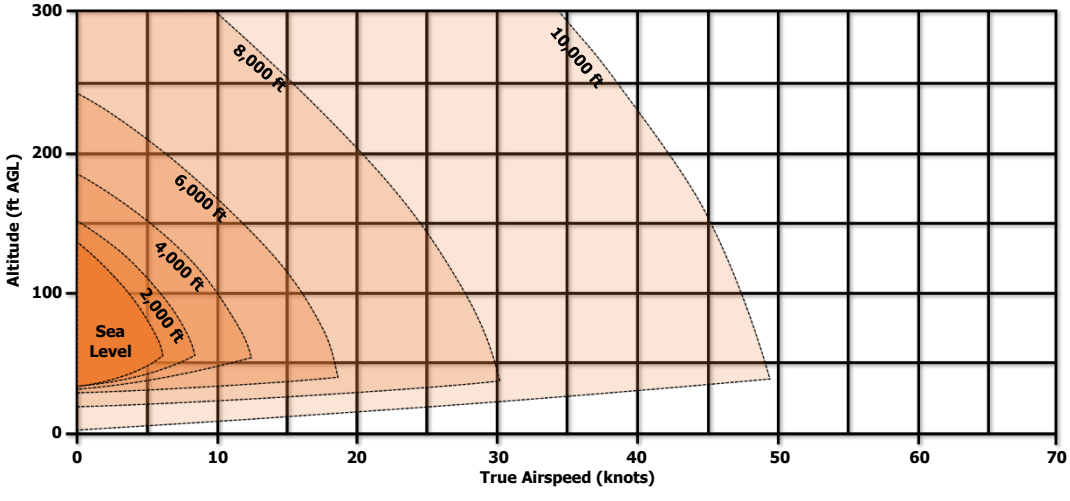
- If the MAX Q – DE value displayed on the Performance (PERF) page is below 100, the rotor will begin to droop before the continuous torque limit of the main transmission is reached.
- If the MAX Q – SE value displayed on the Performance (PERF) page is below 110, the rotor will begin to droop before the continuous torque limit of the nose gearbox is reached; or if the MAX Q – SE value is below 122, the rotor will begin to droop before the 2.5-minute torque limit of the nose gearbox is reached.

Height-Velocity Avoid Region

In the event a multi-engine helicopter suffers a single engine failure, the torque input into the drive train will be immediately reduced to half (assuming the torque load was equally distributed between both engines). When this occurs, the pilot must immediately lower the collective to reduce the drag load on the rotor system and maintain the rotational speed of the rotor blades, in order to prevent rotor droop. However, depending on the environmental conditions and the gross weight of the helicopter, a significant loss of altitude will be likely, particularly at low airspeeds in which the helicopter does not have sufficient power to maintain a hover out of ground effect. Under these conditions, the pilot will need to use the remaining altitude to accelerate above V_{SSE} (Velocity Safe Single Engine) and avoid settling with power or use the remaining engine power of the operational engine to cushion the rate of descent as much as possible before impact with the ground.

Height-velocity avoidance diagrams are used to illustrate the conditions in which recovering from an engine failure without damage to the helicopter and/or injury to the aircrew is unlikely. These diagrams are based on the type of helicopter, the performance of the helicopter at various pressure altitudes, and the assessed average reaction time of the crewmembers to recognize the condition and perform the required corrective actions.

The shaded regions in the chart below correspond to pressure altitudes that, if a single engine failure were to occur within the shaded region of the corresponding pressure altitude, the pilot is not expected to have enough time to accelerate above V_{SSE} nor have sufficient power from the remaining engine to reduce the rate of descent before impact with the ground.



Height-Velocity Avoid Regions

As an example, if the helicopter is between 30 feet and 150 feet above the ground, at a pressure altitude of 2,000 feet, and an airspeed less than 8 knots, the pilot may not be able to avoid an impact with the ground if one of the engines were to fail.

- If the pilot were to hover at an altitude above 150 feet AGL, there would likely be sufficient altitude to accelerate above V_{SSE} and gain translational lift to avoid impact with the ground.
- If the pilot were to hover at an altitude below 30 feet AGL, there would likely be insufficient altitude for the descent rate to build under single engine power before impact with the ground, allowing the pilot to use the remaining engine power to sufficiently cushion the descent rate for a safe landing.
- If the pilot were to maintain a minimum airspeed above 8 knots, the added lift efficiency gained from translational lift will likely allow the pilot to accelerate above V_{SSE} before impact with the ground or supplement the remaining engine power to sufficiently cushion the descent rate for a safe landing.

THE AH-64D

US Army photo
by SSG Thomas Mort

AIRCRAFT HISTORY

The AH-64D is the evolution of the U.S. Army's need for an airborne platform that is lethal against large numbers of armored vehicles, readily and continuously available at day or night to support ground force commanders, and survivable enough to operate in a modern combat environment. Following the experiences of helicopter units in the Vietnam War, which mainly consisted of small teams of helicopters engaged in light combat, the emerging environments that military helicopters were expected to be operating within contained large-scale armor units supported by sophisticated air defense systems. Army Aviation needed to procure an advanced attack helicopter that could be effectively lethal and survivable in heavy combat, regardless of the time of day.

Advanced Aerial Fire Support System

In 1948, the Key West Agreement codified the separation of air assets between the U.S. Army and the newly founded U.S. Air Force. Doctrinally, the Air Force would be tasked to provide fixed-wing aircraft for the close air support (CAS) role with a new generation of fighter aircraft, while Army Aviation was limited to small and light fixed- and rotary-wing aircraft since, at the time, such aircraft were expected to be limited to utility and logistics.

In 1960, the Secretary of Defense, Robert S. McNamara, revisited this agreement by creating the Army Tactical Mobility Requirements Board. The board and its chairman, Lieutenant General Hamilton H. Howze, recommended that Army Aviation be greatly expanded to include a well-developed attack role, among many others. McNamara followed the board's recommendation, which generated contention among Air Force leadership, insistent that fixed-wing fighters were the only effective platforms for performing CAS.

Lockheed AH-56 Cheyenne (US Army)

Army leadership was determined to procure their own close air support aircraft and initiated the Advanced Aerial Fire Support System (AAFSS) program in 1963 to design a purpose-built attack helicopter, rather than an armed variant of an existing utility helicopter. The request for proposals was announced in 1964; and in 1968 Lockheed was awarded the contract with its proposal for the AH-56 Cheyenne.

Consequently, the Air Force initiated the A-X program in 1966 (even before the AH-56 contract had been awarded to Lockheed) to develop a purpose-built CAS aircraft to fulfill the same missions to which the AH-56 was intended to perform, which would eventually result in the A-10. However, by the end of the 1960's the U.S. military's strategic concern shifted to the large numbers of tanks that Warsaw Pact countries could employ in a European ground war. Thus, priorities for aircraft development shifted from close air support to the anti-armor role, and in 1972 the Army canceled development of the AH-56 in favor of a program to develop a more capable anti-tank platform.

Joint Attack Helicopter Instrumented Evaluation

In 1972, the NATO Armaments Group conducted a series of tests in Ansbach, Germany, to determine the viability of employing attack helicopters against large numbers of armored vehicles supported by mobile, short-range air defenses. The final report concluded that helicopters could be extremely effective in destroying an attacking armored ground force by utilizing hovering fire from standoff ranges. When employing anti-armor munitions, the assessed kill ratios averaged 15 tracked vehicles destroyed for every helicopter lost.

By 1975, AH-1G attack helicopters (which were limited to carrying rockets, grenade launchers, and miniguns) were being replaced by AH-1Q variants that could employ BGM-71 TOW anti-armor missiles; and shortly thereafter, night-capable AH-1S helicopters were fielded. However, the TOW-equipped AH-1 was considered an interim solution for an anti-armor helicopter that could fight and survive amongst increasingly sophisticated air defenses consisting of radar-controlled antiaircraft guns and shoulder-fired, infrared-guided missiles.

Advanced Attack Helicopter Program

The U.S. Army's Advanced Attack Helicopter (AAH) program to develop a night-capable, anti-tank helicopter got underway in January 1972. Despite the fact that the AAH requirements were for an aircraft that would be smaller (though more agile), slower, and less sophisticated than what was originally envisioned in the Advanced Aerial Fire Support System, the AAH program still faced several technological hurdles. These challenges were compounded by the need to update U.S. Army doctrine in employing such an aircraft in combat and modernizing Army Aviation's equipment and training for performing low-level flight at night.

The AAH program's request for proposals (RFP) was announced in November 1972, approximately six months after the Ansbach tests concluded. The RFP specified that the helicopter would need to operate at night at extremely low altitudes, should utilize the same General Electric T700 engine as the Utility Tactical Transport Aircraft System (which would eventually evolve into the UH-60), and should be armed with a 30mm cannon and 16 anti-tank BGM-71 TOW missiles. The RFP was later amended to include a requirement to carry 16 AGM-114 missiles in place of the TOW, which would more than double the standoff engagement range of the airframe.

Bell, Boeing-Vertol/Grumman, Hughes, Lockheed, and Sikorsky all submitted proposals for the AAH program. In July of 1973, the Department of Defense selected the Bell Model 409 and the Hughes Model 77 as the prototypes that would be built to compete for the contract in Phase 1 of the AAH program.

Bell Model 409 (US Army)

Hughes Model 77 (US Army)

The Hughes Model 77, designated YAH-64, first flew on September 30, 1975. The Bell Model 409, designated the YAH-63, performed its first flight only a day later. After a series of flight tests and trials, the Army decided to move ahead with the Hughes YAH-64, citing its increased survivability over the YAH-63.

AH-64A

Per Phase 2 of the AAH program, the YAH-64 entered pre-production. The airframe, redesignated as the AH-64A, was integrated with the weapon and targeting systems it would employ in combat.

The AH-64A was equipped with two revolutionary targeting systems: the Integrated Helmet And Designation Sighting System (IHADSS) and the Target Acquisition Designation Sight (TADS). IHADSS and TADS enabled aircrews to navigate mere feet over the terrain and amongst obstacles under total darkness, acquire and engage targets at long-range, and rapidly engage targets with the 30mm cannon using helmet-mounted sights. Combined with the Pilot Night Vision System (PNVS), these sighting systems made the AH-64A a lethal day and night attack aircraft.

Pre-production version of the AH-64A (US Army)

Final production version of the AH-64A (US Army)

Three AH-64As were delivered to the Army in 1981 for Operational Test II at Fort Hunter-Liggett, California. In 1982, the engines were upgraded to the more powerful T700-GE-701, with 1,690 shaft horsepower (SHP), and the Army approved the AH-64A for full-scale production. In 1983, the first production AH-64A rolled off the assembly line at Hughes's production facility in Mesa, Arizona. In January 1984, the Army took delivery of its first AH-64A; and in March 1986, began training its first operational unit, 7th Battalion, 17th Cavalry Brigade, at Fort Hood, Texas.

The AH-64A proved to be exceptionally nimble at low speeds, capable of weaving through tree lines and amongst the terrain contours, even when armed with a full combat load. Each AH-64A could be equipped with four quad-rail missile launchers for carrying a full load of 16 AGM-114 missiles in the anti-armor role. Alternatively, two of the missile launchers could be replaced by a pair of 19-tube rocket launchers for reconnaissance, security, or fire support missions. In addition, 1,200 rounds of 30mm ammunition could be carried for the single-barrel automatic cannon, which was effective against light armor, unarmored vehicles, and personnel.

AH-64A firing unguided rockets (US Army)

The AH-64A was also designed with a high degree of survivability from lessons learned in Vietnam, including strategically placed armor, systems redundancy, fire retarding systems, self-sealing and inerting fuel cells, infrared suppression, and crashworthiness in the event of a high-rate vertical impact with the ground.

Over 1,000 AH-64As were produced, most of which have since been upgraded to the D model. The AH-64A was operated by the U.S. Army until July 2012, when the last A model was taken out of service.

AirLand Battle

Throughout the 1980's, Army Aviation continued to evolve its night-fighting capabilities, with night-time flight training constituting approximately a third of all flight training that was conducted. Simultaneously, the U.S. Army as a whole was devising an entirely new doctrine of warfighting, termed "AirLand Battle".

AH-64A performing weapon tests (US Army)

AirLand Battle doctrine involved a greater integration of combined-arms maneuvers, synchronizing the efforts of armor, artillery, and aviation units at the division level or higher. The AH-64A would play a key role in this combined-arms fight, being employed in entire platoons, companies, or battalions, in a similar manner as tank units. The AH-64A would not only augment armor units by providing fire support along the front line but would be capable of performing deep attacks beyond the FLOT (Forward Line of Own Troops), independently of ground forces, engaging enemy targets from standoff ranges and relying on nap-of-the-earth (NOE) flying to minimize exposure to enemy air defense systems.

Artillery and MLRS units would also play a key role in the Army's attacks in depth by providing fire support and suppression of enemy air defenses (SEAD). Alternatively, when performing deep attacks beyond the range of friendly artillery, Army AH-64's could be supported by Air Force or Navy/Marine Corps fixed-wing aircraft providing SEAD.

Gulf War (Operation Desert Shield/Desert Storm)

The AH-64A first saw combat in 1989 as part of Operation Just Cause, the U.S. invasion of Panama. But it wouldn't be until Operation Desert Shield in 1990 that the AH-64A would be deployed in significant numbers for a large-scale conflict.

In January 1991, eight AH-64A's from the U.S. Army's 101st Airborne Division, along with four MH-53J Pave Low helicopters from the U.S. Air Force's 20th Special Operations Squadron, struck the first targets in Iraq during the opening hours of Operation Desert Storm. Their mission was to destroy two early warning radar sites along the border between Saudi Arabia and Iraq to allow coalition aircraft to funnel through the hole in radar coverage to begin the air campaign against the Iraqi military. Both radar sites needed to be destroyed quickly, simultaneously, and completely, to prevent the Iraqi air defense network from detecting the incoming coalition aircraft or receiving advance warning of the impending air attack.

AH-64As during Desert Shield (US DoD)

Throughout the fall of 1990 and into January 1991, the Army and Air Force crews continuously rehearsed the various aspects of the mission, from formation flying to navigating long distance routes at night while flying no more than 100 feet over the terrain. However, it wasn't until the evening of January 16th, hours before the mission itself, that the aircrews were finally briefed on the nature of their mission. Each team, "Red Team" and "White Team", consisted of four AH-64A's and two MH-53J's, with the western radar site assigned to Red Team and the eastern radar site assigned to White Team.

At midnight the joint helicopter force began spooling up their engines. Each team departed separately using precise timing so they would arrive at their designated targets simultaneously. Flying radio silent and guided across the featureless desert by the GPS navigation units on board the MH-53's, the two teams of Army and Air Force helicopters navigated over 130 miles through the darkness, attracting only momentary small arms fire and an errant missile as they crossed the border into southern Iraq.

As the Pave Lows arrived over the pre-briefed initial points, their crews dropped bundles of chemlights onto the surface to mark the location. One by one, each AH-64 hovered over the chemlights and updated their inertial navigation systems before regrouping and proceeding to their respective targets, while the MH-53's departed to their designated holding area. Advancing slowly at low altitude, the AH-64's successfully reached their attack positions without detection, and each AH-64 aircrew acquired their assigned targets through their Forward-Looking Infrared (FLIR) sensors. With a single radio call, the attack commenced at precisely 2:38 AM on January 17th with an onslaught of Hellfire missiles, followed by rockets and 30mm cannon fire. Within minutes, the radar sites were completely annihilated, and scores of coalition aircraft streamed through the gap in radar coverage to begin the air campaign phase of Operation Desert Storm.

AH-64A equipped for an anti-armor mission during Desert Storm (US DoD)

Leading up to the ground phase of Desert Storm in the following month, AH-64 units began conducting deep attacks at night against Iraqi armor units. These deep attacks were supported by EF-111 and EC-130 electronic warfare aircraft providing suppression of enemy air defenses (SEAD) in the form of jamming and deception, while several artillery battalions remained on call to provide additional SEAD if required. When the ground phase finally commenced on February 24th, battalions of AH-64A attack helicopters were launched en masse against multiple objectives forward of friendly ground forces. On several occasions, an entire brigade of Iraqi armor was decimated by a single battalion of AH-64A helicopters in a single battle, solidifying the Army's use of attack helicopters as an effective anti-armor force that was capable of attacking enemy forces in depth.

AH-64A+, AH-64B, and other upgrade proposals

As early as 1984, upgrades and additional AH-64 variants were being proposed by McDonnell Douglas (which had since acquired Hughes shortly after the AH-64A entered service) and offered to the U.S. Army and other potential buyers. Notably, the U.S. Marine Corps expressed interest in a "Sea Apache" variant, but the type was never procured due to high costs.

AH-64A mock-up with Sidewinder and ATAS missile systems (McDonnell Douglas)

Many alternative weapons were also suggested for addition to the AH-64A's arsenal, including other types of anti-tank missiles, air-to-air missiles, and even anti-ship missiles. In particular, efforts to arm the AH-64A with air-to-air missiles proceeded as far as weapon test-firings of the AIM-9 Sidewinder and the Air-To-Air Stinger (ATAS) system between 1987 and 1989. Even the anti-radar AGM-122 Sidearm (derived from the AIM-9 missile) was successfully tested in 1988. However, none of these efforts gained traction and the U.S. Army never upgraded its AH-64 fleet for air-to-air missile capability.

Multi-Stage Improvement Program (MSIP)

In 1988, McDonnell Douglas began to develop various upgrade proposals for the AH-64A, referred to as "Advanced Apache", "Apache Plus", or the "AH-64B". These proposals would have included numerous upgrades, such as a revised and updated cockpit, digital electronics, a new fire control and gun system, improved sensors and communications, and Stinger air-to-air missiles. However, the MSIP proposals never proceeded beyond their concept stages.

Following the Gulf War, a more modest "AH-64A+" upgrade program was proposed that included improved communications in the form of SINCGARS and HF radios, GPS-aided navigation, a ground-proximity warning system, sand filtration kits, an improved flight computer, and accuracy improvements to the PNVS/TADS and the 30mm gun. Although some of these changes such as the SINCGARS radios and GPS receivers were eventually incorporated into the AH-64A fleet, the original A+ upgrade program was largely abandoned in favor of the much more ambitious AH-64D upgrade program.

Airborne Adverse Weather Weapon System (AAWWS)

Maintenance personnel inspect an AH-64Ds mast-mounted assembly (US Army)

In the late 1980's, research and development was underway for the AAWWS, a radar targeting system that could be mounted on top of the AH-64's rotor mast. The radar system would enable the AH-64 to acquire ground or air targets while remaining masked behind terrain, trees, or other obstructions, even in low visibility. The targeting data could then be passed to other friendly assets in the combined-arms battlespace, such as other helicopters, artillery, command centers, intelligence networks, or fixed-wing fighters and strike aircraft.

By 1992, the AAWWS had evolved into the AN/APG-78 fire control radar and was to be fitted to the AH-64D that was under development. The APG-78 would enable the AH-64D to navigate at low altitudes in low-visibility conditions, acquire and classify battlefield targets faster, remain hidden behind terrain longer to avoid air defenses, and transfer targeting and reconnaissance data to other AH-64Ds in real-time. The AAWWS had the potential to transform a team of AH-64's into a devastating anti-armor force.

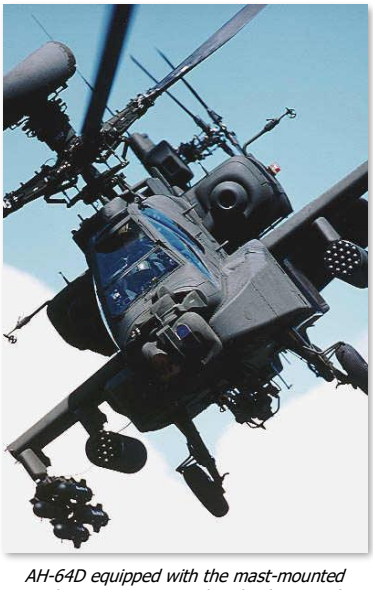
Aviation Restructure Initiative (ARI)

In February of 1993, the U.S. Army Aviation Center at Fort Rucker, Alabama, initiated the Aviation Restructure Initiative with the objective to modernize, reorganize, and standardize aviation units across the Army. At the time, the Army Aviation fleet was composed of many rotary- and fixed-wing airframe types. As part of the modernization, the number of helicopter types was reduced from 10 to 5 and the number of fixed-wing types was reduced from 8 to 4. Among the changes that were to be made as part of the ARI, one particular change impacted the structure of the attack helicopter battalions and the AH-64's role within it.

Leading up to the 1990's, the structure of the Attack Helicopter Battalion (ATKHB) consisted of 18 AH-64A, 13 OH-58C, and 3 UH-60 helicopters. Although the OH-58C's were also used for liaison and courier duties, the principal warfighting function of the OH-58C within the ATKHB was to serve as an "aeroscout" for the AH-64A. However, the OH-58C was a 1960's airframe that was proving to be increasingly limited as an aeroscout for the AH-64. The OH-58C lacked the speed and survivability to operate effectively alongside the AH-64 in a modern conflict, nor did it have adequate sensors to detect and classify targets, relying solely on the pilots' eyesight.

OH-58C and AH-64A "hunter-killer team" (US Army)

Following the reorganization of ARI, the structure of the ATKHB transitioned to a single-airframe unit, consisting of 24 AH-64's across three flight companies. Each flight company would be assigned three AH-64's to fulfill the scout role, with five AH-64's to perform attack missions. These changes in unit structure laid the foundation for integration of the AH-64D within the Army's attack helicopter battalions, with each flight company receiving three FCR kits for each AH-64D within the scout platoon.



AH-64D equipped with the mast-mounted AN/APG-78 Fire Control Radar (US Army)

By employing the AH-64A in the aeroscout role, the scout platoons would gain a significant increase in their ability to detect and classify targets on the battlefield, especially at night. In daytime, the AH-64A had four times the target detection range and eight times the target classification range compared to the OH-58C. At night, the OH-58C's ability to detect targets was practically non-existent while the AH-64A's FLIR could detect and classify targets at approximately two-thirds the range of its own DTV during the day. The weapon systems, defensive equipment, and night operations capability of the AH-64A also increased the aircraft's survivability in combat compared to the OH-58C.

Following the introduction of the upgraded AH-64D, the addition of the APG-78 FCR in the scout platoons greatly enhanced and accelerated the process of target detection and classification. The APR-48 RFI, which shared the mast-mounted assembly with the FCR, allowed the AH-64D scout platoons to receive early warning of enemy air defense systems and subsequently target them for destruction; a capability that neither the AH-64A nor the OH-58C possessed. However, it is worth noting that the improved communications and direct transmission of real-time targeting data to other AH-64Ds is what truly allowed the FCR-equipped AH-64Ds to assume the aeroscout role from the OH-58C.

AH-64D

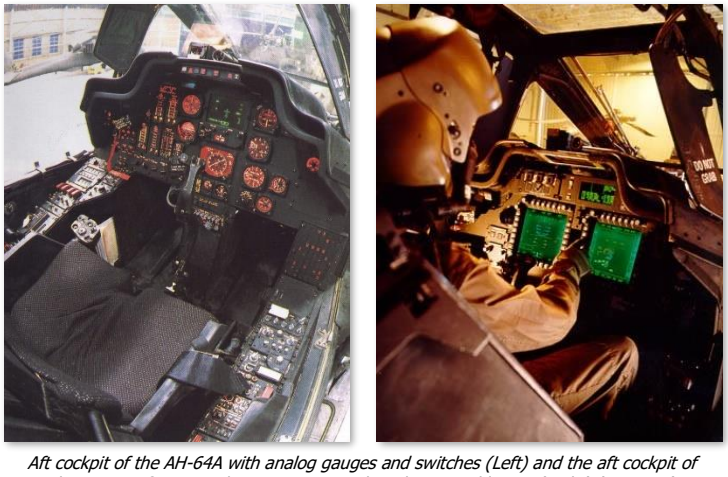
AH-64D (US Army)

Following Operation Desert Storm in 1991, the AH-64A+ upgrade proposed by McDonnell Douglas was approved and funded by the U.S. Congress but was canceled merely a year later in favor of the AH-64D proposal. The AH-64D upgrade program was a significantly more robust update to the AH-64 fleet, incorporating many aspects of the MSIP and AAWWS programs of the late 1980's.

The most obvious external differences between the AH-64A and the AH-64D are the presence of the AN/APG-78 Fire Control Radar (FCR) mounted above the main rotor of some AH-64Ds and the expanded avionics bays on either side of the forward fuselage to accommodate the additional computer processing capability. The AH-64A air data system mounted above the rotor head was replaced by a pair of Airspeed And Direction Sensor (AADS) probes mounted to each engine nacelle. The left and right navigation and anti-collision light assemblies were also relocated to the engine nacelles to accommodate growth options for wingtip mounted air-to-air missiles, though such weapons were never integrated into U.S. AH-64Ds.

The cockpit layout within each crewstation received significant modifications through a program called Manpower and Personnel Integration (MANPRINT), which focused on the human factors in optimizing the cockpit workflows. By replacing the analog instruments with a pair of 6 × 6 inch color multi-purpose displays (MPD) and an upfront display (UFD), the crew is presented with more data in an efficient "management by exception" approach, allowing them to gain and maintain greater situational awareness and make decisions more quickly and effectively. Further, replacing most of the switches and knobs in the cockpit with contextual options on the MPDs, a keyboard unit (KU) for data entry, and expanding the hands-on controls, allowed the crewmembers to interact with the aircraft systems, sensors, and fire control computer more efficiently and accomplish cockpit tasks rapidly.

The avionics improvements also included GPS-integrated navigation, a fully integrated communications suite with SINCGARS radios, a modem for transmitting data, and avionics supporting a MIL-STD 1553B data bus. AH-64Ds would also eventually receive the ARC-220 High Frequency (HF) radio for non-line-of-sight and over-the-horizon voice and data communications.



Aft cockpit of the AH-64A with analog gauges and switches (Left) and the aft cockpit of the AH-64D featuring the MANPRINT cockpit design and layout (Right) (US Army)

Along with the improvements to the avionics and the addition of the mast-mounted FCR, the AH-64D could employ the AGM-114L, a "fire-and-forget" variant of the missile that uses autonomous radar guidance instead of the semi-active laser-homing guidance of previous versions. However, the AH-64D still retained the capability to employ existing laser-guided variants alongside the radar-guided AGM-114L.

Unfortunately, the upgrades and additional equipment came with an increase in gross weight and a reduced power-to-weight ratio. To improve performance in "hot and high" conditions, the engines were replaced with the more powerful T700-GE-701C engines rated at 1,940 shaft horsepower (SHP). It is worth noting that the original plans were for the upgraded airframes to be designated as AH-64C and AH-64D, with the AH-64C lacking the FCR and the upgraded 701C engines. However, this additional designation proved to be redundant since the FCR system components themselves were interchangeable between the AH-64C and AH-64D. The designation was subsequently dropped, with all airframes being designated AH-64D. Eventually, all AH-64Ds (and even some AH-64A's) received the upgraded 701C engines.

The addition of the mast-mounted APG-78 Fire Control Radar and the upgraded communications equipment enhances the organic aeroscout capability for AH-64D-equipped units, allowing a single FCR-equipped AH-64D to instantaneously distribute targeting data to seven other AH-64Ds in the vicinity. In addition, the AH-64D's networking capabilities allows any AH-64D within the attack helicopter battalion to share reconnaissance information or mission updates in near real-time with two entire flight companies of aircraft at once, if necessary.

AH-64D (US Army)

When performing attacks in depth, the AH-64D can relay reconnaissance information and situation updates across long distances with the addition of the near-vertical incidence skywave (NVIS) antenna for non-LOS communications using the HF radio. This can be especially valuable when operating at low altitudes or when terrain obstructs normal radio line-of-sight.

The mast-mounted AN/APR-48 Radar Frequency Interferometer (RFI) provides the AH-64D with an improved early-warning of air defenses. When coupled with the FCR and fire-and-forget AGM-114L missiles, the RFI also provides the AH-64D with an inherent self-defense capability against short-range air defense systems, which is crucial during deep attacks beyond the range of friendly artillery that would otherwise provide suppression of enemy air defenses.

The first D model prototype was flown in April of 1992, and by 1995 testing had concluded and full-scale production was underway. The first Block 1 AH-64D was delivered to the U.S. Army on March 31, 1997.

The Army began receiving Block 2 airframes in 2003, which featured moving map underlays for the Tactical Situation Display (TSD), an Enhanced Upfront Display (EUFD), a new datalink modem, a digital video recording system, and dedicated search and rescue equipment in the form of an emergency locator transmitter (ELT) and an underwater acoustic beacon.

Modernized TADS/PNVS (M-TADS)

Despite the various upgrades within the AH-64D, the original TADS and PNVS sensors from the AH-64A had remained unchanged. In 2005, the Army began re-fitting the AH-64D fleet with the "Modernized TADS/PNVS" system, or simply "M-TADS". The M-TADS upgrade featured next generation FLIR cameras for the nose-mounted TADS and PNVS sensors, and an expanded PNVS turret housing with an additional sensor aperture for future growth. The new FLIR sensors produced video with higher resolution and fidelity, allowing crews to detect and classify targets at greater ranges and see more detail of their surroundings during operations at night.

In addition, the M-TADS included upgraded digital tracking logic with a multi-target tracking capability and an automated boresighting process. The existing Optical Relay Tube (ORT) assembly in the Copilot/Gunner crewstation was replaced with the TADS Electronic Display And Control (TEDAC) assembly, which featured a larger video screen with better resolution.

Survivability Improvements

In the same year that the M-TADS was making its way to the U.S. Army fleet, a new missile warning and defense system was also being fielded. The AN/AAR-57 Common Missile Warning System (CMWS) was intended to improve the AH-64D's defense against infrared (IR)-guided missile threats. The modifications included a missile warning system to notify the crew of potential missile threats within the vicinity and two flare dispensers mounted to the tail boom. The flare dispensers allowed the crew to eject flares to decoy heat-seeking missiles away from the aircraft. The CMWS electronics could also be enabled to automatically dispense flares without crew interaction, if desired.

In 2006, the U.S. Army began modifying AH-64D engine nacelles with a new exhaust cowling and nozzle. These revised nozzles redirected the engine exhaust upward into the rotor system to dissipate the engine exhaust and reduce the effectiveness of IR-guided missiles.

AH-64D departing FOB Tarin Kowt, Afghanistan (US Army photo by SSG Tracy Hohman)

Proliferation and Export

Since August 1997, Boeing (which had acquired McDonnell-Douglas) has produced AH-64Ds domestically for the United States and for foreign partners. Partnered with Boeing, AgustaWestland produced AH-64Ds (designated AH Mk1) for the United Kingdom's Army Air Corps, and Fuji Heavy Industries produced AH-64Ds (designated AH-64DJP) for the Japanese Ground Self Defense Force.

Along with the U.S., U.K., and Japan, the AH-64D is also operated by the militaries of the Netherlands, Greece, Israel, Egypt, Kuwait, Saudi Arabia, United Arab Emirates, and Singapore.

UK Army Air Corps AH Mk1 (UK MoD)

RNLAF AH-64Ds in Afghanistan (RNLAF)

In addition to newly manufactured AH-64Ds, the U.S. Army awarded McDonnell-Douglas a $1.9 billion contract to upgrade existing A models to D models. Starting in August of 1997, Boeing (which had acquired McDonnel-Douglas in 1997) has since upgraded all U.S. Army AH-64A's to D models. In all, 2,400 AH-64's have been produced since 1983; over a thousand of them as AH-64Ds.

AIRCRAFT OVERVIEW

The AH-64D is a two-person day/night attack helicopter initially developed by McDonnell Douglas for the U.S. Army. The helicopter was originally designed by Hughes for the anti-tank role, employing the AGM-114 Hellfire missile as its primary weapon. Its design incorporates significant survivability and systems redundancy after lessons learned in the Vietnam war. The AH-64D provides the U.S Army (and other militaries) with one of the most maneuverable, survivable, and heavily armed rotary-winged aircraft on the modern battlefield.

DCS: AH-64D features a U.S. Army AH-64D Block 2 in service between the years of 2005-2010. The DCS: AH-64D simulates Lot 9.1 avionics, which was fielded in 2005, along with additional equipment that was fielded to the U.S Army fleet between 2005 and 2007, such as the Modernized TADS (M-TADS), Common Missile Warning System (CMWS), and revised engine nozzle assemblies.

Cockpit

The AH-64D uses a tandem cockpit layout, with the Pilot (PLT) in the aft cockpit and the Copilot/Gunner (CPG) in the forward cockpit. Identical flight controls are present in both cockpits, and each can employ any of the AH-64's weapon systems, but the Pilot lacks several targeting and weapon employment controls that are only present in the CPG cockpit.

Both cockpits are protected with ballistic armor, and an additional ballistic shield separates the two cockpits. Each crewmember sits within

an armored seat that is mounted on compressible pistons that stroke downward during high-speed vertical impacts. Coupled with the stroking action of the landing gear, this system is designed to attenuate the impact forces translated to the crewmembers' spines, resulting in higher survival rates during crash sequences.

Both cockpit canopies consist of two heated glass windshields, four acrylic side panels, and a fifth acrylic panel over the Pilot's crewstation. The canopy doors open upward and to the side for ingress and egress, and manually latched for flight. Improper latching is detected and annunciated by the onboard avionics.

For emergency egress, both cockpits include a canopy jettison system. Jettison handles are installed for the Pilot and CPG, as well as an exterior jettison handle for rescue personnel. The jettison system consists of a detonating cord that ejects the four acrylic side panels for crew egress.

Fuselage

The AH-64D fuselage is armored in strategic locations, with 2,500 pounds of ballistic shielding designed to sustain hits from projectiles up to 23mm in caliber. The aft fuselage includes three integral fire/overheat detectors: one adjacent the main transmission, and one on each firewall louver door (where transmission oil is cooled). The indication of a fire in these areas will trigger a visual and audio warning to the crew.

Critical system relays and wiring are installed in opposing areas, permitting redundancy within the avionics in the case of computer failure or damage. Each processor group is composed of two individual computers: one primary and one backup. If the primary processor fails or is damaged from weapons fire, the backup processor immediately takes over the required computing tasks.

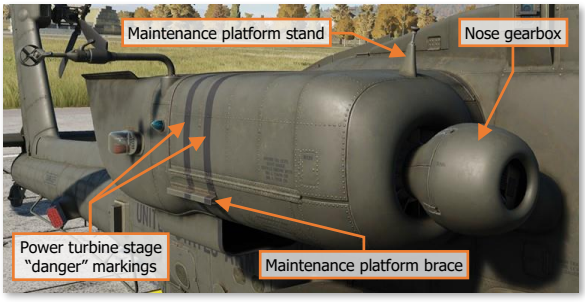
Fire Protection System

Engine fire detection is provided by two optical flame detectors in each engine compartment, and two in the APU compartment. Two fire bottles, a primary and a reserve, contain halon fire suppressant. If a fire is detected in either engine compartment or the APU compartment, a voice warning message will announce to the crew the location of the fire, along with fire warning lights on the instrument panel. These warning lights will illuminate which buttons the crew must press to discharge the fire suppressant in an attempt to extinguish the fire.

An additional fire detection circuit is installed into the aft deck area behind the main transmission, near the accessory gearbox and between the two engines. This fire detection circuit will generate a voice warning message and an AFT DECK FIRE warning on the EUFD, but there is no fire suppression capability in this area.

Engines

The AH-64D is powered by two General Electric T700-GE-701C turboshaft engines, each generating up to 1,940 shaft horsepower. The engine output shafts are coupled with frontal-mounted nose gearboxes and regulated by a Digital Electronic Control (DEC) and integral Hydro-Mechanical Units (HMU). Each engine is assembled in a modular layout, consisting of a cold section, hot section, power turbine section, and accessory section.



The cold section consists of an inlet particle separator for dust and sand protection, a six-stage compressor, variable inlet guide vanes (IGVs), and variable stator vanes. The DEC is mounted to underside of the cold section.

The hot section consists of the annular combustor, nozzle assembly and gas generator turbine stages. The gas generator is connected to the cold section's compressor through a central shaft, which rotates the compressor stage to produce self-sustaining engine power.

The power turbine section consists of two free turbine stages and the exhaust frame. The power turbine shaft rotates within the gas generator compressor shaft and runs the full length of the engine to the front-mounted nose gearbox. The engine turbine gas temperature (TGT) thermocouples are mounted to this stage, just aft of the gas generator stages, along with the engine speed and torque sensors that provide cockpit indications of N_P and TQ respectfully.

The accessory section includes the HMU, N_G speed sensor, fuel boost pump, oil system, and the Air Turbine Starter. Each engine's nose-mounted reduction gearbox powers the main transmission through an over-running "sprag" clutch that will disengage the engine from the main transmission if the drive train system is operating at a higher RPM than the engine's power turbine.

Digital Electronic Control and Hydro-Mechanical Unit

The DEC and HMU work together to manage each engine, managing fuel flow based on the position of the power levers and collective handles. The power lever position is mechanically transmitted to the HMU via a Power Available Spindle (PAS), and the collective position mechanically via a Load Demand Spindle (LDS). During normal operation, the HMU controls fuel flow to the combustor according to the PAS and LDS. The HMU also schedules the inlet guide vanes, controls the anti-ice and start bleed valve, and regulates discharge air pressure and N_G (gas generator RPM). The HMU includes an automatic N_G overspeed cut-off that will flame out the engine to prevent an engine overspeed.

The DEC coordinates automatic torque load-sharing between the two engines, monitors N_P (power turbine RPM), and limits turbine gas temperature (TGT). Like the HMU's automatic N_G overspeed cut-off, the DEC has an automatic N_P overspeed cut-off. The DEC is normally powered by the engine's alternator but can use aircraft power as a backup. The DEC for each engine can be disabled by momentarily placing the engine's power lever into the "lock-out" position.

The DEC has a contingency power feature that automatically activates during single-engine operations. If an engine fails, the DEC of the opposite engine automatically increases the TGT limiter of the remaining engine to a higher value, permitting an increase in operating temperature at the expense of engine life.

Starter System

The starter system consists of a pneumatic starter valve, an ignition system with two igniter plugs, and the DEC. Pneumatic pressure for engine start can be supplied by the Auxiliary Power Unit (APU), Aircraft Ground Power Unit (AGPU), or a running engine (cross-bleed start).

During engine start, the DEC will monitor engine parameters and automatically abort the start if an imminent hot start is detected.

Auxiliary Power Unit (APU)

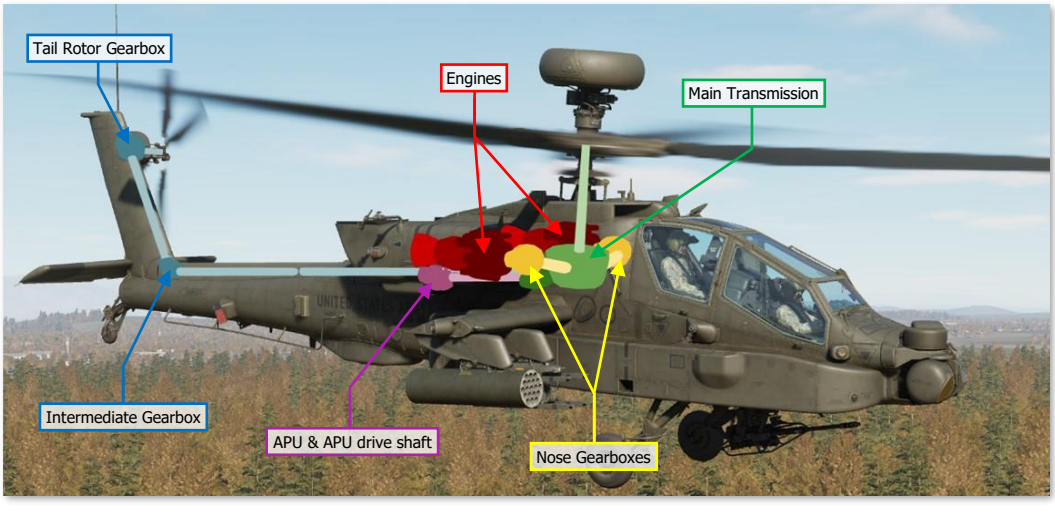
The GTCP36-155 APU, manufactured by Allied Signal/Garret, is a self-contained gas turbine engine that drives the accessory section of the main transmission to generate electrical and hydraulic power without operating the main engines or rotating the rotor blades. The APU can generate pressurized air, which is primarily used to start the main engines without requiring external ground power sources.

The APU draws fuel from the aft fuel cell only and consumes approximately 175 pounds per hour when operating.

The APU is automatically monitored by an Electronic Control Unit (ECU), which detects overspeed and overcurrent anomalies, as well as abnormal oil pressure. The ECU will automatically shut down the APU when an anomaly is detected. The ECU also controls the power takeoff (PTO) clutch engagement to the accessory section of the main transmission.

Drive Train

The main rotor drive system consists of the main rotor drive shaft, main rotor transmission, three-stage reduction gearing, and dual independent integral oil systems. The main transmission receives power from two nose gearbox inputs, one mounted on each turboshaft engine. The main transmission is used to drive the main rotor.



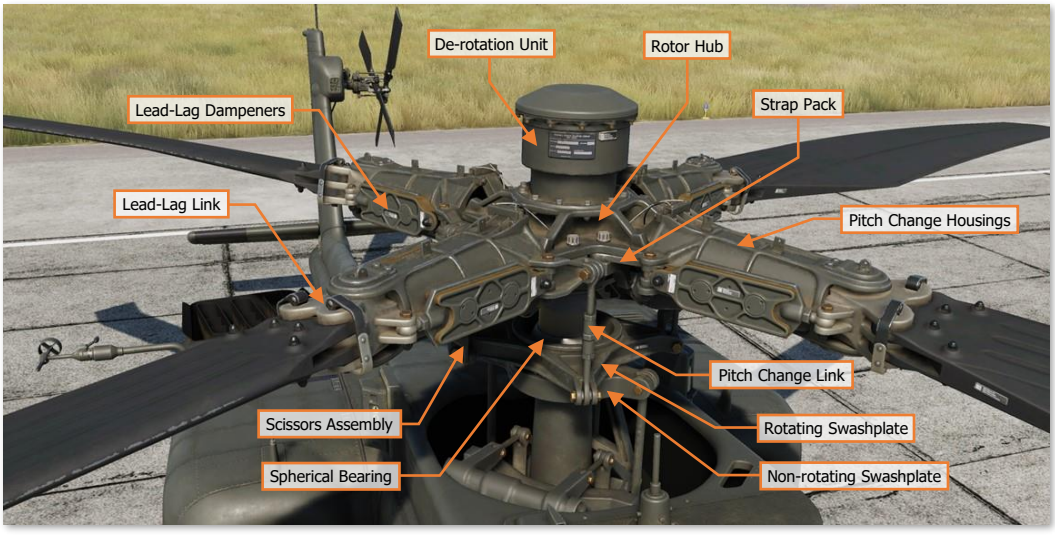
An accessory gearbox is mounted to the aft side of the main transmission. This gearbox provides mechanical power to the aircraft's two electrical AC generators and two hydraulic pumps, one for the Primary hydraulic system and the other for the Utility hydraulic system. This prevents the loss of generator and hydraulic power during an autorotation when both engines have failed. The APU powers the transmission's accessory gearbox via the APU drive shaft, which provides full electrical power to the aircraft avionics and hydraulic power to the flight controls prior to starting the main engines. The accessory gearbox also includes the rotor brake and the main rotor RPM (N_R) sensor.

The tail rotor drive system consists of the tail rotor drive shaft, intermediate gearbox, and tail rotor gearbox. The tail rotor drive shaft consists of four sections within the tail boom. The sections are connected with flexible couplings and mounted with hanger bearings to accommodate aerodynamic and maneuvering loads from the tail boom. The intermediate gearbox is at the base of the vertical stabilizer, and the tail rotor gearbox is at the base of the tail rotor static mast. Both gearboxes reduce the transmission RPM and change the angle of the drive.

The main and tail rotor drive shafts are designed to carry torque loads only. Each of these shafts pass through and rotate within a static mast. The main rotor static mast carries all vertical and bending loads, and the tail rotor static mast absorbs all tail rotor loads. This allows the aircraft to perform aggressive or aerobatic maneuvers while minimizing stresses to the drive train system.

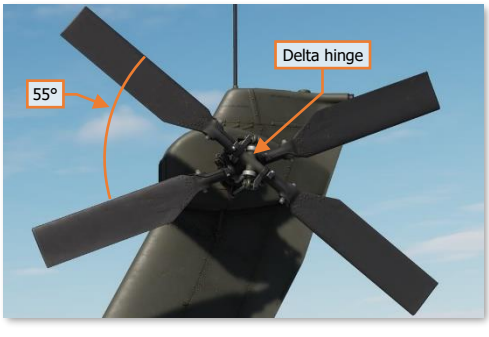
Rotors

The AH-64D has a four-blade main rotor for lift and propulsion, and a four-blade tail rotor for anti-torque and directional control.



The main rotor is fully articulated, with each blade able to flap, feather, lead, and lag independently. Mechanical droop stops under each Pitch Change Housing limits blade droop.

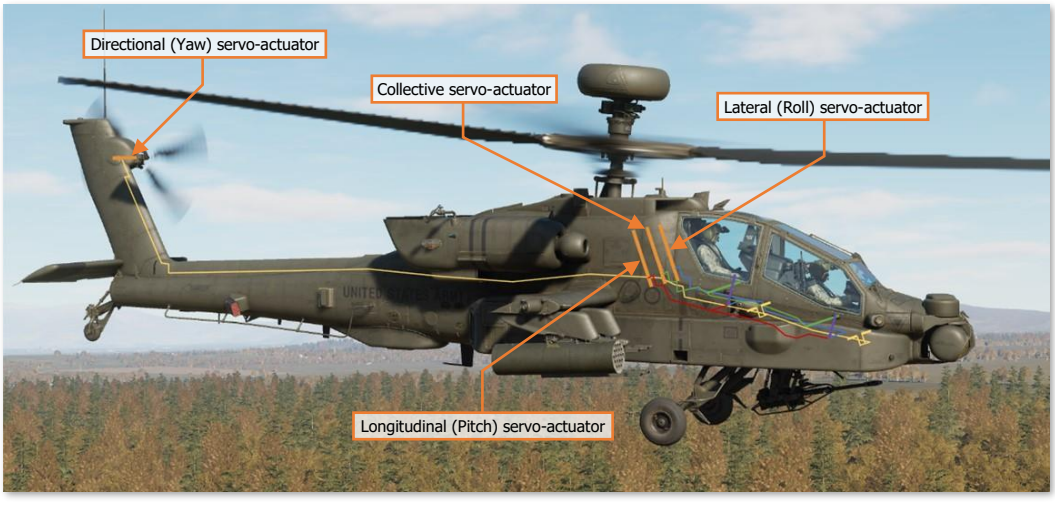
The four-blade tail rotor is semi-rigid of a teetering design. Each opposing pair of rotor blades are offset at 55° for ease of maintenance and to increase tail rotor efficiency. Flapping and feathering of the tail rotor to counter dissymmetry of lift in forward flight is facilitated by the use of a delta hinge installed to each pair of tail rotor blades.



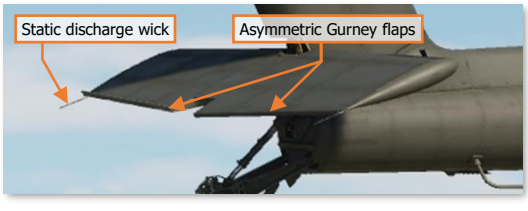
Flight Controls

AH-64D flight controls are hydromechanical, consisting of mechanical linkages between the flight controls and control surfaces, augmented by transmission-driven hydraulic power. The flight controls are conventional and consist of a cyclic stick, collective lever, and anti-torque pedals.

The cyclic is mechanically connected to the swashplate on the rotor mast that tilts the main rotor for attitude control using cyclic feathering of the rotor blades. The collective is mechanically connected to the swashplate and each engine's Load Demand Spindle (LDS) and directly controls lift by collectively feathering all rotor blades at once. The anti-torque pedals feather the tail rotor blades for anti-torque and directional control.



Hydraulic augmentation is provided by the Stability and Command Augmentation System (SCAS), which consists of electro-hydraulic actuators commanded by the Flight Management Computer (FMC). The FMC provides rate damping and enhanced aircraft stability for accurate weapons employment; and command augmentation for immediate, smooth, and consistent control feel across the full range of helicopter airspeeds. The FMC also provides attitude and altitude hold capability for limited hands-off flying.



The AH-64D has an articulating horizontal stabilator controlled by an electric actuator. The horizontal stabilator improves pitch control and improves over-the-nose visibility at low airspeeds. In automatic mode, the FMC schedules the horizontal stabilator position according to collective position and airspeed. In nap-of-the-earth/approach mode (NOE/A), the horizontal stabilator is driven to the 25° trailing edge down position when below 80 knots, to further improve over-the-nose visibility. In manual mode, either crewmember may control the stabilator position with a switch on the collective.

To ease pilot workload, a force trim system is provided for the cyclic and pedals. The force trim system consists of lateral, longitudinal, and directional force trim springs and magnetic solenoids that engage and disengage the force trim. A button on the cyclic disengages the force trim springs, allowing the cyclic and anti-torque pedals to move freely without resistance. When re-engaged, the force trim springs hold the cyclic and pedals in their current position and provide an increasing force gradient as the cyclic and/or pedals are deflected away from this reference position.

Back-Up Control System (BUCS)

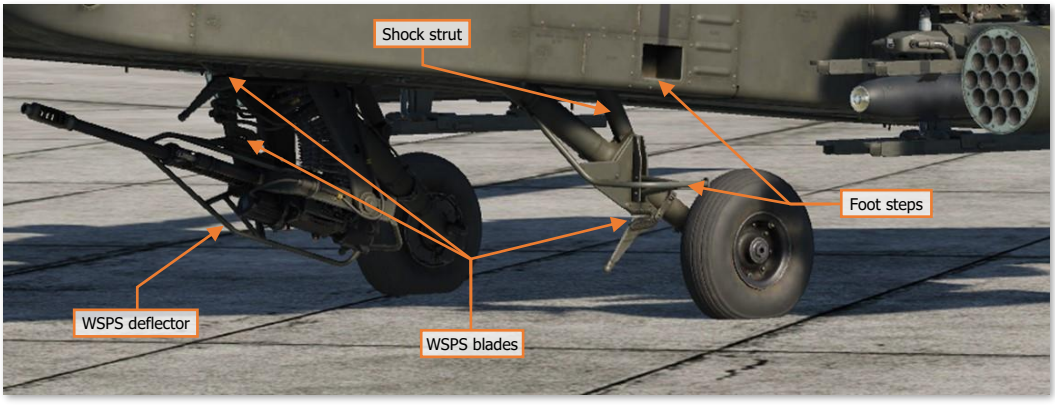
Normally, the Pilot and CPG flight controls are mechanically linked. The mechanical linkages are protected by shear pins and mis-track sensors to prevent a control jam or severance from affecting both sets of flight controls.

If the flight controls are decoupled by the shear pin, or a mis-track is otherwise sensed, the Back-Up Control System is automatically activated. The BUCS is a single-channel, four-axis, non-redundant electric fly-by-wire (FBW) system. The FBW system is designed to replicate the feel of the hydromechanical controls but does not replicate SCAS functionality.

BUCS can only be active for the Pilot or the CPG station. Either the Pilot or the CPG can transfer BUCS control to their station if necessary, depending on the nature and location of the jam or severance within the flight controls.

Landing Gear

The AH-64D has two trailing-link, main landing gear wheels and a lockable, free-castoring tailwheel. The main landing gear consists of two single wheels with integral disc brakes, mounted on separate nitrogen-oil shock struts.



Each anti-torque pedal is connected to a hydraulic disc brake on the corresponding main landing gear wheel. Each brake is connected to its own master cylinder, which provides hydraulic pressure to the braking system. The Pilot and CPG anti-torque pedals, when pressed downwards, actuate the hydraulic brake system for the corresponding wheel. A parking brake valve maintains brake pressure when closed.

The tailwheel is free-castoring in a full 360° of rotation. A spring-loaded tailwheel lock can be hydraulically actuated to hold the tailwheel in its forward position. The tailwheel lock is activated from the Collective Flight Grips or the tail wheel lock pushbuttons.

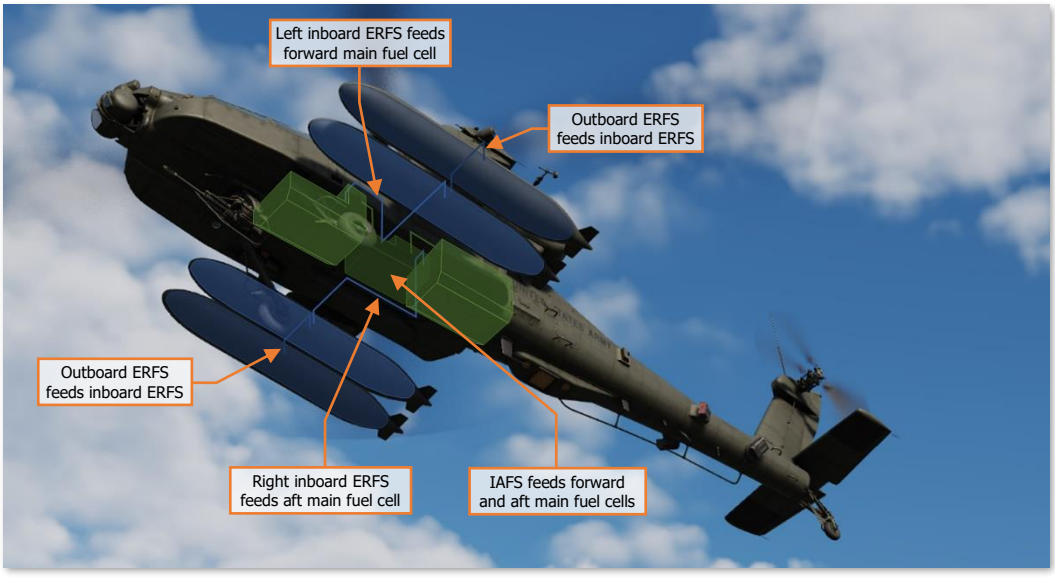
Both main landing gear shock struts have a one-time capability to absorb loads from a high-stress impact. Shear rings and rupture discs on each strut, when activated by a hard landing, start a controlled collapse of the strut to reduce crash loads on the airframe.

Fuel System

The AH-64D includes two internal self-sealing, crash-resistant fuel cells. The forward fuel cell holds up to 156 gallons, and the aft fuel cell holds up to 220 gallons. Fuel is normally balanced between the two cells automatically by the avionics.

A 230-gallon ERFS external fuel tank can be mounted on each of the four stub wing pylons. The external fuel tank mounted under the left inboard pylon feeds the forward fuel cell, and the external fuel tank mounted under the right inboard pylon feeds the aft fuel cell. If an additional two fuel tanks are mounted under the outboard pylons, the outboard external fuel tanks feed fuel to each respective inboard external fuel tank.

An Internal Auxiliary Fuel System (IAFS) may be installed into the ammunition bay, storing 100 gallons at the expense of reducing the 1200 round ammunition capacity to 300 rounds.



Fuel Transfer Sub-system

Fuel is transferred between the forward and aft cells using pneumatic pressure. Transfer is normally automatic but can be manually controlled by the aircrew.

Fuel transfer from the IAFS or external tanks is one-way only. Transfer from the external tanks to the internal cells is pneumatic, and an electric fuel pump transfers fuel from the IAFS to the internal cells. If fuel is being transferred between the forward and aft fuel cells, any fuel transfer from external or internal auxiliary fuel systems will be paused.

Normally, the forward cell feeds engine 1 and the aft cell feeds engine 2. However, if necessary during abnormal circumstances, the aircrew can manually select different crossfeed modes where both engines feed from one fuel cell.

An electric boost pump is used to provide motive flow from the aft cell during engine start. This boost pump can also be manually selected on during an emergency or operations in extreme cold temperatures. The APU has its own electric boost pump that also draws from the aft cell.

Nitrogen Inerting Unit (NIU)

The fuel cells are inerted using nitrogen to reduce the risk of fire. The NIU is completely self-contained and automatic. It uses aircraft power and pressurized air and generates an inerted mix containing around 99% nitrogen. This inerted gas is used to pressurize the internal cells, to include the IAFS during fuel transfer, if the IAFS is installed.

Electrical System

Electrical aircraft power is managed by the Electrical Power Management System (EPMS). The EPMS is a fully redundant and automatic power system consisting of a distributor for battery, AC, and DC power.

The battery is a 24-volt, 15-amp fiber nickel-cadmium (FNC) design. It can provide power for normal flight loads for up to 12 minutes, assuming at least an 80% charge.

AC power is provided by two brushless, air-cooled generators. Each generator outputs 45 kVA three-phase four-wire power at 115 or 200 volts and 400 Hz. Each generator has its own Generator Control Unit (GCU). A single generator is capable of handling full flight loads without shedding. The generators are mounted to the transmission accessory gearbox, which is powered by the main transmission while at flight RPMs or the APU during ground operations.

DC power is provided by two Transformer-Rectifier Units (TRUs), each providing 28 volts and 350 amps of DC power. Like the generators, a single TRU can provide sufficient power for full flight loads without shedding.

Power is distributed by four AC busses, four DC busses, four battery busses, and a battery hot bus. Each bus and power consumer is protected by a resettable circuit breaker.

An external power receptacle can provide DC and AC power for all systems from an Auxiliary Ground Power Unit (AGPU).

Hydraulic System

The AH-64D has two independent hydraulic systems, labeled Primary and Utility. The Primary system exclusively powers the hydraulic flight control system via the FMC and mechanical flight control linkages. It's powered by the main transmission and has a total capacity of six pints with a one-pint reservoir.

The Utility system is a secondary source of hydraulic power for the flight controls (bypassing the FMC), and powers all other hydraulic systems: rotor brake, Area Weapon System turret drive, ammunition handling system, APU start motor, tailwheel unlock actuator, and external weapon pylon elevation actuators. Because of the higher loads placed on the utility system, it has a higher-volume manifold and larger reservoir.

The utility system also charges a 3,000-psi hydraulic accumulator. The hydraulic accumulator is used to provide hydraulic damping during gun fire, hydraulic power to the APU starter, and can be used to temporarily power the flight controls via the utility system in an emergency.

Both hydraulic systems are pressurized by a corresponding hydraulic pump powered by the transmission accessory gearbox, which is powered by the main transmission while at flight RPMs or the APU during ground operations.

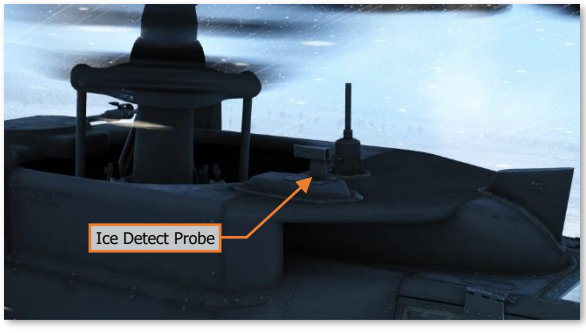
Integrated Pressurized Air System (IPAS)

The IPAS provides pressurized air to aircraft pneumatic systems from engine bleed air. Bleed air is drawn from two ports on each engine: a high-pressure port is exclusively used by each hydraulic pump, and a low-pressure port is used by all other consumers. Low-pressure air is used by the engine air turbine starters, fuel boost and transfer pumps, anti-ice system, ice detection probe, nitrogen inerting unit, vapor cycle cooling system, and environmental control system.

IPAS bleed air can be provided by one or both engines, the APU, or an external source such as an AGPU.

Anti-Ice System

Ice detection is provided by an aspirating ice detect probe, powered by pneumatic air from the IPAS. The ice detect probe activates whenever free air temperature drops to 5° C or below. When the anti-ice system is in AUTO mode, detection of ice will automatically command activation of all anti-ice systems.



Ice protection is provided by engine inlet anti-ice from main engine bleed air, electrical heat to the pitot and air data system (ADS) sensors, electric sensor aperture anti-ice, and electrically heated canopies.

The canopies also include crewmember-controllable windshield wipers and a defog system powered by the IPAS.

Environmental Control System (ECS)

The ECS provides avionics cooling via ventilation fans that force conditioned cooling air into each of the four avionics bays. The ECS also provides crewmember comfort through ventilation, heating, and air conditioning. Cockpit environmental control is provided via four gaspers installed in each crewstation, two over each shoulder and another two mounted within the forward instrument panels.

Cockpit heating is provided by regulated bleed air from the IPAS.

Air conditioning is provided from two independent vapor cycle cooling systems. One system provides cooled air for the Pilot and aft sections of each Extended Forward Avionics Bay (EFAB); the other system provides cooled air for the CPG, the TADS and PNVS turrets, and the forward sections of each EFAB. A digital control unit (DCU) manages the flow of cooled air for each system.

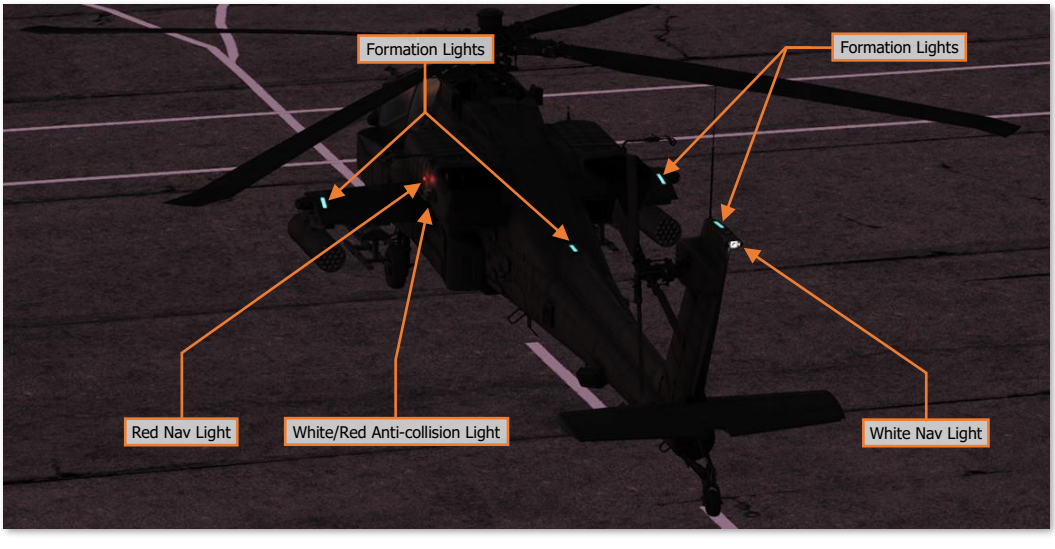
In the event of a failure of one of the ECS systems, the DCU of the functioning system will automatically open an interconnect valve between the two cockpits. The ventilation fans in the failed cockpit will stop, and the functional cockpit's ventilation fans will force cooled air into both cockpits.

Lighting System

The AH-64D's interior lighting consists of primary instrument lighting and secondary floodlights. The primary lighting provides backlighting for all panels within the cockpit, such as switch labels, display bezels, and the keypad. The floodlights are used to illuminate the main instrument panel and side consoles of each cockpit.

Each crewmember also has a dimmable utility light that can be aimed around the cockpit like a flashlight. The standby instruments in the Pilot cockpit have their own independent lighting and, along with the utility light and NVG-compatible floodlights, are powered by the battery in the event of a dual generator failure.

Exterior lighting consists of formation lights, navigation lights, anti-collision lights, and a steerable search and landing light. The landing light is powered by the battery in the event of a dual generator failure.



Avionics

AH-64D avionics subsystems communicate across four redundant multiplex (MUX) bus channels at 1 Mbps. Each bus channel consists of a primary and secondary bus. Channel 1 is used for controls and displays, communications and transponder equipment, and aircraft systems. Channel 2 is used by the Aircraft Survivability Equipment (ASE), Data Transfer Unit (DTU), flight controls, and navigation systems. Channel 3 is used by the sighting, sensors, and weapons systems. Channel 4 is used exclusively by the Fire Control Radar (FCR) and Radar Frequency Interferometer (RFI).

Avionics systems are controlled in both cockpits by Multi-Purpose Displays (MPDs), two per cockpit. Each MPD has six variable-action buttons (VAB) per side. The buttons of the top row are labeled (left to right) T1–T6, the bottom row B1–B6, and the left and right columns are labeled (top to bottom) L1–L6 and R1–R6, respectively. Button B1, labeled "M", returns the crewmember to the MPD Menu page. Each MPD also includes six fixed-action buttons (FAB) that allow immediate access to the FCR, WPN, TSD, A/C, COM and VID pages; and a "favorites" button that allows quick access of up to three frequently used MPD pages.

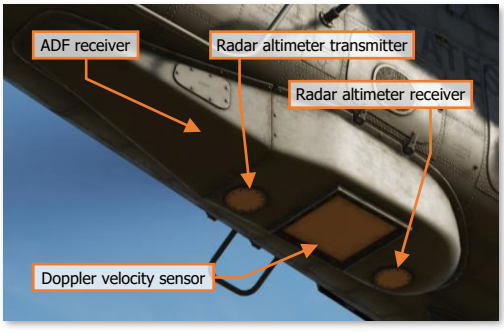
With external power connected and both throttles in the OFF position, the MPDs will enter a "screen saver" mode after five minutes of inactivity. Pressing any MPD button will re-activate all MPDs.

Unlike most other aircraft, the AH-64D's primary flight information is presented to the crewmembers through a helmet-mounted display, in lieu of dedicated instruments or displays on the instrument panel. This not only frees up the MPDs to display mission-, sensor-, or weapons-related data, it also ensures the crewmembers can monitor the flight state of the aircraft while keeping their focus "heads out" of the cockpit, regardless of the direction they may be looking.

Navigation System

The AH-64D's navigation system consists of two Embedded GPS Inertial Navigation Systems (EGI), the Doppler Radar Velocity Sensor (DRVS), radar altimeter, automatic direction finder (ADF), Helicopter Air Data System (HADS), and Flight Management Computer (FMC).

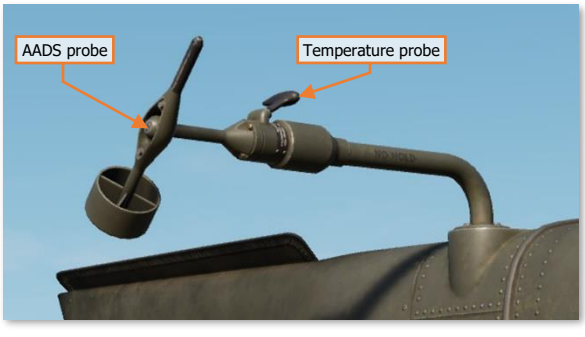
Each EGI consists of a five-channel encrypted GPS receiver that provides position updates to a ring laser gyro (RLG) inertial navigation unit (INU). The two EGIs are labeled INU1 and INU2, and the navigation system will automatically select between each as either primary or backup.



In addition, the AH-64D uses the AN/ASN-157 Doppler Radar Velocity Sensor (DRVS) as a velocity-aiding source for the EGI. The DRVS uses Doppler radar measurements to determine aircraft ground speed and direction.

The AN/APN-209 Radar Altimeter provides height above ground level (AGL) to the navigation system. The APN-209 uses a downward-facing radar transmitter and a separate receiver antenna to determine AGL altitude.

The AN/ARN-149 Automatic Direction Finder (ADF) provides audio and radio direction-finding capability for transmissions between 100 and 2199.5 kHz.



The Air Data System (ADS) consists of two independent air data subsystems: the Flight Management Computer (FMC) and the Helicopter Air Data System (HADS). The HADS is comprised of the High Integrated Air Data Computer (HIADC) and two Airspeed And Direction Sensor (AADS) probes mounted to the engine nacelles. The AADS probes sense airspeed magnitude, direction, and free airstream temperature. The HIADC uses this data, along with ambient and pitot pressure sensors, to compute air mass related data.

The FMC uses static and dynamic air pressures measured from the static ports and pitot tubes to compute pressure altitude, air speed, and density altitude related information. The FMC receives longitudinal and lateral true air speeds, static temperature, and non-filtered true air speeds from the HIADC.

Communications System

The communications system includes an intercom for crewmember communication, an ARC-186(V) VHF-AM radio, an ARC-164(V) UHF-AM radio, two ARC-201D VHF-FM radios, and an ARC-220 HF radio.

The VHF radio can receive between 108.000 and 115.975 MHz and transmit/receive between 116.000 and 151.975 MHz. The VHF radio includes no frequency-hopping or encryption capability.

The UHF can transmit and receive between 225.000 and 399.975 MHz; and includes a separate GUARD receiver tuned to 243.000 MHz. The radio is capable of HAVE QUICK and HAVE QUICK II frequency-hopping as an electronic counter-countermeasures (ECCM) capability. A KY-58 is installed which facilitates voice and data encryption for the UHF radio.

The two FM radios can transmit and receive between 30.000 and 87.975 MHz. The radios support SINCGARS combat nets for frequency-hopping and include internal encryption for secure voice and data. The FM1 radio can be augmented by an improved FM amplifier capable of providing up to 40 watts of transmit power for extending the transmission range of the radio.

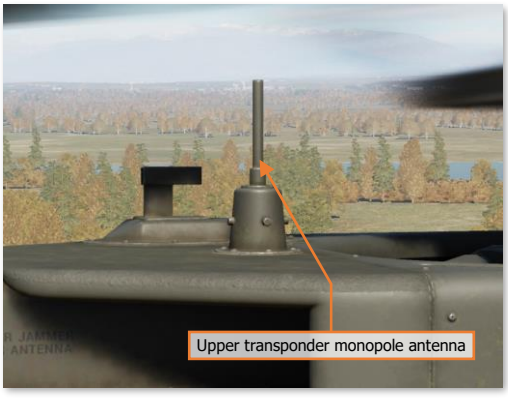
The HF radio can transmit and receive between 2.0000 and 29.9999 MHz and utilizes a KY-100 for voice and data encryption.

The AH-64D includes an MD-1295A modem that can transmit and receive AFAPD (Air Force Applications Program Development) messages over any radio except the ARC-220 HF radio, which has its own internal modem.

All radios are connected to the battery bus and can be utilized without generator power, but are limited to single-channel radio frequencies that have been pre-loaded into the avionics.

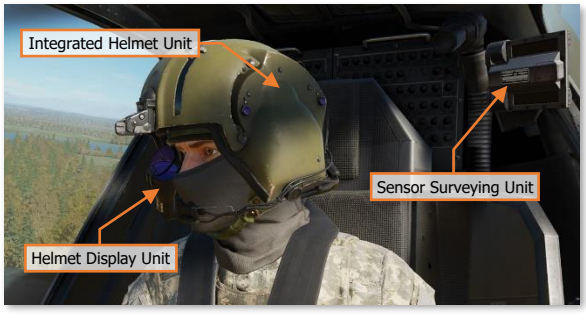
Identification System

The AH-64D includes an APX-118(V) transponder, capable of responding to interrogations in Mode 1, Mode 2, Mode 3/A, and Mode C formats. The APX-118(V) can also reply to encrypted Mode 4 interrogations.



Sensor and Sighting Systems

The primary sensor and sighting system for the AH-64 is the Integrated Helmet And Display Sighting System (IHADSS). The IHADSS consists of the Helmet Display Unit (HDU), a small, collimated display placed in front of the crewmember's right eye (on a rotatable arm); the Integrated Helmet Unit (IHU) and Sensor Surveying Units (SSU), a series of sensors in the cockpit that determine crewmember head position and line-of-sight; the Boresight Reticle Units (BRU), which establishes sensor boresight; and avionics systems that can slave sensor and weapon systems to the IHADSS line of sight.

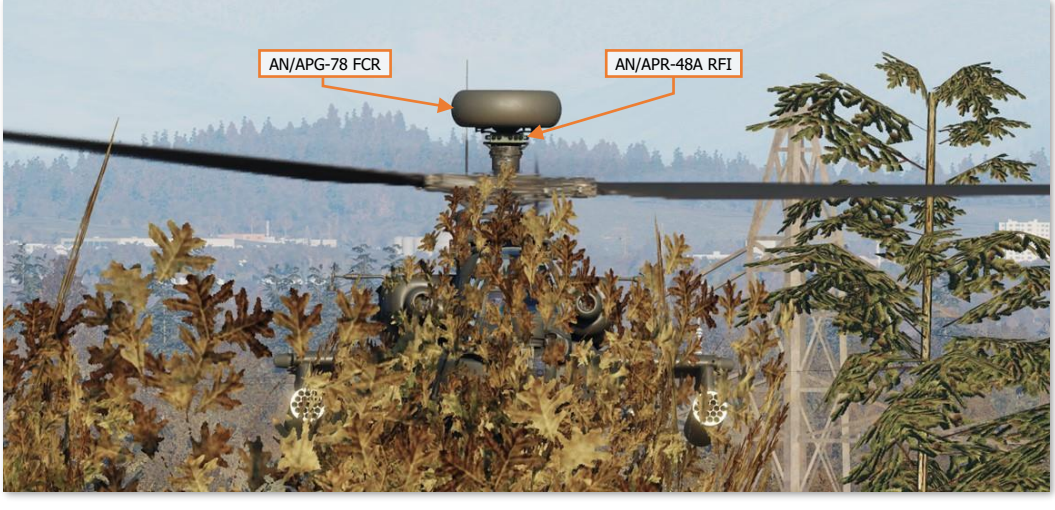


The IHADSS displays sensor, targeting, and aircraft information in the crewmember's line-of-sight, helping the crewmembers to locate and track targets and maintain situational awareness. The HDU symbology format changes depending on the display mode selected by the crew. The display is also capable of overlaying video from the PNVS or TADS sensors, augmenting the crewmembers' view of terrain, obstacles, and targets at night or inclement weather.

FLIR video for the Pilot comes from the AN/AAQ-11 Pilot Night Vision System (PNVS), which provides day- and night-capable infrared video.

The AN/ASQ-170 Target Acquisition Designation Sight (TADS) is an integrated target acquisition and tracking system for the AH-64D's Copilot/Gunner. It consists of both FLIR and Day TV (DTV) video systems, a laser rangefinder/designator (LRF/D), and a laser spot tracker (LST). This gives the CPG the ability to locate, track, and laser designate targets day and night, and in inclement weather conditions.

Unique to the D model AH-64 is the AN/APG-78 Fire Control Radar (FCR) and AN/APR-48A Radar Frequency Interferometer (RFI). The APG-78 is a millimeter-wave radar with the capability to detect and classify up to 256 air or ground targets. The radar is mounted atop the main rotor mast, allowing the helicopter to remain masked while scanning for targets. It has a scan capability of ±45° in azimuth and ±25° in elevation, but can be rotated ±90° in azimuth to scan a sector to either side in air-to-ground mode, or a full 360° in air-to-air mode.



Along with the IHADSS and TADS, the FCR can be used as a source of targeting data for the 30mm Area Weapon System, 2.75-inch unguided rockets, and AGM-114 Hellfire anti-tank missiles.

WEAPONS & MUNITIONS

The AH-64D was designed primarily to employ the Hellfire Modular Missile System (HMMS), along with its Area Weapon System and Aerial Rocket Subsystem. It has four hardpoints, two mounted to each stub wing. Each hardpoint is capable of articulating between +4° to -15° in elevation.

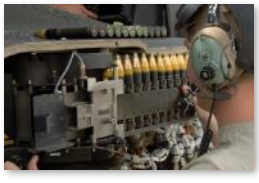
M139 Area Weapon System (AWS)

The Area Weapon System (AWS) consists of an M230 30mm automatic chain-driven gun mounted on the underside of the helicopter between the two main landing gear, its turret, controls, and the ammunition handling system. The weapon is mounted on a hydraulically steered turret that can be slaved to the TADS line-of-sight, the IHADSS line-of-sight, or a fixed forward-firing position. The turret can steer up to ±86° in azimuth and can elevate up to +11° or depress down to -60°.

The M230 fires 30x113mm link-less, tracer-less ammunition at a rate of up to 625 rounds per minute. Ammunition is stored in a magazine in the main fuselage under the transmission and can hold up to 1200 rounds. When the Internal Auxiliary Fuel System (IAFS) is installed, magazine size is reduced to 300 rounds.

M788 Target Practice. The M788 is an inert training round used for target practice. The M788 is ballistically matched to the M789 HEDP rounds.

M789 High Explosive/Dual Purpose. The M789 is a dual-purpose tactical round used for combat operations. The round has a light armor penetrating capability as well as a bursting fragmentation effect for anti-material and anti-personnel use.



Aerial Rocket Sub-System (ARS)

The Aerial Rocket Sub-system consists of M261 lightweight rocket launchers, capable of firing 2.75-inch folding fin aerial rockets (FFARs), primarily variants of the Hydra-70 rocket family. The M261 consists of 19 individual rocket tubes, and may be loaded on all four pylons, for a maximum of 76 rockets. Each M261 rocket launcher is "zoned", allowing for carriage of up to three different rocket types with one pair of launchers mounted, or up to five rocket types with two pairs of rocket launchers mounted. Each tube includes individual firing and fusing circuits.

The Hydra-70 rocket family is typically employed with the Mk 66 motor, with many different warhead options available. Variants employed by the U.S. Army include the following:

M151 High Explosive. Also called the "10-pounder", the M151 is used against lightly armored and soft targets. The warhead may be equipped with the either M423 point-detonating (PD) fuze or the M433 resistance-capacitance (RC) programmable delay fuze.

M229 High Explosive. Also called the "17-pounder", the M229 is used as an enhanced "aerial artillery" warhead over the M151. The warhead is equipped with the M423 point-detonating (PD) fuze. Minimum range: 140 meters.

M156 White Phosphorus. The M156 "Willie Pete" rocket is used for target marking. The warhead is equipped with an M423 point-detonating fuze for ground dispersal of the warhead's effects, which generates a white smoke marking signal for approximately 2 minutes (depending on wind conditions). (N/I)

Not Implemented

M264 Red Phosphorus. The M264 is used for generating smoke-screen concealment. The warhead is equipped with an M439 variable time delay fuze, which generates a white smoke concentration across several hundred meters for approximately 5 minutes (depending on wind conditions). (N/I)

Not Implemented

M261 Multi-Purpose Sub-Munition. The MPSM contains 9 submunitions for use against lightly- to medium-armored vehicles and soft targets. The warhead is equipped with an M439 variable time delay fuze for an airburst just prior to the target. Minimum range 1,000 meters. (N/I)

Not Implemented

M255A1 Flechette. The "Flechette" contains 1,179 60-grain hardened steel flechettes for use against soft targets or personnel. The warhead is equipped with an M439 variable time delay fuze for an airburst just prior to the target. Minimum range 800 meters; effective range 1 to 3 kilometers. (N/I)

Not Implemented

M257 Illumination. The "Overt Illum" is used for battlefield illumination, and is equipped with an M442 fixed time fuze, which will deploy a parachute-equipped flare approximately 3,500 meters from its launch point. Provides illumination for approximately 3 minutes.

M278 IR Illumination. The M278 "Covert Illum" is used for covert battlefield illumination, and is equipped with an M442 fixed time fuze, which will deploy a parachute-equipped flare approximately 3,500 meters from its launch point. Provides IR illumination for night vision goggle-equipped personnel for approximately 3 minutes. (N/I)

Not Implemented

M274 Training. Also called the "blue spear", the M274 training rocket produces a brief smoke signature for target practice. An M423 point-detonating (PD) fuze is integrated into warhead casing, which detonates to provide a small, but noticeable flash and smoke signature for impact spotting. This rocket is ballistically matched to the M151 HE rocket to provide identical targeting and engagement training for aircrews.

Hellfire Modular Missile System (HMMS)

The Hellfire Modular Missile System is the primary weapon system of the AH-64D. It can employ both semi-active laser-guided (SAL) and active radar-guided (RF) variants of the AGM-114 Hellfire missile. The system consists of the M299 four-rail missile launcher, which can fire all variants of the Hellfire missile.

The Hellfire is an air-to-ground, anti-armor missile that has been expanded in capability to include other air-to-surface applications. The Hellfire is an effective standoff weapon which can be employed as a direct- or indirect-fire weapon and can be fired from behind cover or in the open. The Hellfire weighs approximately 100 lbs. and has a 20-pound high-explosive anti-tank (HEAT) warhead, which includes a tandem shaped-charge for defeating reactive armor.

Up to four Hellfires can be loaded on a single launcher, for a total of up to sixteen.

AGM-114K Laser-guided HEAT. The AGM-114K is a semi-active laser-homing variant with both Lock-On Before Launch (LOBL) and Lock-On After Launch (LOAL) capability. In LOBL mode, the Hellfire uses a nose-mounted laser seeker to lock on to a coded laser designation prior to launch. When launched in LOAL mode, the crew can select from multiple trajectories that the missile will fly using a digital autopilot system until it detects a laser designation mid-flight that matches its assigned laser code.

AGM-114L Radar-guided HEAT. The AGM-114L is an active radar-guided variant, making it a fire-and-forget weapon, and retains LOBL and LOAL capability like its laser-guided predecessor. In LOBL mode, the Hellfire uses an onboard millimeter wave (MMW) radar seeker to lock on to the target prior to launch. In LOAL mode, the Hellfire uses an inertial guidance system to fly to the target location prior to acquiring the target with its MMW radar.

Auxiliary Fuel Systems (IAFS & ERFS)

The AH-64D may be equipped with auxiliary fuel systems to increase range and combat radius, extend endurance at the objective area, or enable the AH-64D to self-deploy over long distances.

100-gallon Internal Auxiliary Fuel System (IAFS). The 100-gallon IAFS replaces the standard 1200-round ammunition magazine for the Area Weapon System. The IAFS provides 98 gallons of usable fuel and storage for up to 242 rounds of 30mm ammunition (300 rounds total). Like the main fuel tanks, the IAFS is crashworthy, self-sealing if punctured by hostile fire, and nitrogen-inerted to prevent incendiary effects.

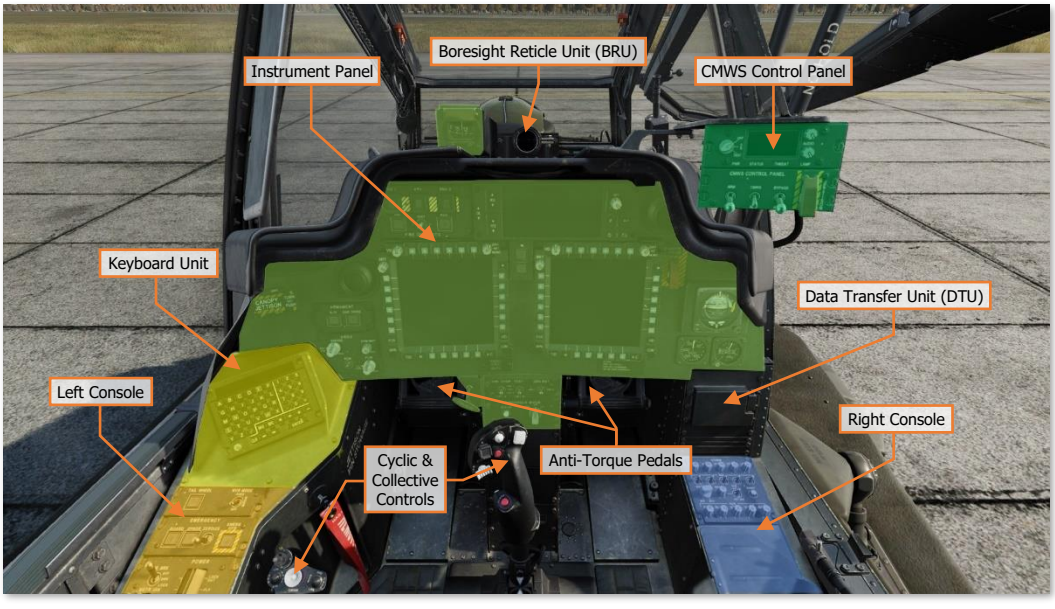
230-gallon Extended Range Fuel System (ERFS). The 230-gallon ERFS tanks can be mounted to the external wing stations. Unlike the IAFS, the ERFS tanks do not have a fuel quantity measurement system, but each ERFS tank does have a sensor to indicate when the tank itself is empty. In addition, the ERFS tanks are not crashworthy or self-sealing, and are typically only used for self-deployment. However, on occasion these tanks may be used in combat areas if absolutely necessary.

PILOT COCKPIT OVERVIEW

The Pilot's primary task is to facilitate the Copilot/Gunner's ability to operate the aircraft sensors and weapon systems. The Pilot maintains awareness of the aircrew's surroundings and the tactical situation; and maneuvers the aircraft as necessary to ensure the Copilot/Gunner (CPG) can perform unimpeded sensor scans or employ weapon systems.

The Pilot's secondary task is to maintain security of the aircraft and aircrew. As the CPG will often be focused inside the cockpit while operating the aircraft sensors, weapons, and radios, the Pilot maintains a "heads-out" focus as much as possible. The Pilot remains on the look-out within the immediate vicinity around the aircraft and is ready to employ the Area Weapon System (AWS) against close-in threats to protect the aircraft or other team members if necessary.

When equipped with the mast-mounted Fire Control Radar (FCR), the Pilot can use the FCR to assist the CPG in the targeting process by directing the CPG to specific areas within which to perform TADS sensor scans, or even hand over individual targets to the CPG for engagement. Alternatively, the Pilot can use the FCR to autonomously detect, acquire, and engage enemy targets with any of the aircraft's three weapon systems.

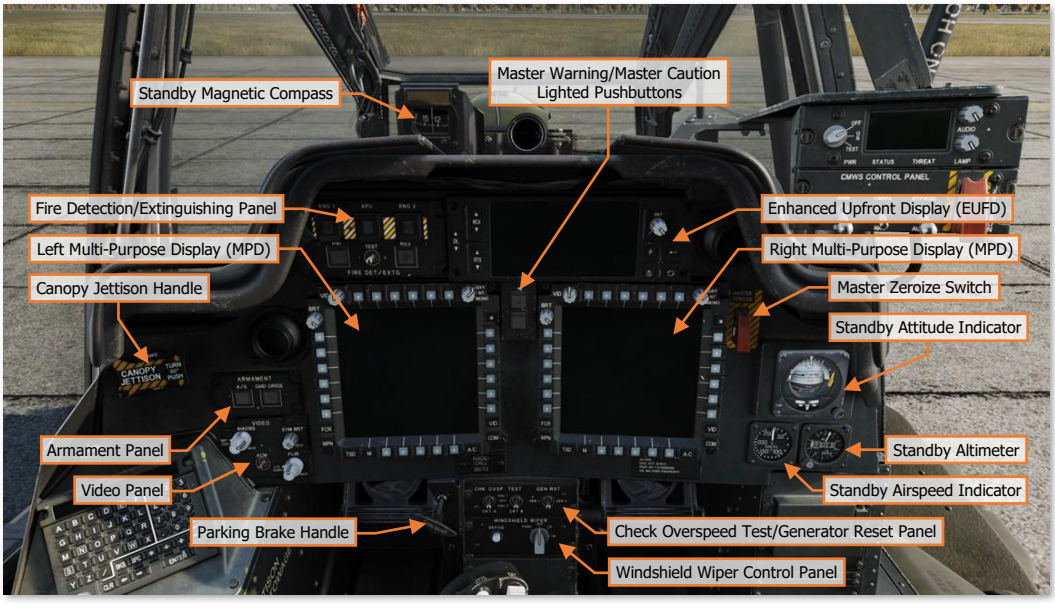


It is important to have a general understanding of where the various controls are located. To help locate items more easily, the cockpit has been delineated into five primary areas: **Instrument Panel**, the **Keyboard Unit (KU)**, **Left Console**, **Right Console,** and the **CMWS Control Panel**.

Each text box above may be selected to jump to a more detailed description of that instrument panel or console, to include the **Cyclic & Collective Controls**. Selecting the image of the instrument panel or console will return the manual back to this page.

The CMWS Control Panel is described in the Aircraft Survivability Equipment (ASE) chapter.

Instrument Panel



Each text box above may be selected to jump to a more detailed description of that instrument or panel. Selecting the image of the instrument or panel will return the manual back to this page.

The Enhanced Upfront Display (EUFD) and Multi-Function Display (MPD) are described in dedicated sections later in this chapter.

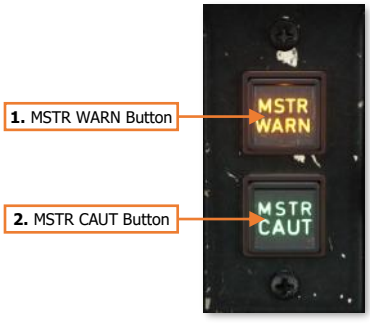
Standby Magnetic Compass

The standby magnetic compass is used by the Pilot for heading reference when there has been a failure of primary power, or the navigation system has become unreliable.

Due to magnetic variances and other inaccuracies during normal flight maneuvers, the standby magnetic compass should not be relied upon for precise heading or navigation information. The aircraft should immediately be recovered to a suitable friendly location. Visual landmarks may be used to maintain awareness of aircraft position and aid in navigation back to maintenance facilities or friendly-controlled areas.

Master Warning/Master Caution Lighted Pushbuttons

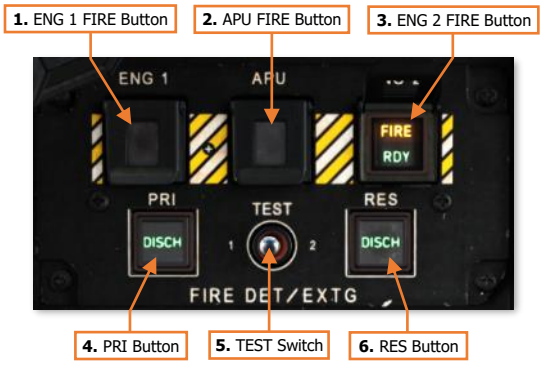
The Master Warning/Master Caution lighted pushbuttons alerts the Pilot to observe the EUFD WCA area for warning and caution messages indicating conditions that require their immediate attention.



1. **MSTR WARN Button.** Acknowledges the MASTER WARNING condition. Extinguishes the MSTR WARN light in the Pilot crewstation and ceases the corresponding voice warning message in both crewstations.
   - **MSTR WARN Light.** Flashes to alert the Pilot to a WARNING message displayed on the EUFD.
2. **MSTR WARN Button.** Acknowledges the MASTER CAUTION condition. Extinguishes the MSTR CAUT light and ceases the corresponding caution audio tone in the Pilot crewstation.
   - **MSTR CAUT Light.** Illuminates to alert the Pilot to a CAUTION message displayed on the EUFD.

Fire Detection/Extinguishing Panel

The FIRE DET/EXTG Panel controls the fire detection and suppression equipment. It consists of three pushbutton warning lights, with covers, that illuminate when a fire is detected and two pushbuttons that discharge extinguishing agents into the selected component.



Fire detection sensors are present in each engine nacelle, the APU compartment, and the aft deck area near the transmission accessory gearbox. However, the Halon extinguishing agent can only be discharged into either engine nacelle or the APU compartment.

1. **ENG 1 Button.** The ENG 1 FIRE button is used to indicate when a fire is detected within the left engine nacelle and to arm the fire extinguishing system for discharge into the left engine nacelle.
   - **FIRE Light.** The yellow FIRE light will illuminate at any time a fire is detected within the left engine nacelle and will extinguish when a fire is no longer detected.
   - **RDY Light.** The green RDY light will illuminate when the ENG 1 FIRE button has been pressed in either crewstation. When pressed, the following occurs:
     - Fuel flow to engine 1 is shut off, however the engine will continue to operate until the remaining fuel within the fuel lines and engine fuel manifold is consumed.
     - The fire extinguishing system is armed.
     - Bleed air from engine 1 is shut off.
     - The MSTR WARN light is acknowledged and the "ENGINE 1 FIRE" voice warning message will cease.
   - Once armed, only the crewstation within which the ENG 1 FIRE button was pressed can dis-arm it and restore the systems to their normal operating conditions.
2. **APU Button.** The APU FIRE button is used to indicate when a fire is detected within the APU compartment and to arm the fire extinguishing system for discharge into the APU compartment.

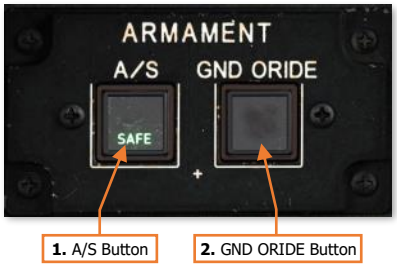
- **FIRE Light.** The yellow FIRE light will illuminate at any time a fire is detected within the APU compartment and will extinguish when a fire is no longer detected.
- **RDY Light.** The green RDY light will illuminate when the APU FIRE button has been pressed in either crewstation. When pressed, the following occurs:
  - Fuel flow to APU is shut off, however the APU will continue to operate until the remaining fuel within the fuel lines and APU fuel system is consumed.
  - The fire extinguishing system is armed.
  - Bleed air from the APU is shut off.
  - The MSTR WARN light is acknowledged and the "APU FIRE" voice warning message will cease.
- Once armed, only the crewstation within which the APU FIRE button was pressed can dis-arm it and restore the systems to their normal operating conditions.

3. **ENG 2 Button.** The ENG 2 FIRE button is used to indicate when a fire is detected within the right engine nacelle and to arm the fire extinguishing system for discharge into the right engine nacelle.
   - **FIRE Light.** The yellow FIRE light will illuminate at any time a fire is detected within the right engine nacelle and will extinguish when a fire is no longer detected.
   - **RDY Light.** The green RDY light will illuminate when the ENG 1 FIRE button has been pressed in either crewstation. When pressed, the following occurs:
     - Fuel flow to engine 2 is shut off, however the engine will continue to operate until the remaining fuel within the fuel lines and engine fuel manifold is consumed.
     - The fire extinguishing system is armed.
     - Bleed air from engine 2 is shut off.
     - The MSTR WARN light is acknowledged and the "ENGINE 2 FIRE" voice warning message will cease.
   - Once armed, only the crewstation within which the ENG 2 FIRE button was pressed can dis-arm it and restore the systems to their normal operating conditions.
4. **PRI Button**. Pressing this button will discharge the Primary fire extinguishing bottle into the compartment selected using the ENG 1, ENG 2, or APU pushbuttons above.
   - **DISCH Light**. Illuminates when the Primary extinguisher bottle is armed and available for use. When the Primary bottle is discharged, the light will extinguish; or if the fire extinguishing system is disarmed by de-selecting the ENG 1, ENG 2, or APU pushbuttons above.
5. **Test Switch**. Pressing this switch to the TEST 1 or TEST 2 positions will test the fire detection circuits. When released, the switch is spring-loaded back to the center position.
   - **TEST 1**. Tests fire detection circuit 1. A successful test is indicated by the following:
     - All three FIRE lights on the ENG 1, ENG 2, and APU pushbuttons are illuminated in both crewstations.
     - The MSTR WARN lighted pushbutton will be illuminated in both crewstations.
     - The "AFT DECK FIRE" warning message will be displayed on the EUFD.
     - "AFT DECK FIRE", "ENGINE 1 FIRE", "ENG 2 FIRE", "APU FIRE" voice warning messages will be heard in sequence.
   - **TEST 2**. Tests fire detection circuit 2. A successful test is indicated by the same items as the TEST 1 position, with the addition of the following:
     - Both DISCH lights on the PRI and RES pushbuttons are illuminated in both crewstations.

6. **RES Button**. Pressing this button will discharge the Reserve fire extinguishing bottle into the compartment selected using the ENG 1, ENG 2, or APU pushbuttons above.
   - **DISCH Light**. Illuminates when the Reserve extinguisher bottle is armed and available for use. When the Reserve bottle is discharged, the light will extinguish; or if the fire extinguishing system is disarmed by de-selecting the ENG 1, ENG 2, or APU pushbuttons above.

Armament Panel

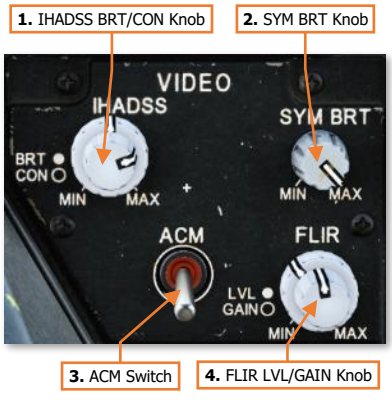
The Armament Panel controls the master arm state of the aircraft. Each button is common to both crewstations, in that pressing a button in one crewstation will change the state of the button in the other crewstation accordingly.



1. **A/S Button.** Pressing this button toggles the master arm state between ARM and SAFE when the aircraft is not weight-on-wheels, or any time the Ground Override is ON.
   - **ARM Light.** Indicates the aircraft is Armed.
     - Weapons may be fired from the aircraft.
     - The laser rangefinder/designator may be fired.
   - **SAFE Light.** Indicates the aircraft is Safe.
     - Weapons are inhibited from firing.
     - The laser rangefinder/designator is inhibited from firing.
2. **GND ORIDE Button.** Pressing this button enables/disables the Ground Override. The Ground Override state will have no effect on aircraft systems when airborne.
   - **ON Light.** Indicates the Ground Override is enabled. When on the ground (weight-on-wheels), the following inhibits are affected:
     - The A/S button may be toggled to the ARM state. Disabling the Ground Override will automatically set the A/S button to the SAFE state.
     - Weapon systems may be actioned. Disabling the Ground Override will automatically de-action any actioned weapon systems.
     - FCR transmissions are permitted. Disabling the Ground Override will automatically cease any FCR transmissions.
     - The Chaff dispenser may be armed. Disabling the Ground Override will automatically set the Chaff state to SAFE.

Video Panel

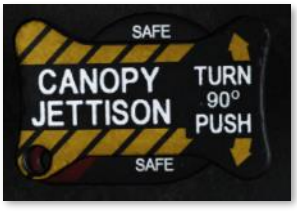
The Video Panel controls the brightness and display of sensor video.



1. **IHADSS BRT/CON Knob.** Two concentric knobs that controls the brightness and contrast of the Helmet Display Unit (HDU). The outer knob controls video brightness and the inner knob controls video contrast.
2. **SYM BRT Knob.** Controls the brightness of the IHADSS symbology displayed on the HDU independently of the video underlay.
3. **ACM Switch.** When on, FLIR gain and level is controlled automatically. When off, the FLIR knob is enabled. (N/I)
4. **FLIR LVL/GAIN Knob.** Two concentric knobs that control the display of FLIR video from the PNVS or TADS. The outer knob controls level and the inner knob controls gain.

Canopy Jettison Handle

The Canopy Jettison handle can be used to aid in emergency egress from the aircraft. When initiated, the canopy side panels on either side of each crewstation will be explosively jettisoned from the canopy frame. Either crewmember can initiate the canopy jettison process, as can rescue crews via an external jettison handle. (N/I)



Each of the three Canopy Jettison handles are physically locked in place via a safety pin, which are stowed prior to flight. A stowage slot is present in each crewstation for storing the safety pins during flight.

Master Zeroize Switch

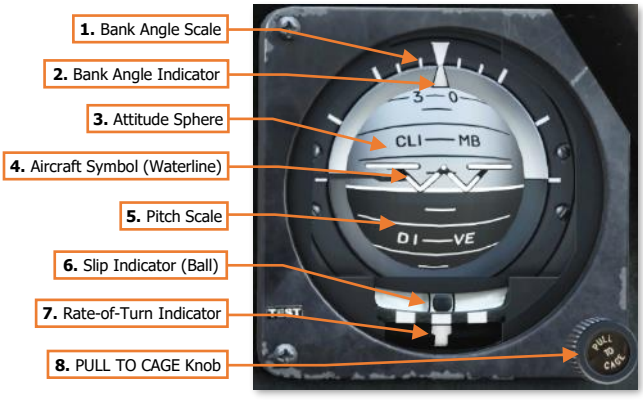
The guarded Master Zeroize switch erases all sensitive data onboard the aircraft in the event the aircraft is forced down in a hostile area. (N/I)

Standby Attitude Indicator

The standby attitude indicator is a self-contained attitude indicator that displays ±85° of aircraft pitch and 360° of aircraft roll. The indicator is used by the Pilot for attitude reference when there has been a failure of primary power, or the flight reference system has become unreliable.

The attitude indicator can develop errors during aggressive maneuvers, which may require it to be caged in flight using the PULL TO CAGE knob.

A yellow OFF warning flag will appear when the indicator is caged, or electrical power to the attitude indicator has been lost.



1. **Bank Angle Scale.** Indicates the bank angle when used in conjunction with the Bank Angle Indicator. A white triangular bank angle index is set at 0° of bank. Major tick marks are placed at 30°, 60° and 90° angles of bank. Minor tick marks are placed at 10° and 20° angles of bank.

2. **Bank Angle Indicator.** Indicates bank angle relative to the horizon. When the indicator is aligned with the fixed triangular bank angle index, the aircraft is in a level attitude.

3. **Attitude Sphere.** Rotates within the indicator to indicate pitch and roll attitude throughout most orientations of flight, in relation to the Aircraft Symbol. The white hemisphere indicates the aircraft nose is pointed above the horizon toward the sky, in a climb. The black hemisphere indicates the aircraft nose is pointed below the horizon toward the ground, in a dive.

4. **Aircraft Symbol (Waterline).** Provides a fixed attitude reference of the aircraft nose around which the Attitude Sphere rotates. The vertical alignment of the symbol can be manually adjusted by rotating the PULL TO CAGE knob.

5. **Pitch Scale.** Provides an attitude reference scale of aircraft pitch in relation to the Aircraft Symbol. Major tick marks are placed at every 10° of pitch and minor tick marks are placed at every 5° of pitch.

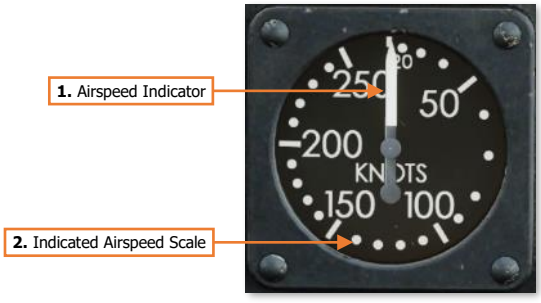
6. **Slip Indicator (Ball).** Indicates whether the aircraft is in coordinated flight. With the ball centered between the two black marks, the aircraft is in coordinated flight, which minimizes drag. If the ball is left of center, applying left pedal will adjust tail rotor thrust to bring the aircraft back into coordinated flight. Likewise, if the ball is right of center, applying right pedal will adjust tail rotor thrust to bring the aircraft back into coordinated flight.

7. **Rate-of-Turn Indicator.** Indicates the aircraft rate of turn, with the lower white bar moving left and right to indicate an increased turn rate in that direction. One bar width equates to 1° to 1.2° per second turn rate. If the lower white bar is aligned with the upper white bar in the center, the aircraft is not turning. If the lower white bar is aligned with the upper white bars on the left or right, the aircraft is in a standard rate, 3° per second turn. If the lower white bar is centered between two of the upper white bars, the aircraft is in a half standard rate turn.

8. **PULL TO CAGE Knob.** Cages the attitude indicator and is used to adjust the relative pitch of the Aircraft Symbol in relation to the Attitude Sphere. When the knob is pulled outward, the Attitude Sphere is caged to a level attitude orientation regardless of the aircraft's actual attitude, causing the OFF warning flag to appear. When pulled outward and rotated fully clockwise, the attitude indicator is locked in the caged position.

Standby Airspeed Indicator

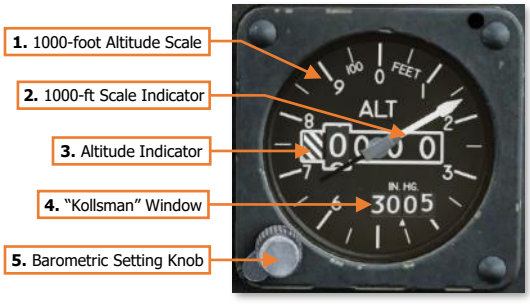
The standby airspeed indicator is used by the Pilot for airspeed reference when there has been a failure of primary power, or the flight reference system has become unreliable. The indicator is pneumatically operated by the right pitot probe.



1. **Airspeed Indicator.** Indicates indicated airspeed along the Indicated Airspeed Scale.
2. **Indicated Airspeed Scale.** The outer scale of the instrument, from 0 to 250 knots. Tick marks are set at 50-knot increments, and dots are set at 10-knot increments starting at 20 knots.

Standby Altimeter

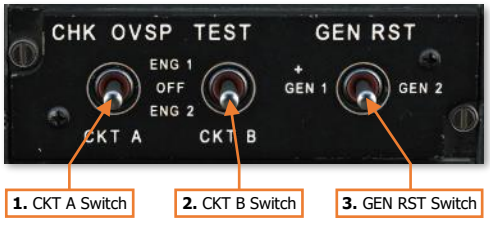
The standby altimeter is used by the Pilot for barometric altitude reference when there has been a failure of primary power, or the flight reference system has become unreliable. The altimeter is pneumatically operated by the static pressure system.



1. **1000-foot Altitude Scale.** Each major tick mark corresponds with 100-foot increments, with minor tick marks corresponding to 50-foot increments.
2. **1000-foot Scale Indicator.** Indicates the aircraft altitude on the outer 1000-foot scale.
3. **Altitude Indicator.** Indicates the current barometric altitude in 1000-foot increments from 0 feet to 20,000 feet.
4. **"Kollsman" Window.** Indicates current altimeter setting correction in inches of mercury (in/Hg). The altimeter setting on the AH-64D is designed to be used in conjunction with QNH barometric altimeter settings to calibrate the altimeter to altitudes above mean sea level (MSL).
5. **Barometric Setting Knob.** Sets altimeter setting correction as displayed in the "Kollsman" Window.

Check Overspeed Test/Generator Reset Panel

Tests engine overspeed circuits and provides a means to reset the generators if the MPDs are non-functional following a power failure.

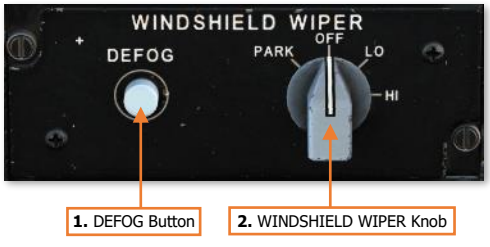


1. **CKT A Switch.** Tests the overspeed protection Circuit A for each engine.
   - **ENG 1.** Not implemented.
   - **OFF.** The switch is spring-loaded to this position.
   - **ENG 2.** Not implemented.

2. **CKT B Switch.** Tests the overspeed protection Circuit B for each engine.
   - **ENG 1.** Not implemented.
   - **OFF.** The switch is spring-loaded to this position.
   - **ENG 2.** Not implemented.
3. **GEN RST Switch.** Performs a reset of either generator in the case of a power failure.
   - **GEN 1.** Resets Generator 1.
   - **GEN 2.** Resets Generator 2.

Windshield Wiper Control Panel

Controls the external windshield wipers and canopy defog functions.



1. **DEFOG Button.** Directs hot air mixed with ambient air from the cockpit against the canopy side panels to remove fogging. (N/I)
2. **WINDSHIELD WIPER Knob.** Sets the speed for the windshield wiper or returns the wiper to the PARK position.
   - **PARK.** Holding the knob in this position will move the windshield wiper to its designated parking location. When released, the knob will be spring-loaded to the OFF position.
   - **OFF.** Powers off the windshield wiper at its current position.
   - **LO.** Powers the windshield wiper and sets the motion to low speed.
   - **HI.** Powers the windshield wiper and sets the motion to high speed.

Parking Brake Handle

The PARK BRAKE handle can be used by the Pilot to set the wheel brakes without needing to continuously apply pressure to the anti-torque pedals themselves. To set the brakes using this method, the brakes are engaged by applying pressure to the anti-torque pedals in either crewstation, and the Pilot then pulls the PARK BRAKE handle out. The pressure on the anti-torque pedals is then released.

To release the brakes after they have been set using the PARK BRAKE handle, either crewmember may simply apply brake pressure using the anti-torque pedals, and the Parking Brake handle will snap inward.

Note that the PARK BRAKE handle can be pulled and locked in the outward position without applying the wheel brakes, and therefore the outward position of the handle does not directly correlate to the brakes being set. However, if the PARK BRAKE handle is in the forward position, the brakes are indeed released.

Keyboard Unit

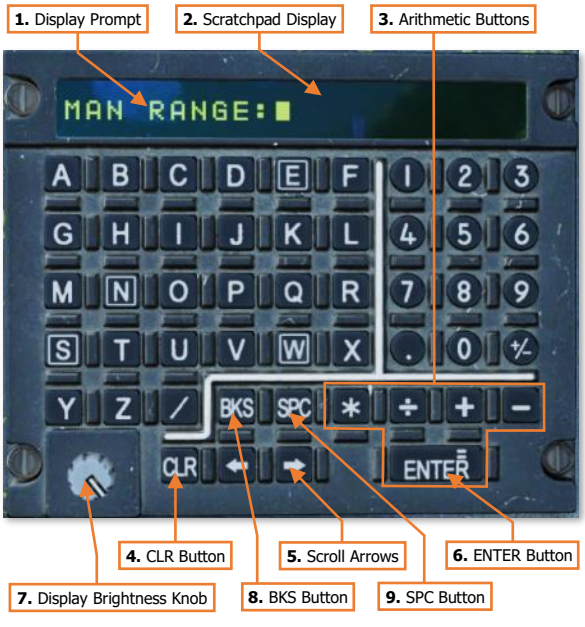
The Keyboard Unit (KU) is used by the crewmembers to input data into the aircraft computers, perform arithmetic functions, or be used as a scratchpad to temporarily record data for a brief time.

Each Keyboard Unit is independently operated by either crewmember, and data is only entered and utilized by the onboard computers when a data prompt is present on the KU display itself.

The N, E, S and W keys are boxed for easy recognition if coordinates are to be input using Latitude and Longitude.

Data Entry and Arithmetic Functions

The KU uses an "overtype" method of data entry, in that any data underneath the flashing cursor will be overwritten by the next character entered, and each subsequent character to the right of the cursor will be continuously overwritten as more characters are entered.



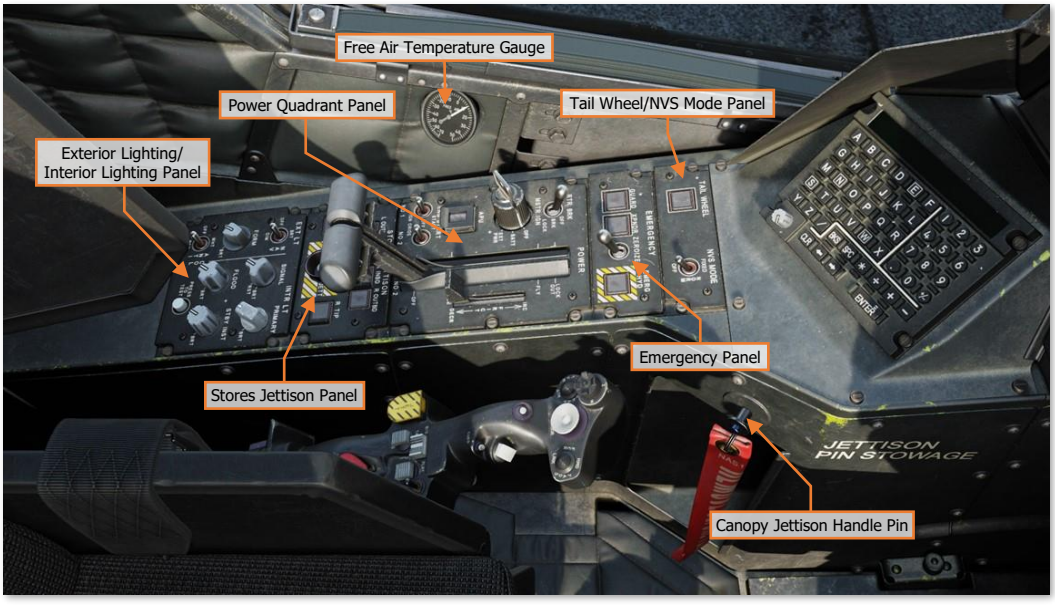
1. **Display Prompt.** Indicates the type of data that will be input if accepted by the avionics. Pressing an MPD pushbutton associated with a data entry symbol > will show the corresponding prompt on the KU followed by a colon. The desired data can then be input into the scratchpad.

2. **Scratchpad Display.** The maximum number of characters that can be displayed on the KU scratchpad itself is 22, but the scroll buttons can be used to move the cursor left or right in a continuous scrolling fashion if the data entry exceeds the 22 characters on the display.

3. **Arithmetic Buttons.** If a display prompt is not present on the scratchpad display, basic arithmetic functions may be performed using these keys. To perform basic arithmetic, enter a number, followed by either the * (multiply), ÷ (divide), + (add), or - (subtract) keys. Enter another number and press Enter (equal). The resultant value will display on the scratch pad.

4. **CLR Button.** Removes all data entered on the scratchpad but will not remove or cancel a display prompt if present.
5. **Scroll Arrows.** Moves the cursor position left or right on the display to set the data entry point over existing characters.
6. **ENTER Button.** Used to accept a data input to an MPD data entry prompt. If data input is invalid, the characters on the scratchpad display will flash, and the data will need to be edited before it can be accepted into the MPD data prompt.
7. **Display Brightness Knob.** Adjusts the brightness of the KU scratchpad display.
8. **BKS Button.** Removes the character to the left of the cursor and shifts the cursor to the left, along with any characters underneath or to the right of the cursor.
9. **SPC Button.** Places a blank character space at the cursor position.

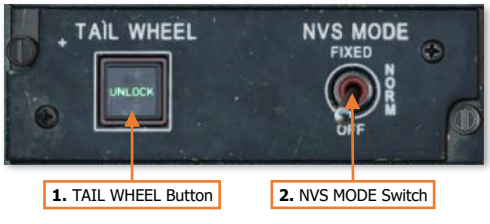
Left Console



Each text box above may be selected to jump to a more detailed description of that panel. Selecting the image of the panel will return the manual back to this page.

Tail Wheel/NVS Mode Panel

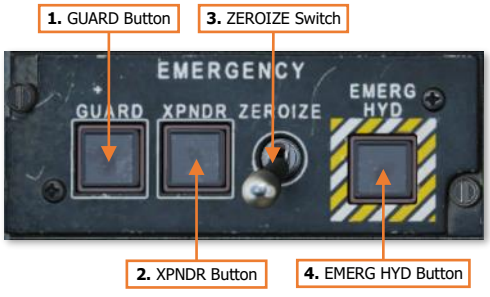
Controls the tail wheel locking mechanism and the operating mode of the crewstation's Night Vision System.



1. **TAIL WHEEL Button.** Toggles the commanded state of the tail wheel locking mechanism between locked and unlocked.
   - **UNLOCK Light.** Illuminates to indicate when the tail wheel is unlocked, regardless of the commanded state of the locking mechanism.
2. **NVS MODE Switch.** Sets the operating mode of the Night Vision System within the crewstation. The default NVS sensor selections are the PNVS in the Pilot crewstation and the TADS in the CPG crewstation, unless the NVS Select Switch on the Collective Flight Grip has been used to swap the NVS sensor selections.
   - **FIXED.** Activates the selected NVS sensor and slaves it to the fixed forward position (0° in azimuth and -4.9° in elevation). If the selected NVS sensor is the PNVS, it will be un-stowed. If the selected NVS sensor is TADS, it will switch to FLIR in Wide field-of-view, regardless of the TEDAC switch settings.
   - **NORM.** Activates the selected NVS sensor and slaves it to the crewmember's IHADSS line-of-sight. If the selected NVS sensor is the PNVS, it will be un-stowed. If the selected NVS sensor is TADS, it will switch to FLIR in Wide field-of-view, regardless of the TEDAC switch settings.
   - **OFF.** Deactivates the selected NVS sensor and stows it. The PNVS will return to the stowed position and the TADS will stow in the fixed forward position (0° in azimuth and -4.9° in elevation).

Emergency Panel

The Emergency Panel provides a singular location for the crewmember to perform miscellaneous emergency actions, without requiring navigation through MPD pages to access the associated functions. (N/I)



1. **GUARD Button.** Tunes the UHF radio to the GUARD frequency of 243.000 MHz. The frequency in the Primary slot of the UHF radio will be moved to the Standby slot, and "GUARD" will be displayed as the frequency callsign.

   Pressing this button when it is already set to ON will return the previous UHF frequency to the Primary slot and place the GUARD frequency in the Standby slot.

   - **ON Light.** Illuminates to indicate that the GUARD button has been pressed in either crewstation.

2. **XPNDR Button.** Sets the transponder Mode 3/A code to 7700 to indicate the aircraft is experiencing an in-flight emergency. If the transponder is in STBY, it will automatically be set to NORM, and EUFD transponder information will indicate a status of "7700 EMER".

   Pressing this button when it is already set to ON will return the transponder to the NORM status, but the Mode 3/A code will need to be manually changed by either crewmember.

   - **ON Light.** Illuminates to indicate that the XPNDR button has been pressed in either crewstation.

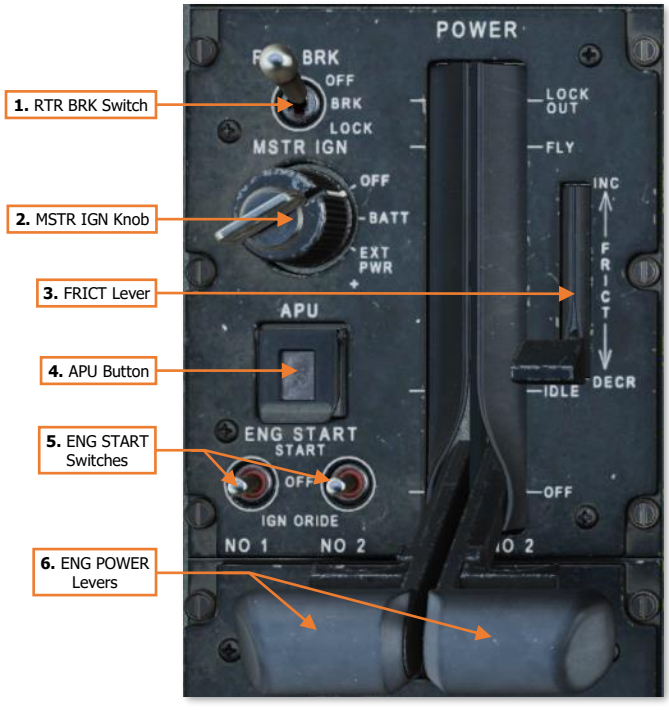
3. **ZEROIZE Switch.** When set to the forward position, all communications encryption, modem settings, and any TSD points within the navigational database will be erased.

4. **EMERG HYD Button.** Activates the emergency hydraulics system. This system provides emergency hydraulic pressure to the utility hydraulic system for a very brief period in order to perform an immediate emergency landing.

   - **ON Light.** Illuminates to indicate that the emergency hydraulics has been activated by either crewmember.

Power Quadrant Panel

The Pilot's Power Quadrant includes controls for battery, APU and engine start, and rotor brake operation. The POWER levers manage engine output during normal and manual control operations.



1. **RTR BRK Switch.** Controls the commanded state of the rotor brake mounted to the accessory gearbox of the main transmission.
   - **OFF.** The rotor brake is commanded to disengage.
   - **BRK.** The rotor brake is commanded to engage in a low-pressure state to reduce the time it takes for the rotor system to decelerate to a stop. Used when shutting down in high winds or when on board a naval vessel in rough sea conditions.
   - **LOCK.** The rotor brake is commanded to engage in a high-pressure state to prevent the rotor from spinning. Used when performing an engine start in high winds or when on board a naval vessel in rough sea conditions.

   Rotor brake operation is electronically inhibited if either ENG POWER lever is beyond the IDLE position.

2. **MSTR IGN Knob.** Enables battery or external power to the aircraft.
   - **OFF.** Disconnects the battery from the DC battery bus.
   - **BATT.** Connects the battery to the DC battery bus. If the aircraft is receiving DC power from the Transformer-Rectifier Units (TRUs), the battery will be set to a charging state, but will automatically provide emergency power to the battery bus if a TRU failure occurs.
   - **EXT PWR.** Enables external AC and DC power to be supplied via the external power receptacle.
3. **FRICT Lever.** Adjusts the friction resistance when moving the engine power levers. (N/I)
4. **APU Button.** Intiates the APU automatic start-up and shutdown sequences.
   - **ON Light.** Illuminates to indicate when the APU has successfully started and is operating.
5. **ENG START Switches.** Controls the pneumatic air starters and ignition systems of each main engine.
   - **START.** Moving the switch momentarily to this position initiates an automatic start sequence for the respective engine and enables the engine ignitors. The System Processor (SP) will automatically activate the fuel boost pump and open the pneumatic valve to the engine air starter to spool the N_G section of the engine. The SP will automatically close the pneumatic valve to disengage the starter when the N_G reaches 52% RPM.

- **OFF.** Normal position of the ENG START switch after initiating a START sequence or motoring the engine using the IGN ORIDE position.
- **IGN ORIDE.** Moving the switch to this position manually opens the pneumatic valve to the engine air starters to spool the N_G section of the engine. The System Processor (SP) will not activate the fuel boost pump nor the engine ignition system. The pneumatic air starters will continue to spool the N_G section of the engine at ~25% RPM until the ENG START switch is returned to the OFF position, which will close the close the pneumatic valve to disengage the starter.

  An engine start sequence may be aborted by setting the ENG START switches to the IGN ORIDE position and then to OFF. This will disable the engine ignition system, disengage the engine air starters, and the fuel boost pump will be automatically deactivated by the SP.

6. **ENG POWER Levers.** Controls the fuel flow and control mode of each main engine. Each ENG POWER lever is connected to the corresponding Hydromechanical Unit (HMU) on the engine through the Power Available Spindle (PAS).

Each ENG POWER lever includes a detent that prevents the lever from being inadvertantly advanced beyond FLY into the LOCK OUT range, or retarded below IDLE to OFF. A finger-lift detent lever on each ENG POWER lever disengages the mechanical detents.

- **LOCK OUT.** Setting the ENG POWER lever to this position will lock out the Digital Electronic Control (DEC) from electronically regulating fuel flow and will set the engine throttle to fully open. This will also disable the NP overspeed protection and TGT limiting functions of the DEC, so the engine throttle will need to be manually controlled using the ENG POWER lever to prevent an overspeed or overtemperature condition.

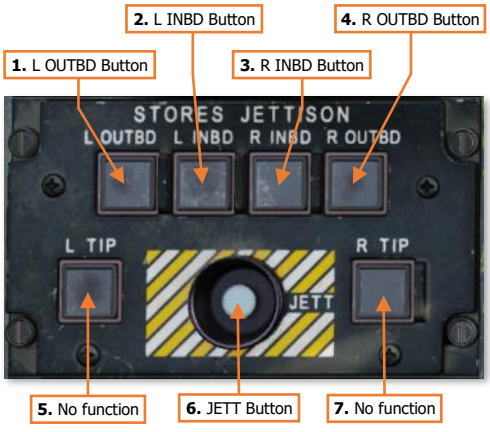
  This position is only used during emergency procedures in which the DEC has malfunctioned or failed in some manner, requiring the aircrew to manually control the engine throttle in order to prevent an engine overspeed or overtemperature, or to maintain the rotor RPM (N_R) within an acceptable range for flight.
- **FLY.** Setting the ENG POWER lever to this position will set the PAS to the FLY position and command the DEC to trim fuel flow to maintain the rotor RPM (N_R) at 101%. Each engine will automatically regulate their respective throttle settings to equally balance the torque requirement between each engine (load-sharing).
- **IDLE.** Setting the ENG POWER lever to this position will set the PAS to the IDLE position. The DEC will no longer regulate the fuel flow based on rotor RPM (N_R) and the load-sharing logic between the engines is disabled.

  Setting the ENG POWER lever to this position will also reset the DEC from the LOCK OUT condition, returning DEC-related functionality to the respective engine.
- **OFF.** Setting the ENG POWER lever to this position will set the PAS to the OFF position, shutting off fuel flow to the engine.

When the RTR BRK switch is in the BRK or LOCK positions, the ENG POWER levers will be physically inhibited from advancing beyond the IDLE position.

Stores Jettison Panel

The Stores Jettison panel allows the crewmembers to selectively jettison individual weapon stations in lieu of performing an emergency jettison of all stations at once. Each weapon station can be armed/disarmed by toggling the corresponding pushbutton on this panel. Each pushbutton includes an ARM light which indicates that that station will be jettisoned when the JETT button is pressed.

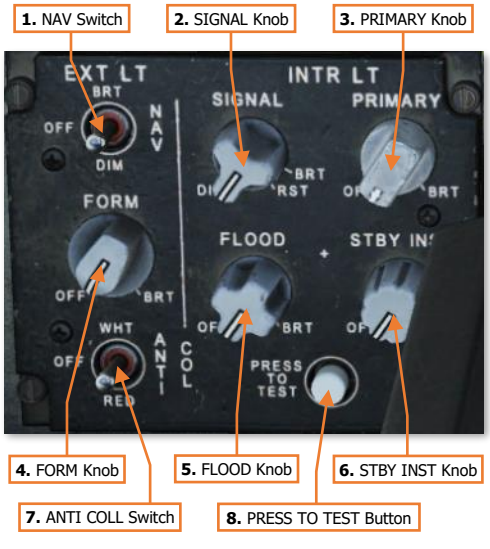


Only the crewstation that has armed a weapon station for jettison can disarm it. However, once any stations are armed, either crewmember can initiate the jettison sequence by pressing the JETT button.

1. **L OUTBD Button.** Arms/disarms the left outboard wing station for jettison.
2. **L INBD Button.** Arms/disarms the left inboard wing station for jettison.
3. **R INBD Button.** Arms/disarms the right inboard wing station for jettison.
4. **R OUTBD Button.** Arms/disarms the right outboard wing station for jettison.
5. **L TIP Button.** No function.
6. **JETT Button.** Jettisons any weapon stations that have been selectively armed.
7. **R TIP Button.** No function.

Exterior Lighting/Interior Lighting Panel

The Exterior Lighting/Interior Lighting panel controls the exterior aircraft lighting and the interior lighting within the Pilot cockpit.



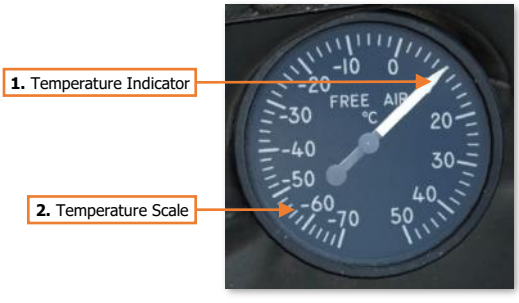
1. **NAV Switch.** Sets the brightness levels of the engine nacelle-mounted red/green and the tail mounted white navigation lights.
   - **BRT.** Sets the navigation lights to bright.
   - **OFF.** Sets the navigation lights to off.
   - **DIM.** Sets the navigation lights to dim.
2. **SIGNAL Knob.** Adjusts the brightness of the signal lights within the cockpit when set to nighttime brightness levels. This knob will have no function if the signal lights are set to daytime brightness level.

   Rotating the knob to the RST (Reset) detent will set the signal light brightness scale to nighttime levels if the PRIMARY knob is not in the OFF position and the FLOOD knob is less than 50%.
3. **PRIMARY Knob.** Adjusts the brightness of the primary instrument backlighting within the cockpit. Rotating this knob to the OFF position will revert the signal lights to daytime mode.

4. **FORM Knob.** Adjusts the brightness of the exterior formation lights on the wing tips, tail boom, and vertical stabilizer.
5. **FLOOD Knob.** Adjusts the brightness of the interior flood lights within the cockpit. Rotating this knob clockwise beyond the 50% setting will revert the signal lights to daytime mode.
6. **STBY INST Knob.** Adjusts the brightness of the standby instrument illumination within the cockpit.
7. **ANTI COLL Switch.** Sets the operating mode of the engine nacelle-mounted anti-collision strobe lights.
   - **WHT.** Sets the anti-collision lights to a white, alternating flash pattern.
   - **OFF.** Sets the anti-collision lights to off.
   - **RED.** Sets the anti-collision lights to a red, alternating flash pattern.
8. **PRESS TO TEST Button.** Illuminates all signal lights to verify their function.

Free Air Temperature Gauge

The Free Air temperature gauge indicates the temperature of the external air mass via a probe directly protruding from the gauge itself through the fuselage to the outside of the aircraft.

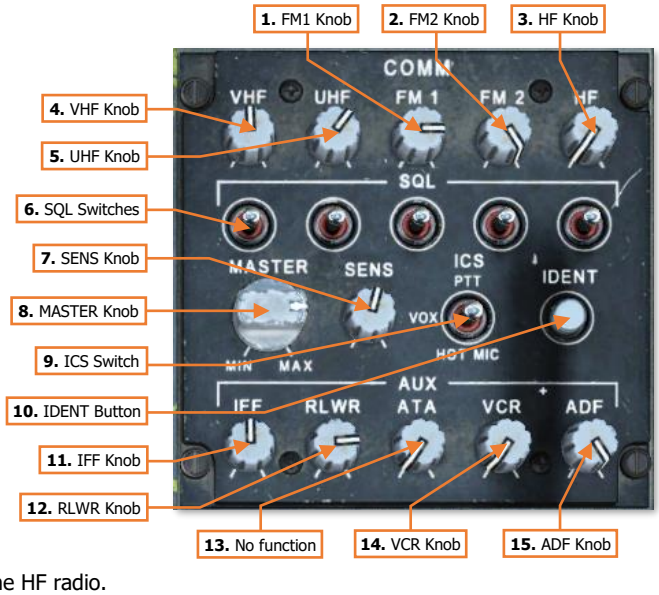


1. **Temperature Indicator.** Indicates air temperature in Celsius (°C) as directly measured outside the pilot cockpit.
2. **Temperature Scale.** Each major tick mark corresponds with 10-degree increments, with minor tick marks corresponding to 2-degree increments.

Right Console

Communications Panel

The Communications panel controls the volume of the intercom, radios, and other audio sources within the crewstation.



1. **FM1 Knob.** Adjusts the volume of the FM1 radio. Rotating the knob clockwise will increase the volume level; and pulling the knob outward will mute the audio from the FM1 radio.
2. **FM2 Knob.** Adjusts the volume of the FM2 radio. Rotating the knob clockwise will increase the volume level; and pulling the knob outward will mute the audio from the FM2 radio.
3. **HF Knob.** Adjusts the volume of the HF radio. Rotating the knob clockwise will increase the volume level; and pulling the knob outward will mute the audio from the HF radio.
4. **VHF Knob.** Adjusts the volume of the VHF radio. Rotating the knob clockwise will increase the volume level; and pulling the knob outward will mute the audio from the VHF radio.

5. **UHF Knob.** Adjusts the volume of the UHF radio. Rotating the knob clockwise will increase the volume level; and pulling the knob outward will mute the audio from the UHF radio.

6. **SQL Switches.** Momentarily pressing these switches to the forward or aft positions will toggle the squelch function of the corresponding radio.

7. **SENS Knob.** Adjusts the voice-activation sensitivity when the intercom switch is in the VOX position. Rotating the knob clockwise will increase the sensitivity and lower the voice-activation threshold.

8. **MASTER Knob.** Adjusts the overall volume level of all audio sources received within the crewmember's helmet.

9. **ICS Switch.** Controls the operating mode of the crewmember's mic on the intercom audio circuit.
   - **PTT.** The crewmember's mic will only be activated when the Push-To-Talk switch on the cyclic or the floor button is depressed.
   - **VOX.** The crewmember's mic will be activated any time the voice level exceeds the threshold set by the SENS knob, or when the Push-To-Talk switch on the cyclic or the floor button is depressed.
   - **HOT MIC.** The crewmember's mic is continuously activated.

10. **IDENT Button.** When pressed, the transponder performs an identification-of-position function. This is used to momentarily highlight the ownship position when replying to non-encrypted transponder interrogations (non-Mode 4 interrogations). (N/I)

11. **IFF Knob.** Adjusts the volume of the IFF interrogation audio. Rotating the knob clockwise will increase the volume level. (N/I)

12. **RLWR Knob.** Adjusts the volume of the voice warning messages received from the APR-39/AVR-2 Radar/Laser Warning Receiver system; as well as the Radar Frequency Interferometer (RFI) if the mast-mounted FCR is installed and the RFI is operational. Rotating the knob clockwise will increase the volume level.

13. **ATA Knob.** No function.

14. **VCR Knob.** Adjusts the volume of the VCR audio when video playback is enabled. Rotating the knob clockwise will increase the volume level; and pulling the knob outward will mute the audio from the VCR playback. (N/I)

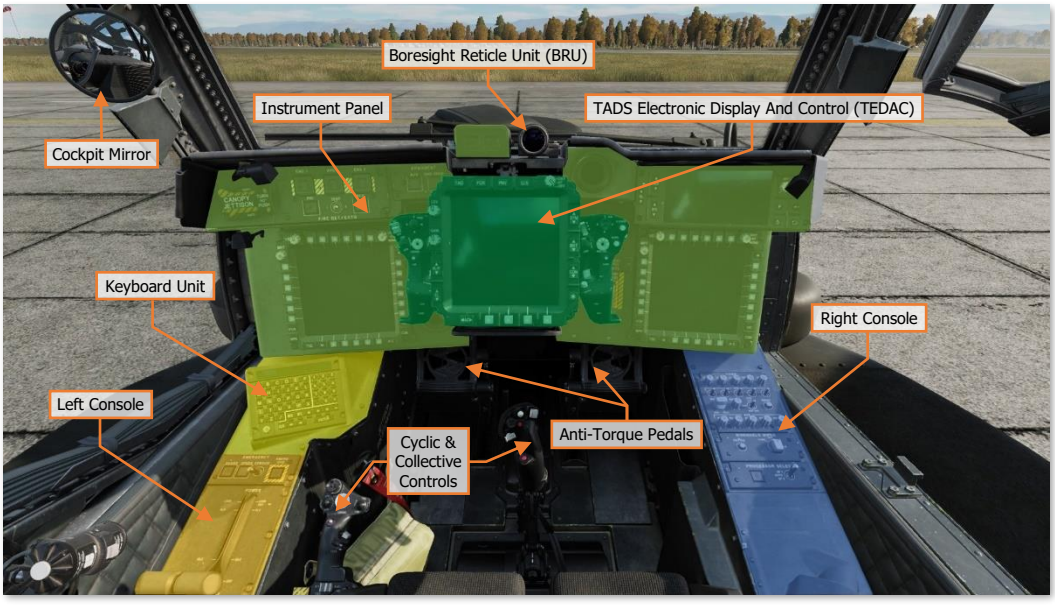
15. **ADF Knob.** Adjusts the volume of the audio received from the ARN-149 Automatic Direction Finder (ADF). Rotating the knob clockwise will increase the volume level; and pulling the knob outward will mute the audio from the ADF receiver.

COPILOT/GUNNER COCKPIT OVERVIEW

The Copilot/Gunner's primary task is to utilize the aircraft sensors to continuously search, acquire, identify, and (when appropriate) engage targets on the battlefield with the aircraft's weapon systems. When enemy targets are located and identified, the Copilot/Gunner (CPG) coordinates with the Pilot (PLT) to determine the best course of action to accomplish the mission. Effective communication and coordination between the crewmembers are critical to mission success.

The CPG's secondary task is to manage the aircraft navigation and communication systems during the mission. As the Pilot will often be focused on flying the aircraft and maneuvering around the terrain and obstacles, the CPG will typically be focused inside the cockpit to tune radio frequencies, monitor the aircraft movement along the current route, and receive or transmit tactical reports. Accordingly, the CPG coordinates with other units, to include ground forces, or the other Copilot/Gunners within the team to delineate sectors of fire, sensor coverage, and fires distribution on enemy targets.

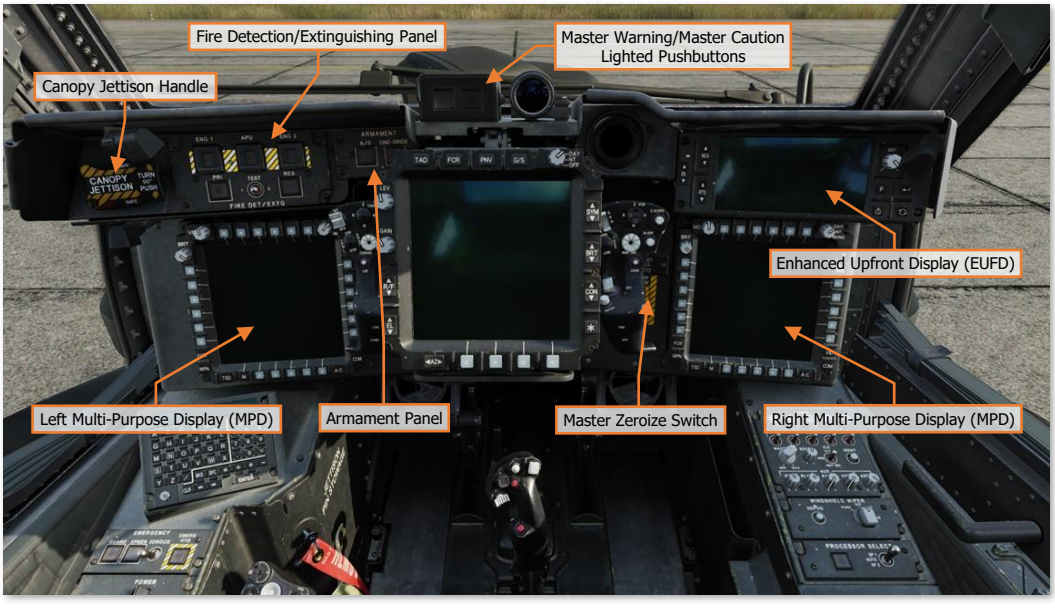
The CPG can effectively utilize any sensor on the aircraft to search for or engage enemy targets. While the Pilot can assist in the targeting process by using the FCR to hand over targets to the Copilot/Gunner, the CPG can also directly control the FCR, and may autonomously hand over targets between the FCR and the TADS. If necessary, the CPG may even hand over a TADS target to the Pilot for an engagement using the FCR, while the CPG continues to scan the battlefield for additional targets with the electro-optical sensors in the TADS.



It is important to have a general understanding of where the various controls are located. To help locate items more easily, the cockpit has been delineated into five primary areas: **Instrument Panel**, the **Keyboard Unit (KU)**, **Left Console**, **Right Console,** and the **TADS Electronic Display And Control (TEDAC)**.

Each text box above may be selected to jump to a more detailed description of that instrument panel or console, to include the **Cyclic & Collective Controls**. Selecting the image of the instrument panel or console will return the manual back to this page.

Instrument Panel



Each text box above may be selected to jump to a more detailed description of that panel. Selecting the image of the panel will return the manual back to this page.

The Enhanced Upfront Display (EUFD) and Multi-Function Displays (MPD) are described in dedicated sections later in this chapter.

The Fire Detection/Extinguishing Panel, Armament Panel, Canopy Jettison Handle, and Master Zeroize Switch function identically to those in the Pilot cockpit.

Master Warning/Master Caution Lighted Pushbuttons

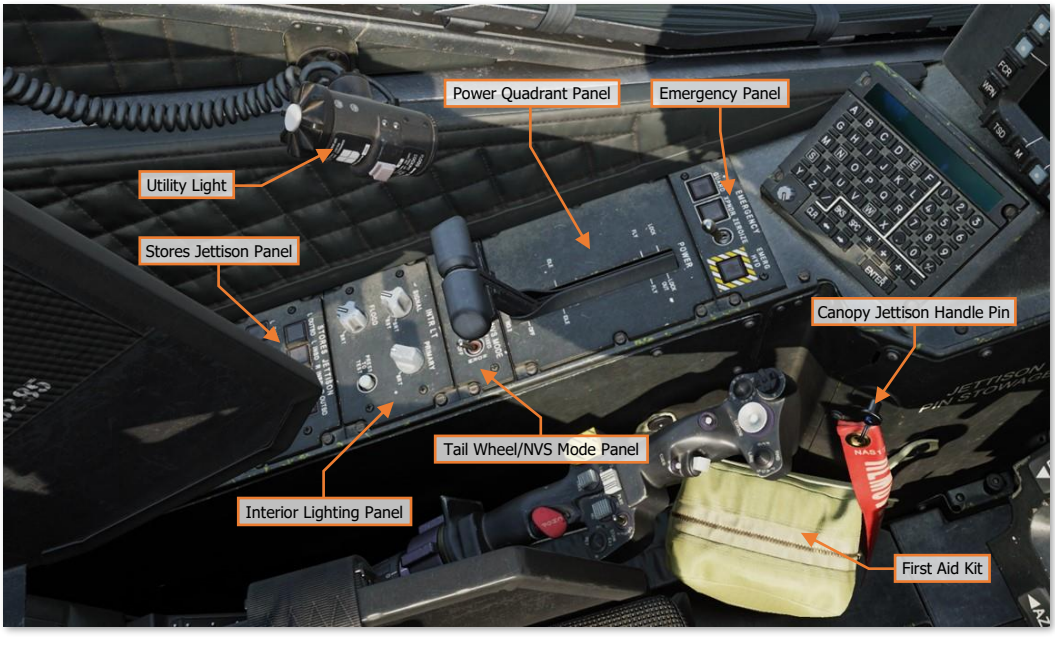
The Master Warning/Master Caution lighted pushbuttons alerts the CPG to observe the EUFD WCA area for warning and caution messages indicating conditions that require their immediate attention.

1. **MSTR WARN Button.** Acknowledges the MAST ER WARNING condition. Extinguishes the MSTR WARN light in the CPG crewstation and ceases the corresponding voice warning message in both crewstations.
   - **MSTR WARN Light.** Flashes to alert the CPG to a WARNING message displayed on the EUFD.
2. **MSTR WARN Button.** Acknowledges the MASTER CAUTION condition. Extinguishes the MSTR CAUT light and ceases the corresponding caution audio tone in the CPG crewstation.
   - **MSTR CAUT Light.** Illuminates to alert the CPG to a CAUTION message displayed on the EUFD.

Keyboard Unit

The Keyboard Unit (KU) functions identically to the KU in the Pilot cockpit.

Left Console



Each text box above may be selected to jump to a more detailed description of that panel. Selecting the image of the panel will return the manual back to this page.

The Emergency Panel, Tail Wheel/NVS Mode Panel, and Stores Jettison Panel function identically to those in the Pilot cockpit.

Power Quadrant Panel

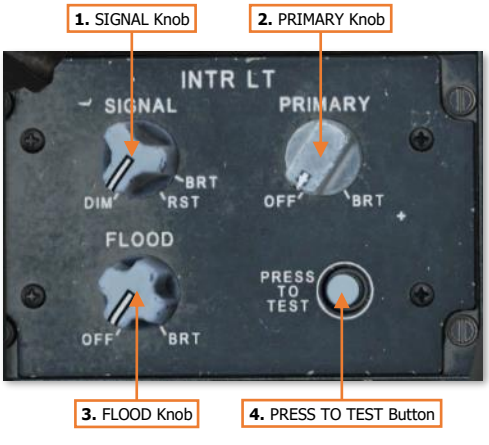
The ENG POWER levers in the Copilot/Gunner cockpit function identically to those located on the Pilot's Power Quadrant Panel.

The CPG's ENG POWER levers are connected to the Pilot's ENG POWER levers through linkages between the cockpits. When either crewmember moves an ENG POWER lever, the corresponding lever in the other cockpit will move accordingly.

However, the CPG's finger-lift detent levers are not mechanically linked to the physical detents of the Pilot's ENG POWER levers. The detent levers on the ENG POWER levers in the CPG cockpit use microswitches to electrically command the detents in the Pilot cockpit. As such, the electrical power is required for the CPG to physically move the ENG POWER levers beyond the LOCK OUT or IDLE detents.

Interior Lighting Panel

The Interior Lighting panel controls the exterior aircraft lighting and the interior lighting within the Copilot/Gunner cockpit.



1. **SIGNAL Knob.** Adjusts the brightness of the signal lights within the cockpit when set to nighttime brightness levels. This knob will have no function if the signal lights are set to daytime brightness level.

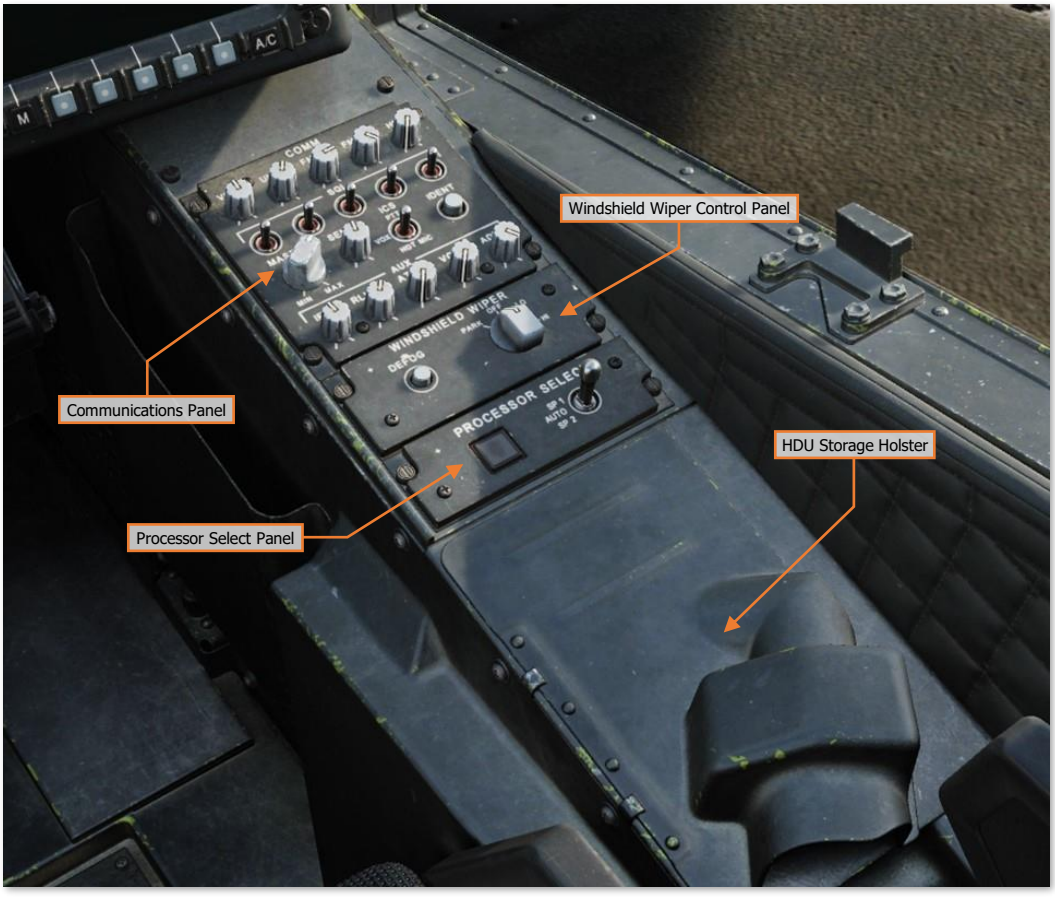
   Rotating the knob to the RST (Reset) detent will set the signal light brightness scale to nighttime levels if the PRIMARY knob is not in the OFF position and the FLOOD knob is less than 50%.

2. **PRIMARY Knob.** Adjusts the brightness of the primary instrument backlighting within the cockpit. Rotating this knob to the OFF position will revert the signal lights to daytime mode.

3. **FLOOD Knob.** Adjusts the brightness of the interior flood lights within the cockpit. Rotating this knob clockwise beyond the 50% setting will revert the signal lights to daytime mode.

4. **PRESS TO TEST Button.** Illuminates all signal lights to verify their function.

Right Console



The Communications Panel and Windshield Wiper Control Panel function identically to those in the Pilot cockpit.

Processor Select Panel

The Processor Select panel controls the System Processor (SP) selection for aircraft functions. (N/I)

1. **SP1/SP2 Lights.** Illuminates either SP1 or SP2 to indicate which System Processor is primary.
2. **Processor Select Switch.** Sets primary SP selection to automatic or manual selection.
   - **SP1.** Manually selects SP1 as the primary SP.
   - **AUTO.** Enables automatic switchover of aircraft functions if the primary SP malfunctions.
   - **SP2.** Manually selects SP2 as the primary SP.

TADS Electronic Display And Control (TEDAC)

The TEDAC is a modernized replacement for the Optical Relay Tube (ORT) from the AH-64A and early AH-64D aircraft. Its primary purpose is to present the CPG with high-resolution sensor video from the Modernized Target Acquisition Designation Sight (M-TADS).

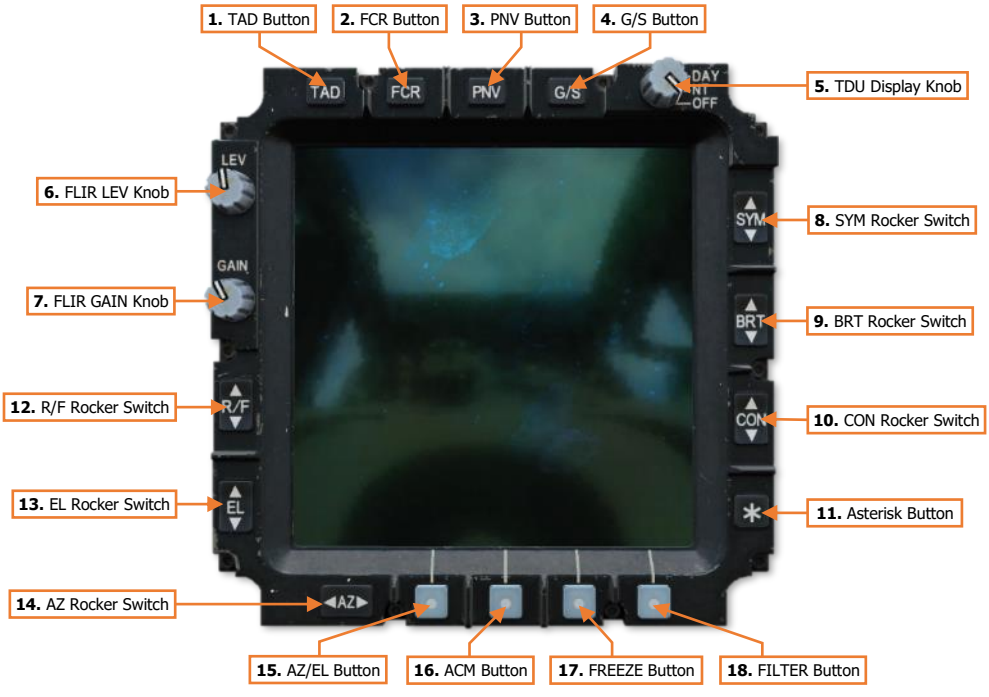
Along with the TDU bezel controls, fixed handgrips on either side of the TEDAC are used to control aircraft sensors, weapons, and the CPG's MPD cursor. Many of these controls replicate functions on the CPG's cyclic and collective controls but allow the CPG to utilize such functions without actively interfering with the Pilot's flight control inputs.

The TEDAC can also be used to display the FCR page as an alternative to an MPD. However, since the TEDAC does not have Variable Action Buttons along the bezel of its display, the bezel FCR controls may only be utilized using the left handgrip cursor controller.

Each text box above may be selected to jump to a more detailed description of that TEDAC component. Selecting the image of the component will return the manual back to this page.

TEDAC Display Unit (TDU)

The TEDAC Display Unit provides the CPG with a "heads-out" display for presenting TADS or PNVS sensor video, or FCR targeting information. The TDU will display sensor video in a grayscale format when the TDU Display Knob is set to DAY mode, or in a greenscale format when the Display Knob is set to NT mode.



If the CPG's NVS Mode switch is set to NORM or FIXED, the TDU will function as a repeater of the CPG's Helmet Display Unit (HDU) and display HMD Flight symbology and NVS sensor video. The TAD, FCR, PNV, and G/S buttons along the top of the TDU will be inhibited.

1. **TAD Button.** If the CPG's NVS Mode switch is set OFF, the TDU will display HMD Weapon symbology when the CPG's selected sight is HMD, or TADS Weapon symbology and TADS sensor video when the CPG's selected sight is TADS.

2. **FCR Button.** If the CPG's NVS Mode switch is set OFF, the TDU will display the FCR page. All FCR page functions (except for accessing the UTIL sub-page) are mirrored on the TDU; however, they may only be accessed by using the MPD cursor.

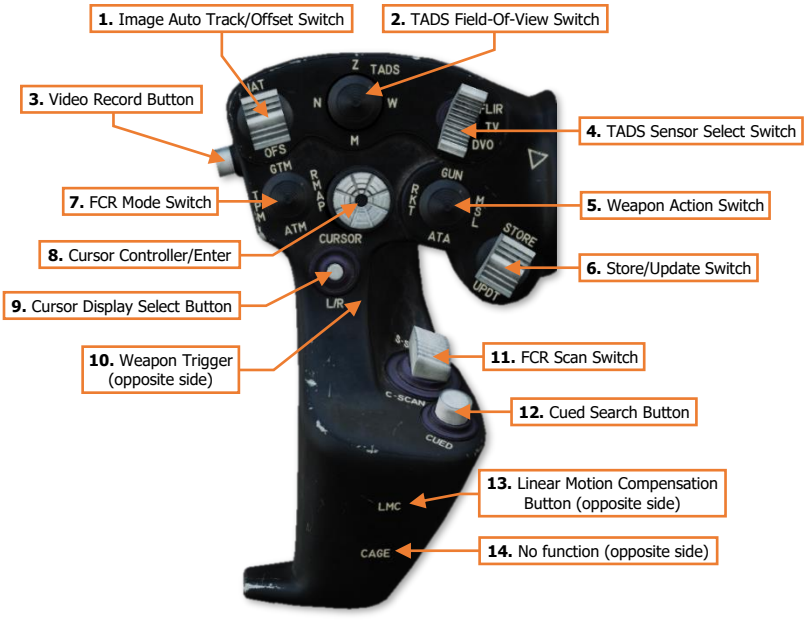
   The MPD cursor can only be moved to the TDU using the "bump" method, and only when the FCR page is displayed. To bump the cursor to the TDU FCR page, move the cursor to the inboard edge of either MPD, release input on the Cursor Controller, and then re-apply pressure input inboard toward the TDU.

3. **PNV Button.** If the CPG's NVS Mode switch is set OFF, the TDU will display the Pilot's HMD Flight symbology and NVS sensor video. If the CPG's selected sight is TADS or FCR, this button will also display the Pilot's HMD Flight symbology and NVS sensor video within the CPG's HDU.

4. **G/S Button.** If the CPG's NVS Mode switch is set OFF, the TDU will display a grayscale pattern. The grayscale pattern is used to set the appropriate brightness and contrast levels for the TDU video output.

5. **TDU Display Knob.** Powers the TDU video screen and selects the overall brightness scale.
   - **DAY.** Powers on the TDU and sets the overall brightness scale to daytime levels.
   - **NT.** Powers on the TDU and sets the overall brightness scale to nighttime levels.
   - **OFF.** Powers off the TDU screen only. All TEDAC functions and TDU bezel buttons remain functional.
6. **FLIR LEV Knob.** Controls the relative brightness scale of thermographic video from the PNVS or TADS FLIR cameras.
7. **FLIR GAIN Knob.** Controls the relative thermographic gain from the PNVS or TADS FLIR cameras.
8. **SYM Rocker Switch.** Controls the brightness level of displayed symbology on the TDU or within the CPG's HDU. When the CPG's selected sight is HMD, the symbology within the CPG's HDU will be adjusted. When the CPG's selected sight is TADS or FCR, the symbology brightness on the TDU will be adjusted. The symbology brightness may be incrementally adjusted using short presses, or continually adjusted using continuous presses.
9. **BRT Rocker Switch.** Controls the overall brightness level of the TDU or CPG's HDU. When the CPG's selected sight is HMD, the overall brightness level of the CPG's HDU will be adjusted. When the CPG's selected sight is TADS or FCR, the overall brightness level of the TDU will be adjusted. The brightness level may be incrementally adjusted using short presses, or continually adjusted using continuous presses.
10. **CON Rocker Switch.** Controls the contrast level of the TDU or CPG's HDU. When the CPG's selected sight is HMD, the contrast level of the CPG's HDU will be adjusted. When the CPG's selected sight is TADS or FCR, the contrast level of the TDU will be adjusted. The contrast level may be incrementally adjusted using short presses, or continually adjusted using continuous presses.
11. **Asterisk Button.** Resets the overall brightness and contrast levels to their default settings. When the CPG's selected sight is HMD, the overall brightness and contrast of the CPG's HDU will be reset. When the CPG's selected sight is TADS or FCR, the overall brightness and contrast of the TDU will be reset.
12. **R/F Rocker Switch.** Adjusts the range focus of the selected TADS sensor. Pressing up on the rocker switch sets the focus to longer ranges. Pressing down on the rocker switch sets the focus to shorter ranges. The focus may be incrementally adjusted using short presses, or continually adjusted using continuous presses.
13. **EL Rocker Switch.** Not implemented.
14. **AZ Rocker Switch.** Not implemented.
15. **AZ/EL Button.** Not implemented.
16. **ACM Button.** Not implemented.
17. **FREEZE Button.** Freezes the current frame on the TDU video screen. The video output will continue to update normally on other displays within either crewstation.
18. **FILTER Button.** Not implemented.

TEDAC Left Handgrip (LHG)



1. **Image Auto Track/Offset Switch.** Controls the Image Auto-Track (IAT) targeting functions of the TADS.
   - **IAT (Forward).** Commands an auto-track on the target within the TADS line-of-sight (LOS) reticle and sets it as the IAT primary track.

     If the TADS LOS reticle is within the IAT primary track gates, commands the primary track Aim Point to update its position to the centroid of the TADS LOS reticle.
   - **OFS (Aft).** If the TADS LOS is outside the IAT primary track gates, a short press (<0.5 second) to the OFS position will command the TADS LOS reticle to return to the IAT primary track from its offset postion.

     If the TADS LOS is within the IAT primary track gates, a short press (<0.5 second) to the OFS position will drop the primary track.

     A long press (>0.5 second) to the OFS position will command the TADS to drop the primary track and any secondary tracks, regardless of the current position of the TADS LOS reticle.
2. **TADS Field-Of-View Switch.** Selects the magnification field-of-view of the TADS FLIR/DTV cameras.
   - **W (Wide, Right).** Sets the FLIR/DTV optical magnification to wide field-of-view.
   - **M (Medium, Aft).** Sets the FLIR optical magnification to medium field-of-view. If DTV is the selected sensor, sets the DTV optical magnification to wide field-of-view.
   - **N (Narrow, Left).** Sets the FLIR/DTV optical magnification to narrow field-of-view.
   - **Z (Zoom, Forward).** Sets the FLIR/DTV video to a 2:1 electronic magnification.
3. **Video Record Button.** Not implemented.

4. **TADS Sensor Select Switch.** Selects the TADS sensor to be used for targeting. This switch position is overridden and commanded to FLIR when the CPG NVS Mode switch is set to NORM or FIXED.
   - **FLIR (Forward).** Sets the TADS sensor video to the FLIR thermographic camera.
   - **TV (Center).** Sets the TADS sensor video to the DTV camera.
   - **DVO (Aft).** No function.
5. **Weapon Action Switch (WAS).** Selects, or "actions", a weapon system for employment. (Also known as "WASing", pronounced "Wahz-ing"). Selecting the same weapon a second time will de-select, or "de-action", the weapon. If the Copilot/Gunner actions a weapon from the TEDAC Left Handgrip (LHG), only the weapon trigger on the LHG will be activated for weapons employment from the CPG station.

   Neither crewstation has priority over the other, allowing either cyclic Weapon Action Switch to action the weapon, taking control away from the other crewstation in a "last actioned" logic.
   - **GUN (Forward).** Actions/de-actions the Area Weapon System (AWS) for employment and slaves the gun to the weapon solution of the selected sight within the crewstation.
   - **RKT (Left).** Actions/de-actions the Aerial Rocket Sub-system (ARS) for employment, activates pylon articulation, and displays the Rocket Steering Cursor symbology within the crewstation.

     If the CPG actions rockets using the Weapon Action Switch on the LHG and the Pilot actions rockets, the crew will enter COOP (Cooperative) rocket mode.

     If the CPG actions rockets using the Weapon Action Switch on the CPG cyclic and the Pilot actions rockets, the rockets will be assigned to either crewstation using the "last actioned" logic.
   - **MSL (Right).** Actions/de-actions the Hellfire Modular Missile System (HMMS) for employment, activates pylon articulation, and displays the Missile Launch symbology within the crewstation.
   - **ATA (Aft).** No function.

   NOTE: Weapons cannot be actioned if the aircraft is weight-on-wheels unless GND ORIDE has been enabled on the Armament Panel to override this inhibit.
6. **Store/Update Switch.** Stores new target or waypoint locations using the CPG's selected sight or performs a position update to the aircraft navigation system.
   - **Store Point (STORE, Forward).** When the CPG's selected sight is TADS, moving the switch momentarily to this position stores a Target (TG) point along the TADS line-of-sight at the current range.

     When the CPG's selected sight is FCR, moving the switch momentarily to this position stores a Target (TG) point at the location of the Next-To-Shoot (NTS) target.

     When used in conjunction with the TSD Point sub-page, may be used to store a Waypoint (WP) or Target (TG) point, and may be used in conjunction with either the HMD or the TADS.
   - **Update Position (UPDT, Aft).** Not implemented.
7. **FCR Mode Switch.** Selects the FCR mode of operation when the CPG's selected sight is FCR and the FCR is not scanning. (See FCR Modes in the Fire Control Radar chapter for more information.)
   - **GTM (Forward).** Selects Ground Targeting Mode to detect and classify ground vehicles and low-flying aircraft.
   - **RMAP (Right).** Selects Radar Map mode to detect and classify ground vehicles and low-flying aircraft; or to analyze the battlefield using a radar-generated surface map of the terrain. Re-selecting RMAP when the FCR mode is already set to RMAP will toggle the terrain video underlay on the FCR page.

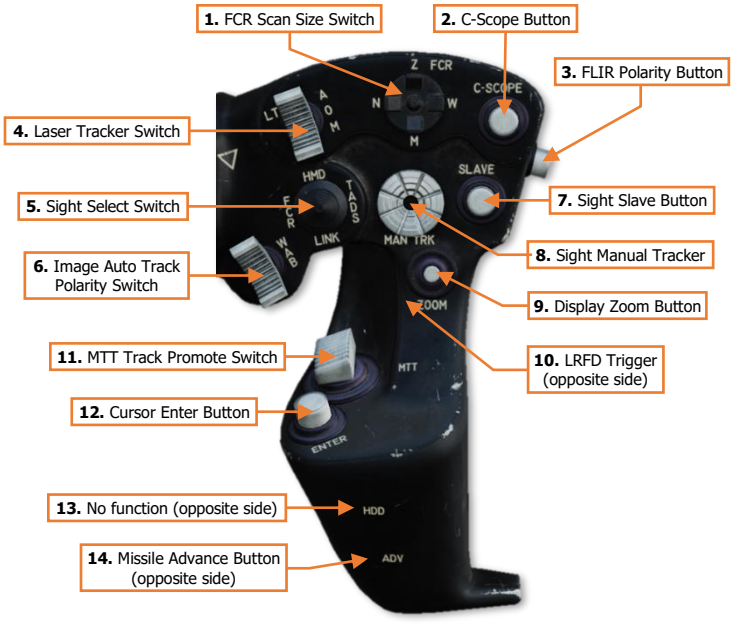
- **ATM (Aft).** Selects Air Targeting Mode to detect and classify rotary- and fixed-wing aircraft within the immediate airspace.
- **TPM (Left).** Selects Terrain Profile Mode to aid in terrain and obstacle avoidance while operating at low altitudes during low-visibility conditions. (N/I)

8. **Cursor Controller/Enter (CURSOR).** Controls the MPD cursor movement on the MPD, allowing bezel options to be selected by the cursor in lieu of the bezel buttons; or cursor-selection of points on the MPD itself. Depressing the Cursor Controller commands the highlighted item underneath the cursor to be selected.
9. **Cursor Display Select (L/R) Button.** Sets the MPD cursor to the center of the opposite MPD.
10. **Weapon Trigger.** Fires the weapon system that has been actioned within the crewstation if the A/S button on the Armament panel is set to ARM.
    - **First Detent.** Fires the weapon system if no Performance or Safety Inhibits are present.
    - **Second Detent.** Fires the weapon system if no Safety Inhibits are present.

    (See Weapon Inhibits in the Weapons Employment chapter for more information.)
11. **FCR Scan Switch.** When the CPG's selected sight is FCR, momentarily setting the switch to either position will initiate an FCR scanburst. If the FCR is already performing a single or continuous scanburst, momentarily setting the switch to either position will terminate the ongoing scanburst. (See Scans and Scanbursts in the Fire Control Radar chapter for more information.)
    - **S-SCAN (Forward).** Initiates a single scanburst. The FCR will perform several scans of the FCR scan volume and then terminate scanning. The number of scans that are performed within a single scanburst are dependent on the selected scan size.
    - **C-SCAN (Aft).** Initiates a continuous scanburst. The FCR will perform scans of the FCR scan volume continuously until manually terminated by the crewmember or until a different sight is selected.

    NOTE: The FCR cannot transmit if the aircraft is weight-on-wheels unless GND ORIDE has been enabled on the Armament Panel to override this inhibit.
12. **Cued Search (CUED) Button.** Not implemented.
13. **Linear Motion Compensation (LMC) Button.** Toggles the Linear Motion Compensation function of the TADS system. (See Target Acquisition Designation Sight (TADS) for more information.)
14. **Cage Button.** No function.

TEDAC Right Handgrip (RHG)



1. **FCR Scan Size Switch.** Selects the FCR scan size when the CPG's selected sight is FCR and the FCR is not scanning.
   - **W (Wide, Right).** Sets the FCR scan volume to 90° in azimuth if the FCR mode is GTM or RMAP. Sets the FCR scan volume to 360° in azimuth if the FCR mode is ATM.
   - **M (Medium, Aft).** Sets the FCR scan volume to 45° in azimuth if the FCR mode is GTM or RMAP. Sets the FCR scan volume to 180° in azimuth if the FCR mode is ATM.
   - **N (Narrow, Left).** Sets the FCR scan volume to 30° in azimuth if the FCR mode is GTM or RMAP. Sets the FCR scan volume to 90° in azimuth if the FCR mode is ATM.
   - **Z (Zoom, Forward).** Sets the FCR scan volume to 15° in azimuth if the FCR mode is GTM or RMAP. Sets the FCR scan volume to 45° in azimuth if the FCR mode is ATM.
2. **C-SCOPE Button.** Enables/disables the FCR C-Scope symbol overlays in the CPG crewstation.
3. **FLIR Polarity Button.** Toggles the FLIR image polarity between white-hot and black-hot.
4. **Laser Tracker (LT) Switch.** Enables/disables the Laser Spot Track (LST) mode of the TADS system.
   - **A (Automatic, Forward).** Enables the LST in Automatic mode and inhibits the LRFD from firing.
   - **O (Off, Center).** Disables the LST and permits the LRFD to fire.
   - **M (Manual, Aft).** Enables the LST in Manual mode and inhibits the LRFD from firing.

5. **Sight Select Switch.** Selects the sight to be used for targeting and weapon employment within the Copilot/Gunner (CPG) crewstation. (See Sights & Sensors in the Tactical Employment chaptor for more information.)
   - **HMD (Forward).** Sets the CPG sight to the CPG's Helmet-Mounted Display. The CPG's HDU will display HMD Flight symbology.
   - **FCR (Left).** Sets the CPG crewstation sight to the Fire Control Radar and displays the FCR page on the left MPD if not already displayed. When selected while the CPG's NVS Mode switch is set to OFF, the CPG's HDU will display TADS Weapon symbology and TADS sensor video. If the Pilot is using the TADS as his/her NVS sensor, the CPG's HDU will display HMD Flight symbology.

     Neither crewstation has priority over the other, allowing either Sight Select Switch to select the FCR as the sight, taking control away from the other crewstation in a "last selected" logic.
   - **TADS (Right).** Sets the CPG sight to the Target Acquisition Designation Sight. The CPG's HDU will display TADS Weapon symbology and TADS sensor video. If either crewmember is using the TADS as their NVS sensor, this switch position will be inhibited.
   - **LINK (Aft).** If the CPG's selected sight is FCR, this position will slave the TADS to the FCR Next-To-Shoot (NTS) target. If the CPG's selected sight is TADS, this position will slave the FCR centerline to the azimuth of the TADS line-of-sight. (See the Fire Control Radar chapter for more information.)
6. **Image Auto Track Polarity Switch.** Not implemented.
7. **Sight Slave Button.** Slaves/de-slaves the CPG's selected sight to the selected acquisition source.
8. **Sight Manual Tracker.** Manually controls the CPG's selected sight (TADS or FCR) when de-slaved from the selected acquisition source. Also called the "thumb force controller".
9. **Display Zoom Button.** Enables/disables the FCR ZOOM format on the FCR page when the CPG's selected sight is FCR.
10. **LRFD Trigger.** Fires the laser rangefinder/designator if the A/S button on the Armament panel is set to ARM and the LRFD is powered (VAB L6 on the WPN Utility sub-page).
    - **First Detent.** Fires a short pulse of laser energy for range-finding purposes. To fire additional range-finding pulses, the trigger must be released prior to pulling the trigger again.
    - **Second Detent.** Fires a continuous pulse of laser energy for designation purposes, for the duration the trigger is depressed.
11. **MTT Track Promote Switch.** When using the Multi-Target Track sub-mode of the Image Auto-Track, this switch cycles the primary track through each auto-tracked target.
    - **– (Forward).** Promotes the previous secondary track as the primary track and commands the TADS LOS reticle to the Aim Point of the new primary track.
    - **+ (Aft).** Promotes the next secondary track as the primary track and commands the TADS LOS reticle to the Aim Point of the new primary track.
12. **Cursor Enter Button.** Commands the highlighted item underneath the cursor to be selected. Used as an alternate method of cursor-selection in lieu of depressing the Cursor Controller itself.
13. **Heads-Down Display (HDD) Button.** No function.
14. **Missile Advance Button.** Steps to the next AGM-114 missile in sequence. This button is only functional when the missile Mode is set to MAN on the WPN page MSL format.

CYCLIC & COLLECTIVE HAND CONTROLS

The cyclic and collective hand controls allows either crewmember to control many of the aircraft functions regarding sensors, weapons, communications, and defensive systems without removing their hands from the flight controls.

The Pilot and Copilot/Gunner cyclic and collective grips are identical in form and function. The only exceptions to this are the BUCS trigger on the Pilot's Collective Flight Grip is non-functional, and the Pilot is unable to select TADS as a sight using the Sight Select switch on the Collective Mission Grip.

Cyclic Grip

The Cyclic Grip is used to control weapons, communications, and countermeasure functions. It also includes controls for selecting IHADSS Flight symbology modes or FMC functions.

1. **Force Trim/Hold Mode Switch.** Controls the force trim and Hold modes provided by the Flight Management Computer (FMC).

   - **R (Release, Forward).** When held forward, the force trim is interrupted, releasing the magnetic brakes on the cyclic and pedals. While force trim is interrupted, Heading Hold and Attitude Hold will be disengaged.

     When the switch itself is released, the force trim will re-engage the magnetic brakes on the cyclic and pedals, set a new force trim reference point at the current cyclic/pedal positions in pitch, roll and yaw, and any applicable hold modes will re-engage (assuming their specific re-engagement logic is met).

   - **AT (Attitude Hold, Left).** Activates/deactivates Attitude Hold.
   - **AL (Altitude Hold, Right).** Activates/deactivates Altitude Hold.
   - **D (Disengage, Aft).** Deactivates Attitude Hold and Altitude Hold.

2. **Weapon Action Switch (WAS).** Selects, or "actions", a weapon system for employment. (Also known as "WASing", pronounced "Wahz-ing"). Selecting the same weapon a second time will de-select, or "de-action", the weapon. If the Copilot/Gunner actions a weapon from the Cyclic Grip, only the weapon trigger on the Cyclic Grip will be activated for weapons employment from the CPG station.

   Neither crewstation has priority over the other, allowing either cyclic Weapon Action Switch to action the weapon, taking control away from the other crewstation in a "last actioned" logic.

   - **G (Gun, Forward).** Actions/de-actions the Area Weapon System (AWS) for employment and slaves the gun to the weapon solution of the selected sight within the crewstation.
   - **R (Rocket, Left).** Actions/de-actions the Aerial Rocket Sub-system (ARS) for employment, activates pylon articulation, and displays the Rocket Steering Cursor symbology within the crewstation.

     If the CPG actions rockets using the Weapon Action Switch on the TEDAC Left Handgrip (LHG) and the Pilot actions rockets, the crew will enter COOP (Cooperative) rocket mode.

     If the CPG actions rockets using the Weapon Action Switch on the CPG cyclic and the Pilot actions rockets, the rockets will be assigned to either crewstation using the "last actioned" logic.
   - **M (Missile, Right).** Actions/de-actions the Hellfire Modular Missile System (HMMS) for employment, activates pylon articulation, and displays the Missile Launch symbology within the crewstation.
   - **A (Air-To-Air, Aft).** No function.

3. **Symbology Select Switch.** Selects the IHADSS symbology mode. The symbology mode is common to both crewstations, in that the symbology will remain the same for both crewmembers, regardless of which Symbology Select Switch was used to change the IHADSS symbology mode. (See Integrated Helmet and Display Sighting System for more information.)

   - **CT (Cruise/Transition, Forward).** Selects Transition symbology mode. If Transition symbology is already displayed, each subsequent press will toggle between Cruise and Transition symbology modes.
   - **HB (Hover/Bob-Up, Aft).** Selects Hover symbology mode. If Hover symbology is already displayed, each subsequent press will toggle between Bob-Up and Hover symbology modes. Each time Bob-Up mode is entered, a new Bob-Up box will be "dropped", and the command heading will be referenced to the current heading value.
   - **FLT Page Access/Return (Z-Axis, Depress).** Displays the FLT page on the left MPD within the crewstation. If the FLT page is already displayed, it will have no effect. If the FLT page is displayed on the right MPD, the MPD pages will be swapped.

     If no button is pressed on the FLT page within 10 minutes, depressing the Symbology Select Switch will return the left MPD to the previous page. After 10 minutes, the return logic will timeout and will no longer be available.

4. **PTT/RTS Switch.** Activates the crewmember's microphone or selects the next radio for transmission.

   - **RADIO (Left).** Transmits over the radio currently selected by the RTS indicator on the EUFD.
   - **ICS (Right).** Transmits over the cockpit intercom to the opposite crewstation and/or ground crews.
   - **RTS (Depress).** Cycles the Radio Transmit Select indicator on the EUFD to the next radio in sequence. If the RTS indicator is set to the HF radio at the bottom of the list, RTS indicator will cycle to the VHF radio at the top of the list.

   (See Enhanced Up-Front Display for more information.)

5. **Chaff Dispense (C) Button.** Dispenses a single chaff program if the Chaff Mode is set to PROGRAM. Dispenses an individual chaff cartridge if the chaff mode is set to MANUAL. (See the Aircraft Survivability Equipment page for more information.)

6. **Flare Dispense (FLARE) Button.** Dispenses a single flare program. (See the Common Missile Warning System for more information.)
7. **Weapon Trigger (Guarded).** Fires the weapon system that has been actioned within the crewstation.
   - **First Detent.** Fires the weapon system if no Performance or Safety Inhibits are present.
   - **Second Detent.** Fires the weapon system if no Safety Inhibits are present.

   (See Weapon Inhibits in the Weapons Employment chapter for more information.)
8. **Cage Button.** No function.
9. **FMC Release Button.** Deactivates the Pitch, Roll, Yaw, and Collective FMC channels. The FMC channels may be re-activated from the Utility page, if necessary.

Collective Flight Grip

The Collective Flight Grip is used to control critical aircraft functions and Night Vision System (NVS) settings.

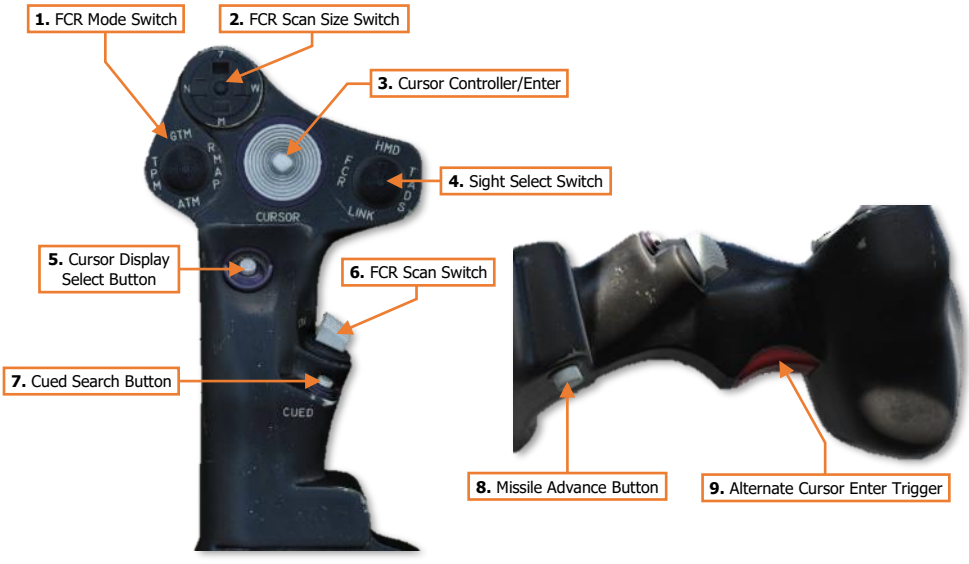
1. **Emergency Jettison (JETT) Button (Guarded).** Jettisons all weapon stations from the wing pylons.
2. **Boresight/Polarity Switch.** Controls the FLIR polarity for the NVS sensor assigned to the crewstation.
   - **B/S (Boresight).** No function.
   - **PLRT (Polarity).** Toggles the FLIR image polarity between white-hot and black-hot.
3. **Searchlight Switch.** Activates, deactivates, or stows the fuselage-mounted search/landing light.
   - **ON (Forward).** Powers the searchlight on.
   - **OFF (Center).** Powers the searchlight off.
   - **STOW (Aft).** Commands the searchlight to retract to the stowed position. The switch will be spring-loaded from STOW to the OFF position.

4. **Searchlight Position Switch.** Controls the position of the fuselage-mounted search/landing light. Searchlight position control will be inhibited for 1 minute after STOW is commanded.
   - **EXT (Extend, Forward).** Rotates the searchlight bulb forward and up.
   - **L (Left).** Rotates the searchlight bulb left/counter-clockwise.
   - **R (Right).** Rotates the searchlight bulb right/clockwise.
   - **RET (Retract, Aft).** Rotates the searchlight bulb down and back.
5. **NVS Select Switch.** Selects the NVS sensor within the crewstation. When this occurs, the format of the Field-Of-Regard Box within each crewmember's IHADSS symbology will update to reflect their selected NVS sensor azimuth/elevation slew limits. (See IHADSS Flight Symbology for more information.)
   - **TADS (Forward).** Selects the TADS as the NVS sensor in the crewstation.
   - **PNVS (Aft).** Selects the PNVS as the NVS sensor in the crewstation.

   Neither crewstation has priority over the other, allowing the NVS Select Switch in either crewstation to select either NVS sensor.
6. **Stabilator Control Switch.** Sets the horizontal stabilator to Manual or Automatic mode, and controls the stabilator angle when set to Manual mode.
   - **ND (Nose-Down, Forward).** Slews the stabilator trailing edge down, causing the nose to pitch forward. If the stabilator is in Automatic mode, this position will set the mode to Manual.
   - **NU (Nose-Up, Aft).** Slews the stabilator trailing edge up, causing the nose to pitch up. If the stabilator is in Automatic mode, this position will set the mode to Manual.
   - **RESET (Depress).** Resets the stabiliator mode to Automatic.
7. **Engine Chop (CHOP) Button (Guarded).** Pressing this button activates the Engine Chop circuit, which reduces engine power to idle. Pressing it again resets the Engine Chop circuit and restores normal engine power. (N/I)
8. **Tail Wheel Lock/Unlock Button.** Toggles the commanded state of the tail wheel locking mechanism between locked and unlocked. (See Ground Taxi in the Procedures chapter for more information.)
9. **BUCS Trigger (CPG only).** Enables the Copilot/Gunner (CPG) to override the flight controls in the Pilot crewstation when the Back-Up Control System (BUCS) is on. This trigger is non-functional in the Pilot crewstation. (N/I)

Collective Mission Grip

The Collective Mission Grip is used to control the Fire Control Radar (FCR), the MPD cursor, and sight selection.



1. **FCR Mode Switch.** Selects the FCR mode of operation when the crewmember's selected sight is FCR and the FCR is not scanning. (See FCR Modes in the Fire Control Radar chapter for more information.)
   - **GTM (Forward).** Selects Ground Targeting Mode to detect and classify ground vehicles and low-flying aircraft.
   - **RMAP (Right).** Selects Radar Map mode to detect and classify ground vehicles and low-flying aircraft; or to analyze the battlefield using a radar-generated surface map of the terrain. Re-selecting RMAP when the FCR mode is already set to RMAP will toggle the terrain video underlay on the FCR page.
   - **ATM (Aft).** Selects Air Targeting Mode to detect and classify rotary- and fixed-wing aircraft within the local airspace.
   - **TPM (Left).** Selects Terrain Profile Mode to aid in terrain and obstacle avoidance while operating at low altitudes during low-visibility conditions. (N/I)
2. **FCR Scan Size Switch.** Selects the FCR scan size when the crewmember's selected sight is FCR and the FCR is not scanning.
   - **W (Wide, Right).** Sets the FCR scan volume to 90° in azimuth if the FCR mode is GTM or RMAP. Sets the FCR scan volume to 360° in azimuth if the FCR mode is ATM.
   - **M (Medium, Aft).** Sets the FCR scan volume to 45° in azimuth if the FCR mode is GTM or RMAP. Sets the FCR scan volume to 180° in azimuth if the FCR mode is ATM.
   - **N (Narrow, Left).** Sets the FCR scan volume to 30° in azimuth if the FCR mode is GTM or RMAP. Sets the FCR scan volume to 90° in azimuth if the FCR mode is ATM.
   - **Z (Zoom, Forward).** Sets the FCR scan volume to 15° in azimuth if the FCR mode is GTM or RMAP. Sets the FCR scan volume to 45° in azimuth if the FCR mode is ATM.

3. **Cursor Controller/Enter (CURSOR).** Controls the MPD cursor movement on the MPD, allowing bezel options to be selected by the cursor in lieu of the bezel buttons; or cursor-selection of points on the MPD itself. Depressing the Cursor Controller commands the highlighted item underneath the cursor to be selected.

4. **Sight Select Switch.** Selects the sight to be used for targeting and weapon employment within the crewstation. (See Sights & Sensors in the Tactical Employment chaptor for more information.)

   - **HMD (Forward).** Sets the crewstation sight to the Helmet-Mounted Display. The crewmember's HDU will display HMD Flight symbology.

   - **FCR (Left).** Sets the crewstation sight to the Fire Control Radar and displays the FCR page on the left MPD if not already displayed.

     When selected in the Copilot/Gunner (CPG) crewstation while the CPG's NVS Mode switch is set to OFF, the CPG's HDU will display TADS Weapon symbology and TADS sensor video. If the Pilot is using the TADS as his/her NVS sensor, the CPG's HDU will display HMD Flight symbology.

     Neither crewstation has priority over the other, allowing either Sight Select Switch to select the FCR as the sight, taking control away from the other crewstation in a "last selected" logic.

   - **TADS (Right).** Sets the Copilot/Gunner (CPG) sight to the Target Acquisition Designation Sight. If the CPG's NVS Mode switch is set to OFF, the CPG's HDU will display TADS Weapon symbology and TADS sensor video. If either crewmember is using the TADS as their NVS sensor, this switch position will be inhibited.

     This switch position is non-functional in the Pilot crewstation.

   - **LINK (Aft).** If the crewmember's selected sight is FCR, this position will slave the TADS to the FCR Next-To-Shoot (NTS) target. If the CPG's selected sight is TADS, this position in the CPG crewstation will slave the FCR centerline to the azimuth of the TADS line-of-sight. (See the Fire Control Radar chapter for more information.)

5. **Cursor Display Select Button.** Sets the MPD cursor to the center of the opposite MPD.

6. **FCR Scan Switch.** When the crewmember's selected sight is FCR, momentarily setting the switch to either position will initiate an FCR scanburst. If the FCR is already performing a single or continuous scanburst, momentarily setting the switch to either position will terminate the ongoing scanburst. (See Scans and Scanbursts in the Fire Control Radar chapter for more information.)

   - **S-SCAN (Forward).** Initiates a single scanburst. The FCR will perform several scans of the FCR scan volume and then terminate scanning. The number of scans that are performed within a single scanburst are dependent on the selected scan size.

   - **C-SCAN (Aft).** Initiates a continuous scanburst. The FCR will perform scans of the FCR scan volume continuously until manually terminated by the crewmember or until a different sight is selected.

   NOTE: The FCR cannot transmit if the aircraft is weight-on-wheels unless GND ORIDE has been enabled on the Armament Panel to override this inhibit.

7. **Cued Search (CUED) Button.** Not implemented.

8. **Missile Advance Button.** Steps to the next AGM-114 missile in sequence. This button is only functional when the missile Mode is set to MAN on the WPN page MSL format.

9. **Alternate Cursor Enter Trigger.** Commands the highlighted item underneath the cursor to be selected. Used as an alternate method of cursor-selection in lieu of depressing the Cursor Controller itself.

INTEGRATED HELMET AND DISPLAY SIGHTING SYSTEM (IHADSS)

The IHADSS allows the crewmembers to view flight and navigation information, sensor video, targeting information, and weapon status. The IHADSS also allows each crewmember to independently cue weapons and sensors using their head movements. The system is an integral part of flight operations during the day, and a crucial system in performing flight operations at night.

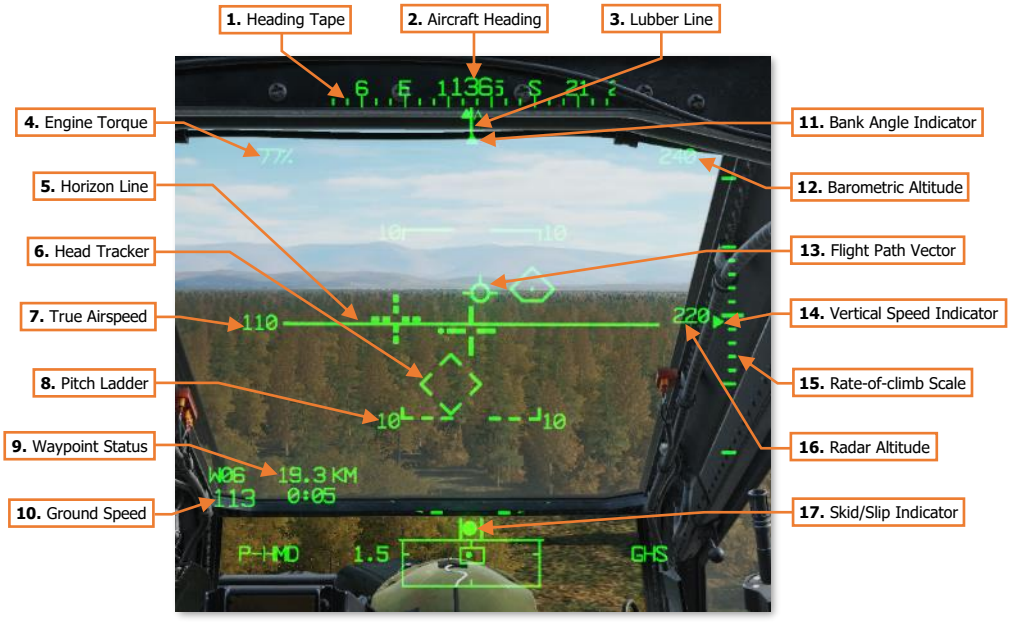
As a subcomponent of the IHADSS, each crewmember's individual Helmet Display Unit (HDU) projects symbology and video onto a combiner lens directly in front of the crewmembers' right eye. Similar to a Heads-Up Display (HUD) found in many other aircraft types, the HDU is the primary source of flight and navigation data for the crewmember that is on the controls. However, unlike many HUD designs that are fixed to an aircraft's instrument panel, the HDU in the AH-64 is designed to allow a crewmember to view and effectively utilize this data without requiring them to focus their attention straight ahead over the nose of the aircraft.

Symbology is displayed within the crewmember HDU's in one of two formats: Flight symbology or Weapon symbology. Weapon symbology is displayed within the CPG's HDU when the CPG's selected sight is TADS.

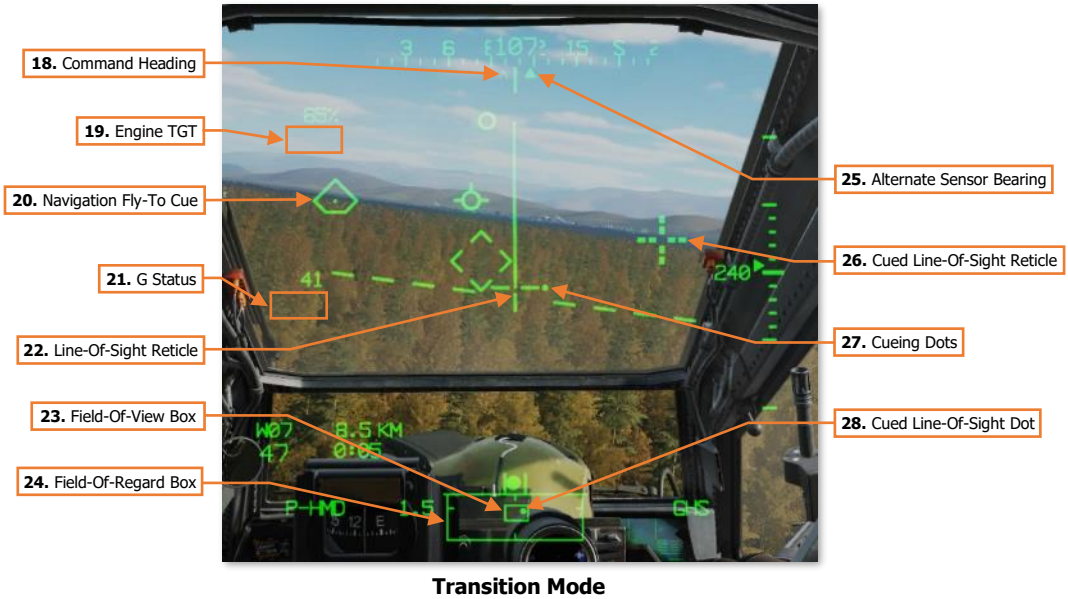
(See TADS Weapon Symbology for more information.)

Flight Symbology

The Pilot is always presented with Flight symbology within the HDU. The Copilot/Gunner (CPG) is presented with Flight symbology within the HDU when the CPG's selected sight is HMD, or any time the CPG's NVS Mode is set to NORM or FIXED. Flight symbology is presented to the crewmembers in one of four symbology modes: Cruise, Transition, Hover, or Bob-Up. The Symbology Select Switch on either Cyclic Grip is used to change the selected symbology mode for both crewstations simultaneously.

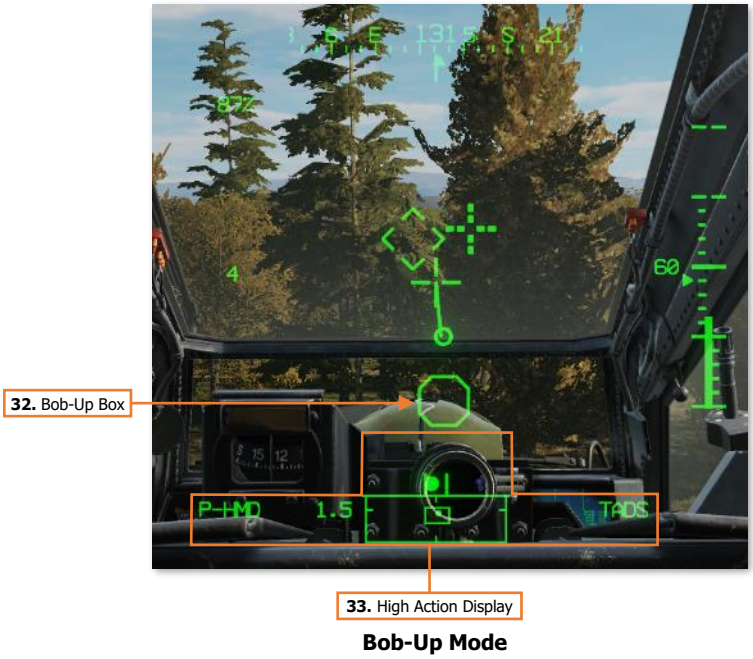


Cruise Mode



Transition Mode

Hover Mode



Bob-Up Mode

1. **Heading Tape.** Displays a 180° hemisphere of magnetic headings. Major tick marks are displayed in 30° increments and marked by a cardinal direction or heading in the tens value. Minor tick marks are displayed in 10° increments.

2. **Aircraft Heading.** Displays a digital readout of the aircraft's current magnetic heading in 1° increments, superimposed over the Heading Tape.

3. **Lubber Line.** The Lubber Line is aligned to the centerline of the aircraft and serves as a reference for both the aircraft heading and for the Bank Angle Indicator when in Cruise symbology mode.

4. **Engine Torque.** Displays the highest torque value of the two engines, in 1% increments. A box will be displayed around the torque at 98% or greater. If the difference in engine torque values exceeds 12%, the torque digital readout will flash.

5. **Horizon Line.** Indicates the horizon position and orientation relative to the aircraft nose, which is referenced to the LOS Reticle.

   When in Cruise symbology mode, the the Horizon Line is displaced in pitch in a 2:1 movement ratio.

   When in Transition symbology mode, the Horizon Line is displaced in pitch in a 4:1 movement ratio, up to a maximum of ±30°. When aircraft pitch attitude exceeds ±30° in pitch, the Transition mode Horizon Line will remain saturated at maximum deflection until the pitch attitude is less than ±30°.

6. **Head Tracker.** Represents the armament datum line (ADL, or centerline) of the aircraft; 0° in azimuth and -4.9° in elevation. The Head Tracker assists the crewmembers in maintaining awareness of their head position relative to the nose of the aircraft, especially under low-light conditions while using the PNVS or TADS sensors for flight and navigation.

7. **True Airspeed.** Indicates the true airspeed (TAS) of the aircraft in 1 knot increments, from 0 to 210 knots. The airspeed indication is boxed if the airspeed exceeds V_{NE}.

   When Attitude Hold is engaged, a rounded "status window" box is displayed around the TAS digital readout.

8. **Pitch Ladder.** Indicates aircraft pitch attitude when in Cruise symbology mode. Pitch ladder increments are displayed at ±10°, ±20°, ±30°, ±45° and ±60° pitch.

9. **Waypoint Status.** Displays the point selected for navigation, its distance in kilometers or nautical miles, and estimated time enroute (ETE). The ETE is based on the current ground speed and distance remaining, and is presented in HH:MM format when the ETE is ≥5 minutes, or M:SS format when ETE is <5 minutes.

   The ETE is not displayed when ground speed is <15 knots or ETE is >10 hours. Waypoint Status information is not displayed if there is no active destination point.

10. **Ground Speed.** Indicates the speed across the surface in 1 knot increments. Ground Speed is only displayed in Cruise and Transition symbology modes, and only when the primary INU is aligned.

11. **Bank Angle Indicator.** Indicates bank angle relative to the horizon when in Cruise symbology mode. When the Bank Angle Indicator is aligned with the lubber line below the heading tape, the aircraft is in a level attitude.

12. **Barometric Altitude.** Indicates the barometric altitude when Cruise mode symbology is displayed. Barometric Altitude is displayed in 10-foot increments from -2,300 feet to 20,000 feet.

13. **Flight Path Vector.** The Flight Path Vector (FPV) represents the point towards which the helicopter is flying. It is a 3-dimensional representation of the aircraft's velocity vector. The FPV is not displayed in Hover or Bob-Up symbology modes, if the 3-dimensional velocity is <5 knots ground speed, or if the aircraft is weight-on-wheels.

14. **Vertical Speed Indicator (VSI).** The Vertical Speed Indicator moves up and down the rate-of-climb scale to indicate vertical speed. The VSI becomes saturated at the ±1,000 fpm tick marks at the top or bottom of the Rate-of-climb Scale, augmented by digital readouts of rate-of-climb in 100 fpm increments.

15. **Rate-of-climb Scale.** Major tick marks are placed at 0, ±500 and ±1,000 feet per minute (fpm) rates of climb/descent. Minor tick marks are placed in 100 fpm increments between 0 and ±500 fpm. When the rate-of-climb/descent exceeds ±1,000 fpm, a digital readout to the nearest 100 fpm value is displayed adjacent to the 1,000 fpm major tick marks.

    When Altitude Hold is engaged, a rounded "homeplate" box is displayed next to the Rate-of-climb Scale at 0 fpm.

16. **Radar Altitude.** Indicates the radar-detected altitude above ground level from 0 to 1,428 feet. The Radar Altitude is displayed in increments of 1 foot from 0 to 50 feet in altitude, and increments of 10 feet between 50 feet and 1,428 feet in altitude.

    The Radar Altitude is not displayed when the altitude exceeds 1,428 feet above ground level.

17. **Skid/Slip Indicator.** Also called the "trim ball"; indicates whether the aircraft is in coordinated flight (also known as "in aerodynamic trim", or simply "in trim"). With the ball is centered between the tick marks, the aircraft is in coordinated flight, which minimizes drag. If the ball is left of center, applying left pedal will adjust tail rotor thrust to bring the aircraft back into coordinated flight. Likewise, if the ball is right of center, applying right pedal will adjust tail rotor thrust to bring the aircraft back into coordinated flight.

18. **Command Heading.** Indicates the magnetic heading to the Navigation Fly-To Cue when in Cruise, Transition, or Hover symbology modes. When Bob-up symbology mode is entered, the Command Heading chrevron is set to the heading of the aircraft, and maintained at that value until Bob-Up mode is exited.

19. **Engine TGT.** Displays the highest of the two engines' Turbine Gas Temperature (TGT) indications if operating in an intermediate or contingency TGT limit.

    When operating under dual engine intermediate power, the TGT (in °C) will be displayed during the final two minutes of either the 30-minute or 10-minute allowable timers.

    When operating under single engine contingency power, the TGT (in °C) will be displayed during the entire 2.5 minutes allowable for operating in the contingency power temperature range.

20. **Line-Of-Sight (LOS) Reticle.** Indicates the crewmember's helmet line-of-sight (LOS). The LOS Reticle is used as a positional reference for the Head Tracker, Horizon Line, Velocity Vector, Acceleration Cue, and Bob-Up Box. It is also used as an aiming crosshair for weapons employment, and is bolded when in Cruise symbology mode.

    The LOS Reticle flashes when the crewmember's LOS is invalid, the selected NVS sensor is at its slew limit, or if the gun is actioned and the gun system has failed and is no longer following the crewmember's helmet.

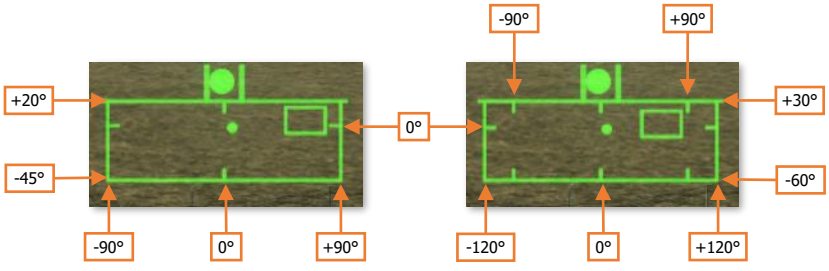
21. **Navigation Fly-To Cue.** Indicates the location of the current point selected for navigation. Also called the "homeplate" symbol, the Navigation Fly-To Cue is sized so the Flight Path Vector fits within it for precise 3-dimensional navigation.

    The Navigation Fly-To Cue is not displayed when the aircraft is weight-on-wheels.

22. **G Status.** Displays the accelerometer measured G-force on the aircraft when the load factor exceeds 2G's, or if within ¼G of the G load factor limit under the current conditions of velocity, density altitude, and gross weight.

23. **Field-Of-View (FOV) Box.** The FOV box indicates the relative position of the crewmember's helmet line-of-sight within the larger Field-of-Regard box. The FOV box represents a 30° x 40° field of view and is driven by the crewmember's helmet orientiation as detected by helmet sensors within each resepective cockpit.

24. **Field-Of-Regard (FOR) Box.** The FOR box indicates azimuth limits for the crewmember's Night Vision System (NVS) sensor turret. The format of the FOR box is determined by the NVS sensor (PNVS or TADS) assigned to that crewstation. Tick marks around the edges of the PNVS FOR box mark 0° in azimuth and elevation. Tick marks around the edges of the TADS FOR box mark 0° and ±90° in azimuth, and 0° elevation.



PNVS Format (Left) & TADS Format (Right)

25. **Alternate Sensor Bearing.** Indicates the magnetic heading of the opposite crewmember's selected sight when the opposite crewmember's sight is HMD or TADS.

    The Alternate Sensor Bearing symbol is not displayed when the other crewmember's selected sight is FCR.

26. **Cued Line-Of-Sight Reticle.** Indicates the virtual location of the crewmember's selected acquisition source.

    If CUEING is deselected on the Pilot's WPN Utility (UTIL) sub-page, this symbol is not displayed.

27. **Cueing Dots.** Indicates the quadrant direction of the selected acquisition source to "cue" the crewmember's helmet position to the location of the Cued LOS Reticle. The dots are removed when the Cued LOS Reticle is with 4° of that quadrant relative to the LOS Reticle.

    All four dots flash when the "IHADSS B/S REQUIRED" message is present within the Sight Status field of the High Action Display, indicating the crewmember needs to boresight their IHADSS.

    If CUEING is deselected on the Pilot's WPN Utility (UTIL) sub-page, these dots are not displayed.

28. **Cued Line-Of-Sight Dot.** Indicates the relative location of the selected acquisition source within the Field-of-Regard box.

29. **Acceleration Cue.** The Acceleration Cue indicates magnitude and direction of the aircraft's rate of acceleration. The Acceleration Cue is displayed in Transition, Hover, and Bob-Up symbology modes.

    When in Transition mode, or in Hover or Bob-Up modes when the ground speed is <6 knots, the Acceleration Cue is displaced from the outer point of the Velocity Vector. When in Hover or Bob-Up modes and the Velocity Vector becomes "saturated" at 6 knots ground speed, the Acceleration Cue displacement originates from the center of the LOS reticle.

30. **Velocity Vector.** The Velocity Vector indicates the aircraft's 2-dimensional direction and magnitude of velocity across the surface.

    In Hover and Bob-Up symbology modes, the Velocity Vector will become "saturated" (reaching it's maximum displacement) at 6 knots ground speed. In Transition symbology mode, the Velocity Vector will become saturated at 60 knots ground speed.

31. **Radar Altimeter Tape.** The Radar Altimeter Tape displays altitude above ground level in an "analog" format. Major tick marks are displayed in 50-foot increments between 0 and 200 feet. Minor tick marks are displayed in 10-foot increments between 0 and 50 feet.

When the aircraft has exceeded 200 feet AGL, the Radar Altimeter Tape will be removed from the symbology. The Radar Altimeter Tape will not be subsequently displayed until the aircraft descends below 180 feet AGL.

32. **Bob-Up Box.** The Bob-Up Box represents a 12-foot wide octogonal box anchored to a position on the surface below the helicopter.

    When Bob-Up symbology mode is entered, the Bob-Up Box is displayed and referenced to the 2-dimensional position on the surface the helicopter was located over when Bob-Up mode was entered. This is termed "dropping a Bob-Up box". The box will remain in this position until the crew changes symbology modes.

    As the aircraft moves laterally across the surface, the Bob-Up Box moves within the symbology to indicate the relative position of the reference location. When the Bob-Up box has become "saturated" (reaching it's maximum displacement), the aircraft has displaced 40 feet from the reference position on the surface. Once the aircraft returns to within 40 feet of the reference position, the Bob-Up Box will become de-saturated.

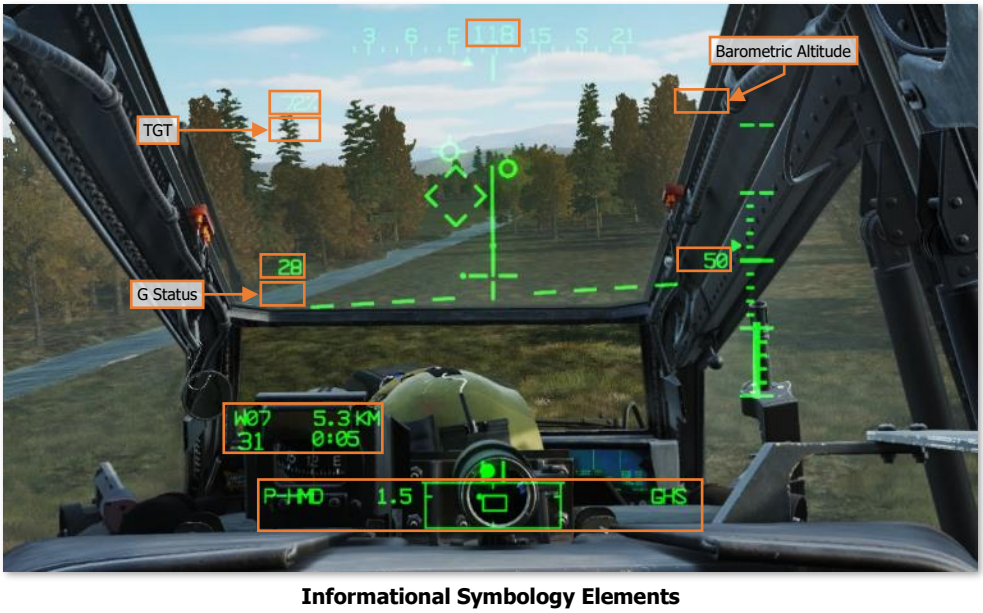
33. **High Action Display.** The High Action Display is displayed in both Flight and Weapons symbology. The HAD provides prioritized sight and weapon status messages to the crew for targeting and weapons employment. (See High Action Display in the Helmet-Mounted Display chapter for more information.)

Symbology Categories

Symbology elements can be grouped into one of four categories: Informational elements, Longitudinally scaled elements, Laterally scaled elements, and Virtual elements.

Informational Symbology Elements

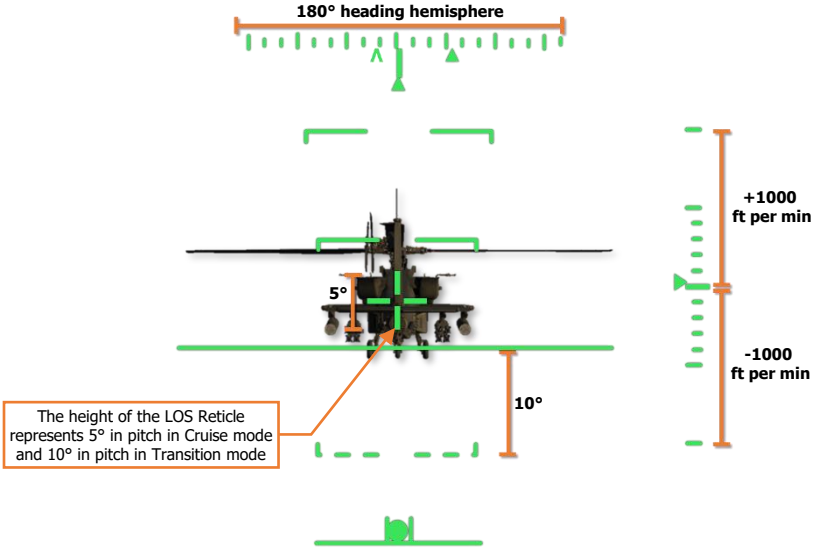
Symbology elements that provide data and status indications are fixed in location within the symbology. Some of these elements are only displayed in specific symbology modes, such as Ground Speed and Barometric Altitude. Other elements are only displayed when relevant; or when approaching an aircraft limitation, such as the G Status or Turbine Gas Temperature (TGT) indications.

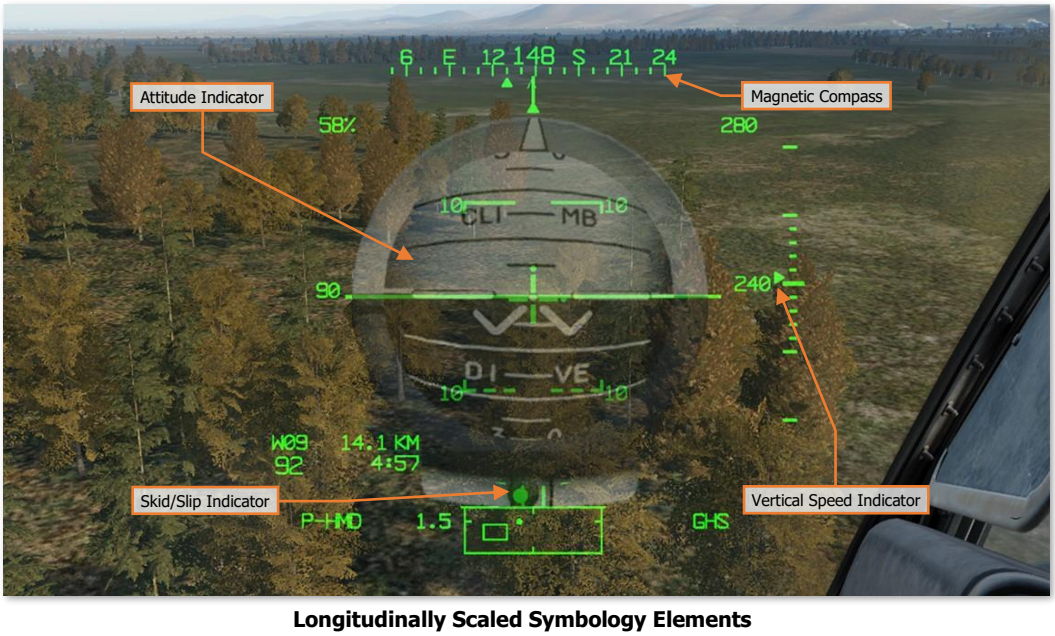


Informational Symbology Elements

Longitudinally Scaled Symbology Elements

Symbology elements that are longitudinally scaled include the Horizon Line, Pitch Ladder, Bank Angle Indicator, Skid/Slip Indicator, Vertical Speed Indicator and Rate-of-climb Scale, and the Heading Tape along with its associated azimuth indicators. These symbology elements can be thought of as representing a front-facing viewpoint from behind the helicopter, or as the IHADSS equivalent of the MPD FLT page.

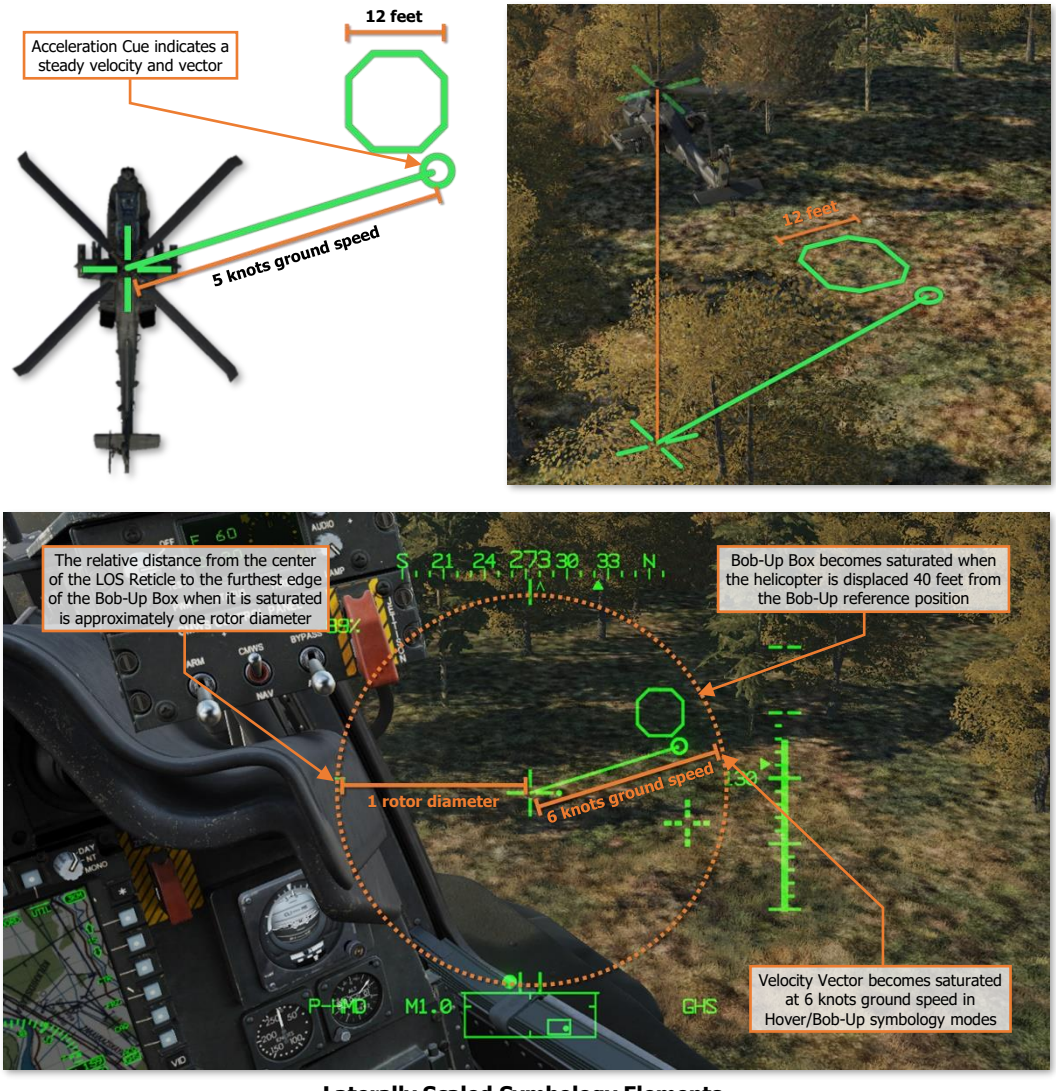




Longitudinally Scaled Symbology Elements

Laterally Scaled Symbology Elements

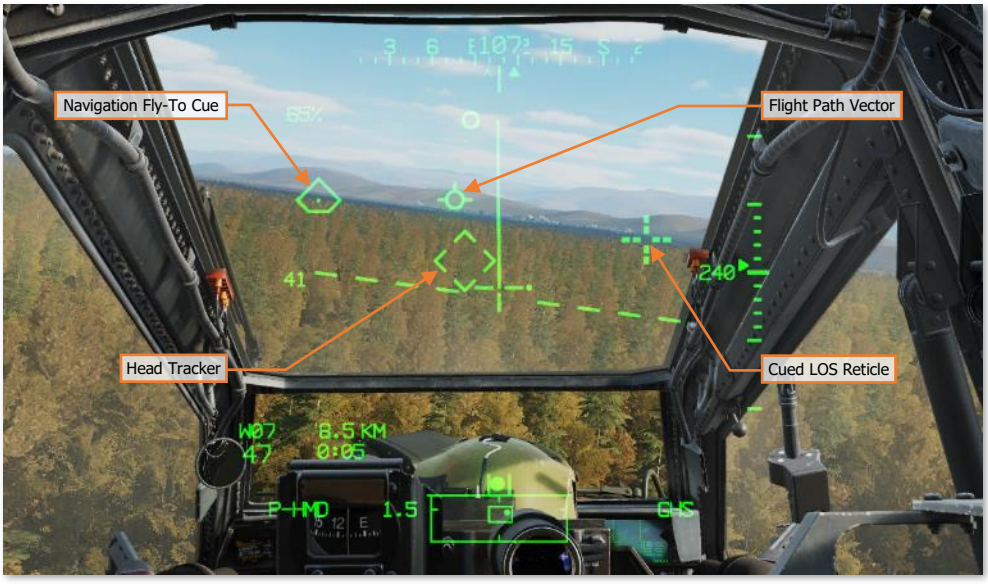
Symbology elements that are laterally scaled include the Velocity Vector, Acceleration Cue, and Bob-Up Box. These symbology elements can be thought of as representing a top-down view of the helicopter over the surface.



Laterally Scaled Symbology Elements

Virtual Symbology Elements

Virtual symbology elements include the Flight Path Vector, Head Tracker, Cued LOS Reticle, and Navigation Fly-To Cue. These symbology elements are displayed at their true positions relative to the crewmember's line-of-sight, as virtual representations of locations "out-the-window". As the crewmember turns his or her head, the positions of these symbols are updated within the symbology field-of-view in real-time so they reflect the true positions of their respective sources.



Virtual Symbology Elements

When C-Scope is enabled within the crewstation, FCR target data will also be displayed as virtual symbology elements.

Night Vision System (NVS)

The IHADSS integrates the use of a Night Vision System (NVS) mode for flight operations at night. Each crewmember can enable a FLIR video underlay within their respective HDU by setting the NVS Mode switch in their crewstation to NORM or FIXED.

(See Tail Wheel/NVS Mode Panel for more information.)

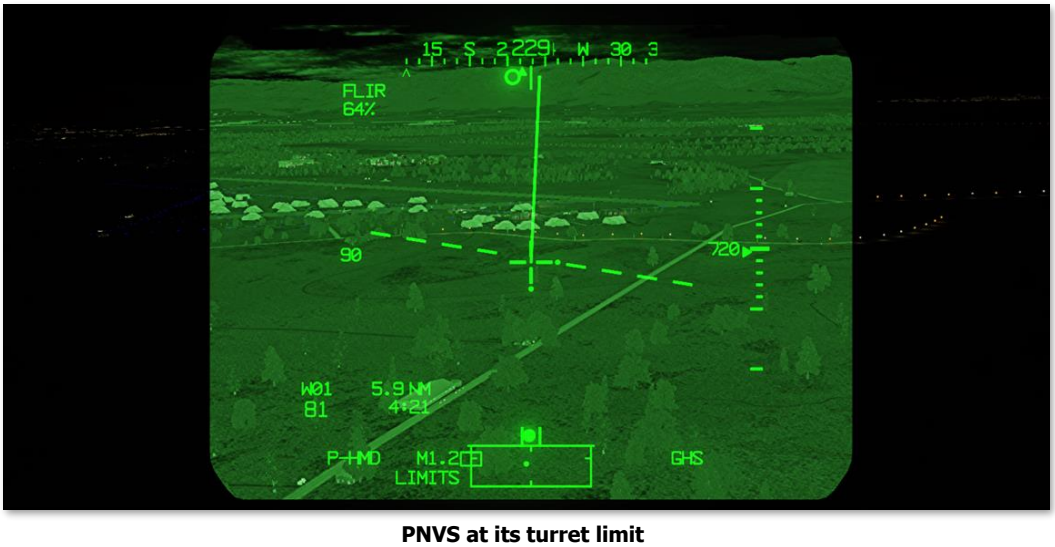
By default, the PNVS is assigned to the Pilot crewstation and the TADS assigned to the CPG crewstation, but either crewmember can take control of either NVS sensor by using the NVS Select switch on the Collective Flight Grip. This can be especially critical in the case of a failure in the NVS system while operating at extremely low altitudes at night. (See Collective Flight Grip for more information.)

When the NVS Mode switch is set to NORM, the NVS sensor assigned to the crewstation will unstow if necessary and become slaved to the crewmember's helmet line-of-sight. If the crewmember's helmet reaches or exceeds the slew limits of their NVS sensor, the LOS Reticle will flash and "LIMITS" will be displayed within the Sight Status field of the High Action Display.

When the NVS Mode switch is set to FIXED, the NVS sensor assigned to the crewstation will slave to the fixed forward location (0° in azimuth/-4.9° elevation). This can be used in the case of a failure in the IHADSS helmet tracking, which will result in the sensor turret remaining at its last commanded position. If this were to occur, the last detected helmet position may be off to one side or at an extreme look-down angle, preventing the crewmember from viewing the aircraft's current flight path and any imminent obstacles.

When the NVS is set to NORM or FIXED, virtual symbology elements within the HDU become "video-stabilized". This is to reduce visual disorientation if the crewmember rotates their head faster than the NVS turret can slew. If this occurs, virtual elements such as the Flight Path Vector will remain stabilized to their relative locations within the FLIR video, to prevent a false perception of the aircraft's flight path within the FLIR imagery.

The exception to this logic is the Head Tracker symbol, which will always remain "helmet-stabilized" to the crewmember's line-of-sight, even when the NVS is in FIXED mode.



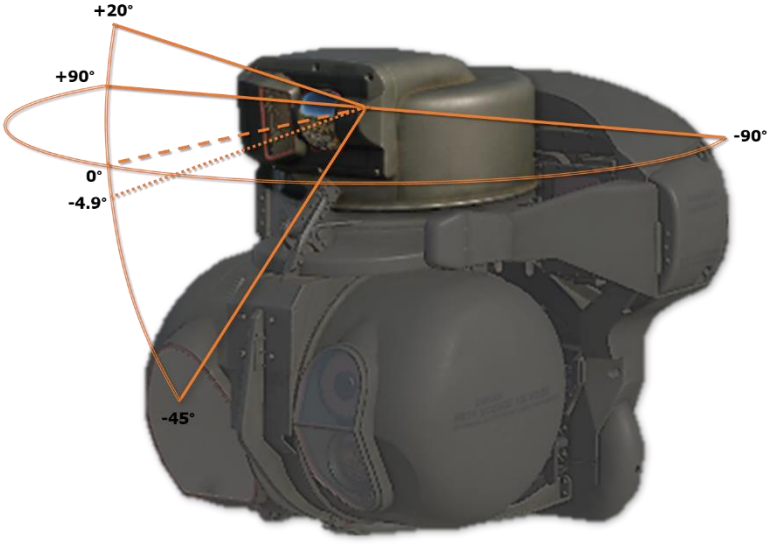
PNVS at its turret limit

AN/AAQ-11 Pilot Night Vision System (PNVS)

The PNVS is a Forward-Looking Infrared (FLIR) sensor housed within a steerable turret on the topside of the aircraft nose sensor assembly. The PNVS is primarily intended to aid the Pilot in performing low-altitude flight under any lighting conditions, ranging from twilight to total darkness without ambient lighting from celestial or terrestrial light sources.

The PNVS can slew ±90° in azimuth and +20° to -45° in elevation, at up to 120° per second. As the crewmember moves his or her head, the IHADSS sensors within the cockpit track the movements of the helmet and translate those motions into steering commands. As the crewmember looks left or right, the PNVS turret slews left and right to follow. As the crewmember looks up or down, the FLIR sensor itself articulates up and down within the turret housing.

The Modernized PNVS (M-PNVS) includes an enlarged sensor housing with a second optical sensor aperture for potential upgrades and "growth" within the system.



PNVS Sensor Turret Slew Range

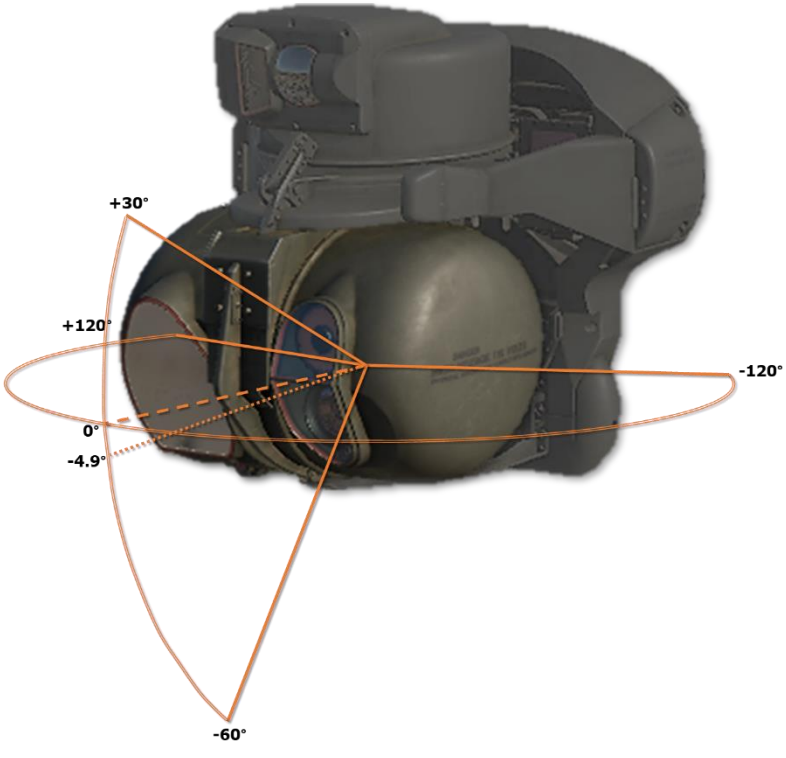
AN/ASQ-170 TADS as Night Vision System

The TADS is a multi-sensor targeting system housed within a steerable turret on the underside of the aircraft nose sensor assembly. The TADS is primarily intended to allow the Copilot/Gunner to target and designate enemy locations and vehicles for the aircraft's weapon systems. Like the PNVS, the TADS includes a Forward-Looking Infrared (FLIR) sensor. Unlike the PNVS, the TADS FLIR sensor is intended for targeting purposes, and includes three levels of optical magnification. However, if required, the TADS FLIR can be used as an NVS sensor for the Copilot/Gunner, or as a backup NVS sensor for the Pilot (should the PNVS fail).

The TADS can slew ±120° in azimuth and +30° to -60° in elevation, at up to 60° per second. As the crewmember moves his or her head, the IHADSS sensors within the cockpit track the movements of the helmet and translate those motions into steering commands. As the pilot looks around, the TADS turret rotates in azimuth and elevation to follow. However, due to the slower slew rate of the TADS, the crewmember must be more deliberate when moving his or her head to avoid "outrunning the TADS" and inducing visual disorientation.

If the CPG is using the TADS for targeting as their selected sight and moves their NVS Mode switch to NORM or FIXED, their sight selection will automatically switch to HMD, the TADS video will switch to FLIR (overriding the TADS Sensor Select switch on the TEDAC Left Handgrip), the TADS Field-Of-View will switch to Wide, and the TADS will be slaved to the CPG's helmet position.

If the Pilot's NVS Mode switch is in NORM or FIXED and the Pilot presses forward on the NVS Select Switch, the same events will occur, except the TADS turret will be slaved to the Pilot's helmet position.

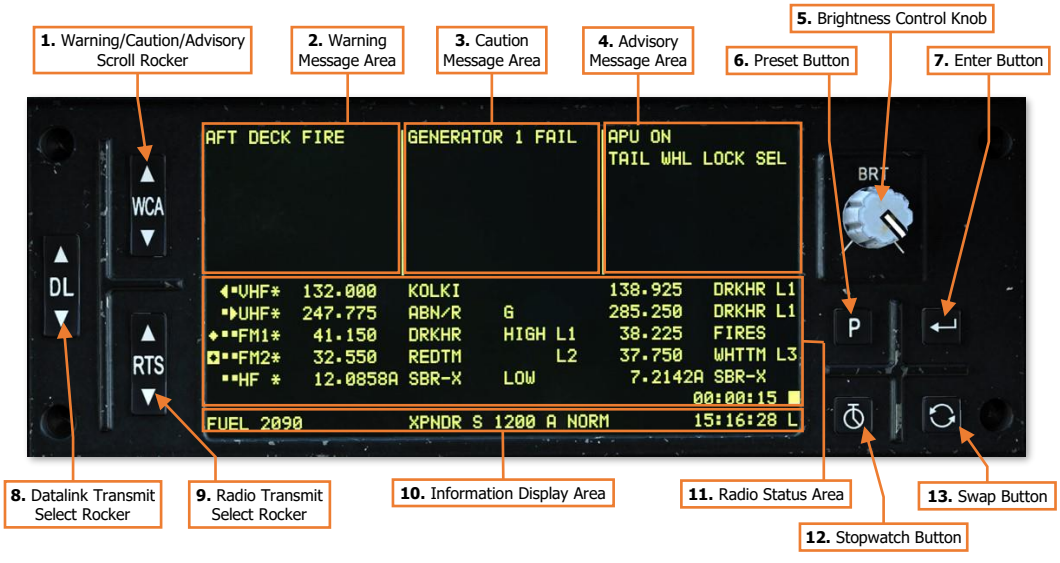


TADS Sensor Turret Slew Range

ENHANCED UP-FRONT DISPLAY (EUFD)

The Enhanced Up-Front Display (EUFD) provides the aircrew with a consolidated location for viewing critical message alerts about aircraft systems and managing voice and data communications. Unlike the MPDs, the EUFD functionality is retained when the aircraft is operating on battery power.

The display itself is divided into three primary areas: warnings/cautions/advisories (WCA), radio status, and information display. Additional controls for interacting with and controlling the EUFD are located to either side of the LED display.



1. **Warning/Caution/Advisory (WCA) Scroll Rocker.** Accesses additional WCA messages by scrolling the WCA areas up or down in a scrolling manner. This may be necessary if 8 or more messages exist in any of the three WCA columns. A double arrowhead symbol is displayed along the EUFD display if any column contains 8 or more active message alerts to indicate to the crew that WCA scrolling is necessary to view all messages. (See Warnings, Cautions, Advisories for more information.)A

2. **Warning Message Area.** Warning messages alert the crew to critical aircraft emergencies or malfunctions that could result in death to the aircrew and/or catastrophic loss of the aircraft. These emergency conditions will be accompanied by the flashing illumination of the MSTR WARN pushbutton light and an audio voice message alerting the crew to the nature of the emergency.

   Examples of warning alerts include an engine fire, an engine flameout, or a total loss of hydraulics.

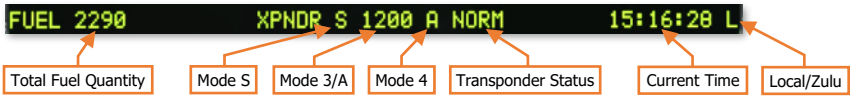
3. **Caution Message Area.** Caution messages alert the crew to less critical but potentially hazardous aircraft malfunctions or conditions that could affect safe flight operations. These conditions will be accompanied by the illumination of the MSTR CAUT pushbutton light and an audio caution tone to the crew.

   Examples of caution alerts include a loss of oil or transmission pressure, overtemperature conditions, failures in the electrical system, or low fuel levels.

4. **Advisory Message Area.** Advisory messages alert the crew to non-critical conditions, status of systems, or reception of datalink transmissions. Some messages may be accompanied by unique audio tones.

   Examples of advisory alerts include the commanded state of the tail wheel lock (when weight-on-wheels), completion of an automatic fuel check, or an unlatched canopy door.

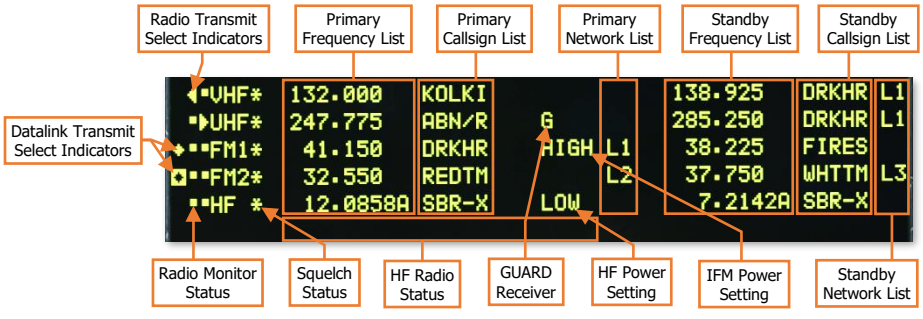
5. **Brightness Control Knob.** Adjusts the brightness of the EUFD display.
6. **Preset Button.** Toggles display of the Preset frequency list. (See Tuning a Radio using the EUFD for more information.)
7. **Enter Button.** Tunes the currently selected radio frequency from the displayed Preset frequency list.
8. **Datalink (DL) Transmit Select Rocker.** Selects a radio for datalink transmission.
9. **Radio Transmit Select (RTS) Rocker.** Cycles the Radio Transmit Select indicator on the EUFD to the next or previous radio in sequence. If the RTS indicator is set to the HF radio at the bottom of the list, pressing down on the RTS rocker will cycle the indicator to the VHF radio at the top of the list. If the RTS indicator is set to the VHF radio at the top of the list, pressing up on the RTS rocker will cycle the indicator to the HF radio at the bottom of the list.
10. **Information Display Area.** Displays fuel, transponder and time information in a single line.
    - Total onboard fuel quantity, in pounds (lbs).
    - Transponder Mode S enabled status. This data field will be blank if Mode S is disabled. (N/I)
    - Transponder Mode 3A code ("squawk" code). This data field will be blank if Mode 3/A is disabled. (N/I)
    - Transponder Mode 4 code (A or B). This data field will be blank if Mode 4 is disabled. (N/I)
    - Transponder status (STBY, NORM or EMER). (N/I)
    - Current time (Local or Zulu). If the stopwatch is enabled, elapsed time is displayed above current time.



11. **Radio Status Area.** The 6 rows in the center of the EUFD display each of the five radios, their various states and settings, and the primary and standby frequency information for each radio.
    - Primary Frequency List. Displays the currently tuned frequency for each radio.
    - Primary Callsign List. Displays the 5-character callsign associated with the currently tuned preset frequency. If the primary frequency is manually tuned, "MAN" will be displayed in this data field. If the primary frequency is a GUARD frequency, "GUARD" will be displayed in this data field.
    - Primary Datalink Network List. Displays the datalink network number currently tuned to the radio. If no datalink protocol has been tuned, this data field will be blank.
    - Standby Frequency List. Displays the standby frequency for each radio.
    - Standby Callsign List. Displays the 5-character callsign associated with the standby preset frequency. If the standby frequency is manually tuned, "MAN" will be displayed in this data field. If the standby frequency is a GUARD frequency, "GUARD" will be displayed in this data field.
    - Radio Monitor Status. Displays which radios are being monitored by each crewmember. If a dot is present along the left row, the respective radio is being monitored within the crewstation. If a dot is present along the right row, the respective radio is being monitored within the opposite crewstation.

      Pulling out the volume knob of the VHF, UHF, FM1, FM2, or HF radio on the crewstation's Communications panel will blank the dot that corresponds with that radio on in this data field.
    - Squelch Status. Displays which radios have squelch enabled. If an asterisk is present alongside a radio, squelch is enabled for that radio. Squelch can be toggled using the Squelch switches on the Communications panel in either cockpit.

- HF Radio Status. When the RTS indicator for the current crewstation is set to the HF radio, the 6th radio status line will display additional information regarding the HF transmit frequency. (N/I)
- UHF GUARD Receiver. Displays "G" if the dedicated GUARD receiver of the ARC-164 radio is enabled to monitor 243.0 MHz.
- HF Power Setting. Displays the current power setting of the ARC-220 HF radio. (N/I)
- IFM Power Setting. Displays the current power setting of the IFM amplifier for the ARC-201D FM1 radio.
- Standby Datalink Network List. Displays the datalink network number in standby. If no datalink protocol is present, this data field will be blank.



- **Radio Transmit Select Indicator.** The icons shown indicates which radio has been selected for voice transmission:

Voice transmissions from the current crewstation are selected to this radio.

Voice transmissions from the opposite crewstation are selected to this radio.

Voice transmissions from both crewstations are selected to this radio.

Voice transmissions from neither crewstation are selected to this radio.

- **Datalink Transmit Select Indicator.** The icons shown indicates which radio has been selected for data transmission:

Data transmissions from the current crewstation are selected to this radio.

Data transmissions from the opposite crewstation are selected to this radio.

Data transmissions from both crewstations are selected to this radio.

12. **Stopwatch Button.** Starts and stops the stopwatch, which is displayed above the current time. A square symbol is displayed to the right of the stopwatch timer when the stopwatch is paused.

Holding this button for >2 seconds resets the stopwatch timer and removes it from the EUFD.

NOTE: The EUFD stopwatch in each crewstation is independent of the other. Starting, stopping, or resetting the EUFD stopwatch in one crewstation will have no effect on the EUFD stopwatch in the other crewstation.

13. **Swap Button.** Swaps the radio frequency, encryption mode, and network configuration with the standby values of the currently selected radio.

Warnings, Cautions, Advisories (WCA)

WCA messages will be displayed when the corresponding conditions within the table below are met.

Warning Messages

The following messages are displayed in the Warning message area (left column) of the EUFD.

MESSAGE	CONDITION(S)	CORRECTIVE ACTION(S)
AFT DECK FIRE	Fire is detected in aft transmission deck area.	Land as soon as possible.
APU FIRE	Fire is detected in the Auxiliary Power Unit compartment.	**1.** APU button – Press, if APU is on. **2.** APU FIRE button – Press. **3.** PRI/RES DISCH button(s) – Press. **4.** Land as soon as possible, if airborne.
ENGINE 1 FIRE	Fire is detected in the left engine nacelle.	**1.** POWER lever NO 1 – OFF. **2.** ENG 1 FIRE button – Press. **3.** PRI/RES DISCH button(s) – Press. **4.** Land as soon as possible, if airborne.
ENGINE 1 OUT	Left engine N_G <63% and POWER lever NO 2 is not set to OFF. *or* Left engine N_P <94%, POWER lever NO 2 is set to FLY, and TQ <28%.	If airborne: **1.** Maintain airspeed above V_{SSE}. **2.** Jettison wing stores, if necessary. **3.** Land as soon as practicable.
ENGINE 1 OVERSPEED	Left engine N_P >114% and N_G >52%.	**1.** Adjust collective to maintain rotor speed (N_R) within acceptable limits. **2.** Retard POWER lever NO 1 as necessary to equalize torque. **3.** Land as soon as practicable.
ENGINE 2 FIRE	Fire is detected in the right engine nacelle.	**1.** POWER lever NO 2 – OFF. **2.** ENG 2 FIRE button – Press. **3.** PRI/RES DISCH button(s) – Press. **4.** Land as soon as possible, if airborne.
ENGINE 2 OUT	Right engine N_G <63% and POWER lever NO 2 is not set to OFF. *or* Right engine N_P <94%, POWER lever NO 2 is set to FLY, and TQ <28%.	If airborne: **1.** Maintain airspeed above V_{SSE}. **2.** Jettison wing stores, if necessary. **3.** Land as soon as practicable.
ENGINE 2 OVERSPEED	Right engine N_P >114% and N_G >52%.	**1.** Adjust collective to maintain rotor speed (N_R) within acceptable limits. **2.** Retard POWER lever NO 2 as necessary to equalize torque. **3.** Land as soon as practicable.
HIGH ROTOR RPM	Rotor speed (N_R) is >105%.	Increase collective as necessary to arrest the rotor speed (N_R) or reduce the severity of the maneuver.

LOW ROTOR RPM	Rotor speed (N_R) is <95%.	Reduce collective as necessary to regain rotor speed (N_R) or reduce the severity of the maneuver.

Caution Messages

The following messages are displayed in the Caution message area (center column) of the EUFD.

MESSAGE	CONDITION(S)	CORRECTIVE ACTION(S)
AFT FUEL LOW	Fuel quantity within the aft main fuel tank is <260 lbs.	Manually transfer fuel between the main fuel tanks as necessary.
APU ON	Auxiliary Power Unit is operating and the helicopter is airborne.	Turn off the APU.
FMC DISENGAGED	One or more Flight Management Computer channels are disabled and the N_R is >90%.	Enable FMC PITCH, ROLL, YAW and COLLECTIVE channels on UTIL page as necessary.
FORWARD FUEL LOW	Fuel quantity within the forward main fuel tank is <240 lbs.	Manually transfer fuel between the main fuel tanks as necessary.
GENERATOR 1 FAIL	Generator 1 has failed and is not supplying AC power to AC bus 1.	Set GEN RST switch to the GEN 1 position to attempt a generator reset.
GENERATOR 2 FAIL	Generator 2 has failed and is not supplying AC power to AC bus 2.	Set GEN RST switch to the GEN 2 position to attempt a generator reset.
MAG FORCE TRIM OFF	Magnetic force trim system on the cyclic/anti-torque pedals is disabled.	Enable FMC TRIM on the UTIL page.
RECTIFIER 1 FAIL	Rectifier 1 has failed and is not supplying DC power to DC bus 1.	Caution removed when Rectifier 1 failure is no longer detected.
RECTIFIER 2 FAIL	Rectifier 2 has failed and is not supplying DC power to DC bus 2.	Caution removed when Rectifier 2 failure is no longer detected.
ROTOR BRAKE ON/LK	Rotor brake is set to BRK or LOCK and one or both POWER levers are not set to OFF.	Set RTR BRK switch to OFF after first engine start is complete if performing an engine start with the rotor locked.

Advisory Messages

The following messages are displayed in the Advisory message area (right column) of the EUFD.

MESSAGE	CONDITION(S)	REMARKS
ACCUM OIL PRESS LO	Hydraulic accumulator oil pressure <1,250 PSI.	Advisory removed when hydraulic accumulator oil pressure >1,250 PSI.
ALTITUDE DRIFT	Barometric Altitude Hold is engaged and aircraft is vertically displaced ±100 feet from altitude reference. *or* Radar Altitude Hold is engaged and aircraft is vertically displaced ±5 to ±100 feet from altitude reference.	Advisory removed when the criteria for the message is no longer met. See Flight Control Advisories in the Flight Management Computer section for more information.

APU ON	Auxiliary Power Unit is operating, APU speed is >95%, and the helicopter is on the ground.	Advisory removed when APU shut-down sequence is commanded or the helicopter is airborne.
APU POWER ON	APU Electronic Control Unit is powered and APU speed is <95%.	Advisory removed when APU speed >95%.
APU START	Auxiliary Power Unit start-up sequence is in progress.	Advisory removed when APU start-up sequence is complete.
APU STOP	Auxiliary Power Unit shut-down sequence is in progress.	Advisory removed when APU shut-down sequence is complete.
ATTITUDE HOLD	Attitude Hold is enabled.	Advisory removed when Attitude Hold is disabled.
BAR ALT HOLD	Barometric Altitude Hold is enabled.	Advisory removed when Altitude Hold is disabled.
BDA REPORT	Bomb Damage Assessment Report has been received via the datalink.	Advisory removed when all BDA Reports have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
BDA QUERY	Bomb Damage Assessment Report has been requested via the datalink and REPLY has been set to OFF.	Advisory removed when all BDA Queries have been replied on the TSD page; or replied, reviewed, or deleted on the COM MSG-REC sub-page.
BLEED AIR OFF	Bleed air from both engines is disabled.	Advisory removed when bleed air is enabled from either engine.
CANOPY OPEN	Either crewstation door is not closed and latched.	Advisory removed when both crewstation doors are closed and latched.
CHARGER	Battery charger is not operating or has failed.	Advisory removed when battery charger is detected as operating.
CTRLM	Control Measure point has been received via the datalink.	Advisory removed when all CTRLM messages have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
CTR TANK EMPTY	Internal auxiliary fuel tank installed in the center ammunition bay is empty.	Advisory removed when either crewmember displays the FUEL page.
DL INHIBIT	Datalink transmissions are inhibited.	Advisory removed when DL INHBT is de-selected on the DL page.
DL MESSAGE	Text message or mission file has been received via the datalink.	Advisory removed when all text messages and mission files received via the datalink have been reviewed on the COM MSG-REC sub-page.
ENGINE 1 OVERRIDE	Air turbine starter (ATS) on the left engine is manually engaged and the engine ignition system is disabled.	Advisory removed when ENGINE START NO 1 switch is set to OFF.

ENGINE 1 START	Air turbine starter (ATS) on the left engine is engaged and the automatic start-up sequence is in progress.	Advisory removed when ATS disengages or the ENGINE START NO 1 switch is set to IGN ORIDE.
ENGINE 2 OVERRIDE	Air turbine starter (ATS) on the right engine is manually engaged and the engine ignition system is disabled.	Advisory removed when ENGINE START NO 2 switch is set to OFF.
ENGINE 2 START	Air turbine starter (ATS) on the right engine is engaged and the automatic start-up sequence is in progress.	Advisory removed when ATS disengages or the ENGINE START NO 2 switch is set to IGN ORIDE.
EXTERNAL 1 EMPTY	External auxiliary fuel tank installed on the left outboard pylon is empty.	Advisory removed when either crewmember displays the FUEL page.
EXTERNAL 2 EMPTY	External auxiliary fuel tank installed on the left inboard pylon is empty.	Advisory removed when either crewmember displays the FUEL page.
EXTERNAL 3 EMPTY	External auxiliary fuel tank installed on the right inboard pylon is empty.	Advisory removed when either crewmember displays the FUEL page.
EXTERNAL 4 EMPTY	External auxiliary fuel tank installed on the right outboard pylon is empty.	Advisory removed when either crewmember displays the FUEL page.
EXT PWR DOOR OPEN	Door covering the external power receptacle is open.	Advisory removed when external electrical power is disconnected.
FARM REPORT	Fuel/Ammo/Rocket/Missile Report has been received via the datalink.	Advisory removed when all FARM Reports have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
FARM QUERY	Fuel/Ammo/Rocket/Missile Report has been requested via the datalink and REPLY has been set to OFF.	Advisory removed when all FARM Queries have been replied on the TSD page; or replied, reviewed, or deleted on the COM MSG-REC sub-page.
FCR TGT REPORT	FCR Target Report has been received via the datalink.	Advisory removed when all FCR TGT Reports have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
FUEL CHK COMPLETE	Fuel Check is complete.	Advisory removed when either crewmember displays the FUEL page in CHECK format.
HOVER DRIFT	Position Hold is engaged and aircraft is laterally displaced >48 feet from position reference.	Advisory removed when the criteria for the message is no longer met. See Flight Control Advisories in the Flight Management Computer section for more information.
INU SEA TYPE	INU Navigation mode is set to SEA.	Advisory removed when the INU Navigation mode is set to LAND.
MANUAL STAB ON	Horizontal tail stabilator is in Manual mode.	Depress the Stabilator Control switch on the Collective Flight Grip to reset the stabilator to automatic mode.

NF ZONE	No Fire Zone file has been received via the datalink.	Advisory removed when all NF Zone files have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
PF ZONE	Priority Fire Zone file has been received via the datalink.	Advisory removed when all PF Zone files have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
PF/NF ZONE	Priority Fire Zone file and No Fire Zone file have been received via the datalink.	Advisory removed when all PF/NF Zone files have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
PP REPORT	Present Position Report has been received via the datalink.	Advisory removed when all PP Reports have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
PP QUERY	Present Position Report has been requested via the datalink and REPLY has been set to OFF.	Advisory removed when all PP Queries have been replied on the TSD page; or replied, reviewed, or deleted on the COM MSG-REC sub-page.
RAD ALT HOLD	Radar Altitude Hold is enabled.	Advisory removed when Altitude Hold is disabled.
RFHO	Radar Frequency Handover has been received via the datalink.	Advisory removed when all RFHO messages have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
ROTOR BRAKE ON	Rotor brake is set to BRAKE or LOCK and both POWER levers are set to OFF.	Advisory removed when the RTR BRK switch is set to OFF or either POWER lever is moved from the OFF position.
SAS SATURATED	SAS sleeve in one or more flight control servo-actuators is saturated at the limit of its control authority within the corresponding flight control axis.	Depress the Force Trim for 3-5 seconds and re-trim the aircraft. See Flight Control Advisories in the Flight Management Computer section for more information.
TAIL WHL LOCK SEL	Tail wheel locking mechanism has been commanded to the Lock position and the helicopter is on the ground.	Advisory removed when the helicopter is airborne or the tail wheel locking mechanism has been commanded to the Unlock position.
TAIL WHL UNLK SEL	Tail wheel locking mechanism has been commanded to the Unlock position and the helicopter is on the ground.	Advisory removed when the helicopter is airborne or the tail wheel locking mechanism has been commanded to the Lock position.
TGT/THRT	Target/Threat point has been received via the datalink.	Advisory removed when all TGT/THRT messages have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.

UPDATE HEADING	Magnetic heading error of primary INU is >10°.	Advisory removed when INU obtains more accurate heading data.
WAYPOINT PASSED	Current route has sequenced to the next point and a non-frozen TSD is not displayed in either crewstation.	Advisory removed when either crewmember displays a non-frozen TSD page or 60 seconds have elapsed.
WPT APPROACHING	Estimated time enroute (ETE) to the next point within the current route is <60 seconds and a non-frozen TSD is not displayed in either crewstation.	Advisory removed when either crewmember displays a non-frozen TSD page, ETE is >60 seconds, or the route is sequenced to the next point.
WPT/HZD	Waypoint/Hazard point has been received via the datalink.	Advisory removed when all WPT/HZD messages have been stored on the TSD page; or stored, reviewed, or deleted on the COM MSG-REC sub-page.
XMIT NAK FM1	Datalink message has been transmitted over the FM1 radio but no acknowledgement has been received from one or more recipients to which the datalink message was addressed.	Advisory removed when a datalink message is transmitted over the FM1 radio.
XMIT NAK FM2	Datalink message has been transmitted over the FM2 radio but no acknowledgement has been received from one or more recipients to which the datalink message was addressed.	Advisory removed when a datalink message is transmitted over the FM2 radio.
XMIT NAK UHF	Datalink message has been transmitted over the VHF radio but no acknowledgement has been received from one or more recipients to which the datalink message was addressed.	Advisory removed when a datalink message is transmitted over the UHF radio.
XMIT NAK VHF	Datalink message has been transmitted over the UHF radio but no acknowledgement has been received from one or more recipients to which the datalink message was addressed.	Advisory removed when a datalink message is transmitted over the VHF radio.

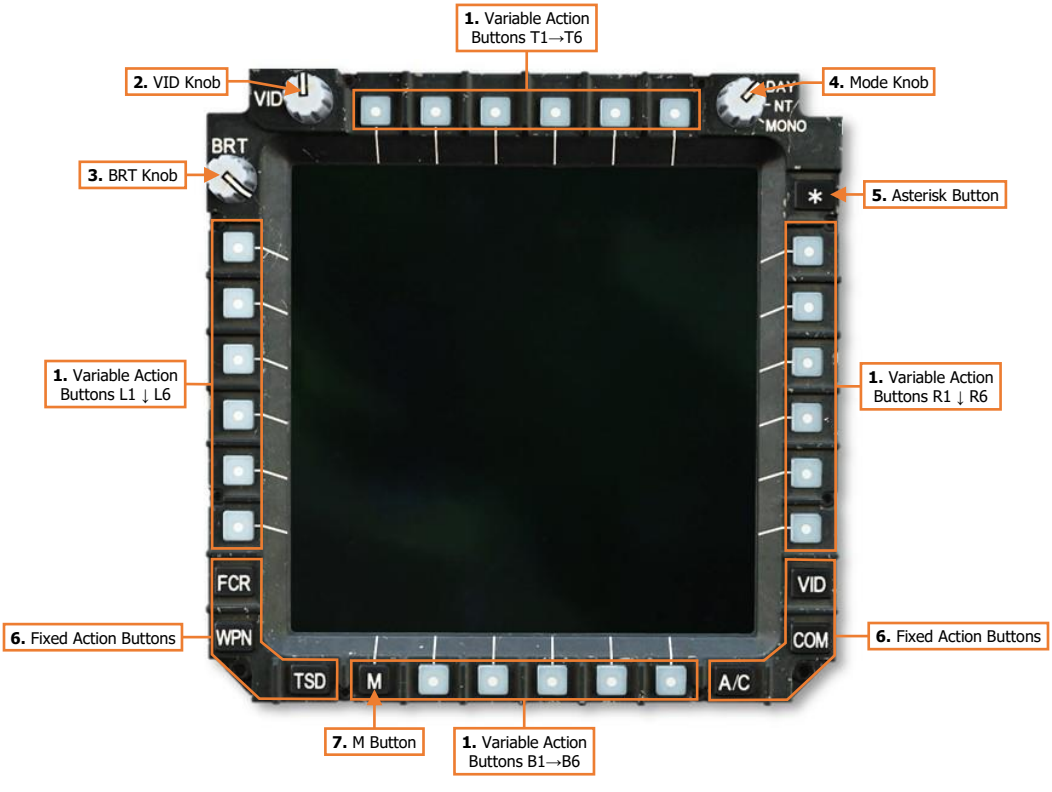
MULTI-PURPOSE DISPLAYS (MPD)

The revised cockpit and avionics of the AH-64D were designed to provide an efficient pilot interface, through which the human factors were heavily considered to optimize cockpit workflow, known as MANPRINT. The predominant means of facilitating this interface is through two Multi-Purpose Displays (MPD) within each crewstation, and incorporating a "management by exception" principle within the avionics:

- Most aircraft systems are managed automatically without aircrew interaction by default; but may be monitored or managed directly by the aircrew if necessary.
- Information that is not relevant to the current task, conditions, or mode is not presented to the aircrew.
- Information that is of critical importance to the aircrew is displayed automatically without crewmember action, also known as auto-paging.
- Functions or commands that would create a conflict between crewstations or would otherwise interfere with the current task are disabled or inhibited, also known as "barriered".

The MPDs themselves are 6 × 6 inch color liquid crystal displays that allow the Pilot and CPG to independently access different functions or view different elements of information. There are two identical MPDs in each crewstation. Functions that would otherwise be controlled by switches or physical controls in other aircraft are accessed through the MPDs in the AH-64D.

If on external power, weight-on-wheels, and the Power Levers are set to OFF, the MPDs will enter a screensaver mode if no buttons are pressed within 5 minutes. Pressing a button on either MPD will re-initialize the MPDs.



1. **Variable Action Buttons (VAB).** Selects the option corresponding with the displayed text adjacent to the MPD button itself.
   - **VAB T1-T6.** The top row of Variable Action Buttons are numbered from T1 starting on the far left to T6 on the far right.
   - **VAB L1-L6.** The left column of Variable Action Buttons are numbered from L1 starting on the at the top to L6 at the bottom.
   - **VAB R1-R6.** The right column of Variable Action Buttons are numbered from R1 starting on the at the top to R6 at the bottom.
   - **VAB B1-B6.** The bottom row of Variable Action Buttons are numbered from B1 starting on the far left to L6 on the far right.
2. **VID Knob.** Adjusts the brightness of the video or map underlay independently of the primary symbology displayed on the MPD.
3. **BRT Knob.** Adjusts the overall brightness setting of the MPD display within the overall brightness level selected by the Mode Knob.
4. **Mode Knob.** Sets the brightness level of the MPD.
   - **DAY.** Sets the MPD to daytime brightness levels.
   - **NT.** Sets the MPD to nighttime brightness levels.
   - **MONO.** Sets the MPD to nighttime brightness levels and an NVG-friendly monochromatic color scheme.
5. **Asterisk (*) Button.** Not implemented.
6. **Fixed Action Buttons.** Sets the MPD to the corresponding page.
   - **FCR.** Displays the Fire Control Radar page.
   - **WPN.** Displays the Weapon page.
   - **TSD.** Displays the Tactical Situation Display page.
   - **VID.** Displays the Video page.
   - **COM.** Displays the Communications page.
   - **A/C.** Displays the Flight page if in the air. Displays the Engine page if on the ground with weight-on-wheels.
7. **M Button.** Variable Action Button B1 is used to access the Menu and DMS pages.
   - **Menu page:** If any page is displayed on the MPD other than the Menu page, this button will display the Menu page.
   - **DMS page:** If the Menu page is displayed on the MPD, this button will access the DMS page.

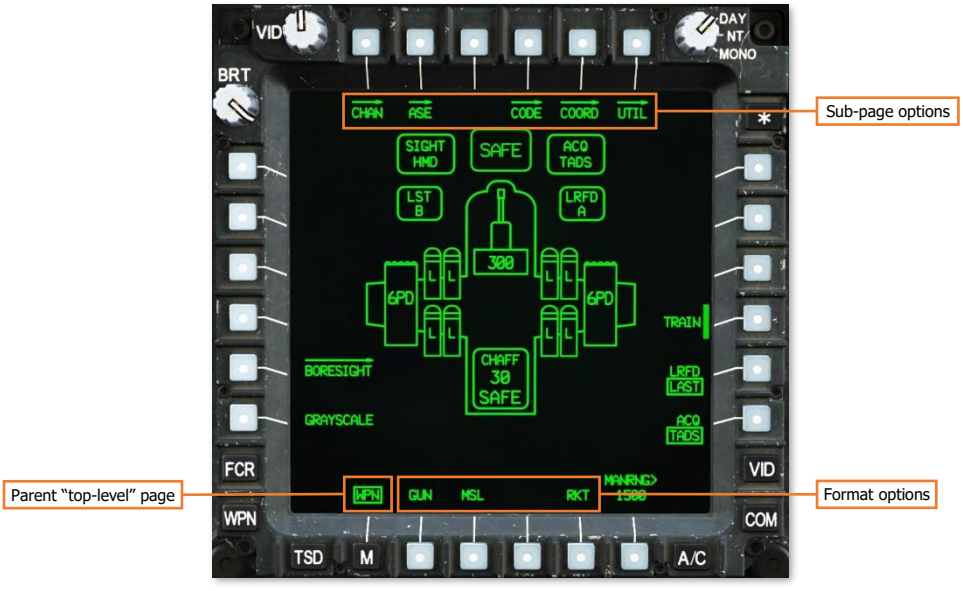
MPD Paging

The MPD Fixed Action Buttons and the Menu page provide immediate access to most aircraft systems or information. Upon pressing any Fixed Action Button or selection of any page option from the Menu page, the MPD will display the requested page, which will be denoted by the text displayed above the M button (VAB B1). If this text is boxed, the MPD is displaying the corresponding parent, or "top-level", page. If the text is un-boxed, a sub-page has been accessed from the parent page.

Sub-page options are denoted by a right-facing arrow placed above the text of the sub-page option. When the first sub-page level is accessed, the corresponding sub-page text becomes boxed, removing the box from the parent page text above the M button (VAB B1). If a second sub-page level is accessed from the first sub-page, the second sub-page text becomes boxed, with the first sub-page text boxed in a "partial-intensity" green.

Some MPD pages include options to display the existing page in a different format, which presents different elements of information on the current page. Format options differ in appearance from sub-page options in that a right-facing arrow is not displayed above the corresponding text.

An example of this distinction can be seen on the Weapon (WPN) page below. Five sub-page options are displayed along the top row of Variable Action Buttons, whereas three additional WPN page formats may be selected along the bottom row.



Auto-paging

Some MPD pages will be displayed automatically when certain events occur; this is called "auto-paging". Autopaging by the Data Management System (DMS) is automatic based on specific aircraft conditions.

DMS autopaging occurs when a critical aircraft emergency or malfunction occurs that could result in death to the aircrew and/or catastrophic loss of the aircraft, or when an engine start sequence is initiated by the Pilot. DMS autopaging can be suppressed in the CPG crewstation from the DMS Utility page.

- The ENG page will be displayed in Emergency format when a new Warning message is displayed.
- The ENG page will be displayed in Emergency format when the EMERG HYD button on the Emergency panel in either crewstation is pressed.
- The ENG page will be displayed in Ground format when an ENG START switch is engaged on the Pilot's Power Quadrant panel.

ASE autopaging occurs when a threat is detected that exceeds the ASE Autopage threshold set within the crewstation on the TSD Utility or ASE pages. (See Aircraft Survivability Equipment for more information.)

- The TSD page will be displayed when the RLWR or RFI detects radar or laser energy exceeding the ASE Autopage threshold. If the ASE page is displayed on either MPD, ASE autopaging is suppressed.

FCR autopaging occurs when the FCR is selected as that crewstation's sight.

- The FCR page will be displayed when the selected sight is changed from HMD or TADS to FCR. If the FCR page is displayed on the CPG's TDU, FCR autopaging is suppressed in the CPG crewstation.

Variable Action Button (VAB) Functions

The function of a Variable Action Button is indicated by the format of its label. When a VAB command is in-progress, the label will be displayed in "inverse video".

Page button

Displays a different MPD page or sub-page, annotated by an arrow. When a sub-page is accessed, the button label will be boxed.

Momentary button

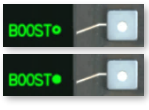
Commands an action. The button label will be displayed in inverse video while the action is being performed.

Maintained button

Changes the page format or toggles an option or mode. The state of the button is maintained if the MPD is switched to a different page.

On/Off button

Toggles a system or component on or off. If the circle is hollow, the system is not powered. If the circle is filled, the system is powered.

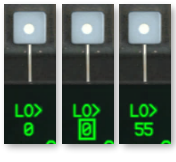


Disabled button

Buttons that are inhibited or "barriered" from selection will be marked with a green line next to their label.

Data Entry button

Pressing a button marked with a **>** symbol will activate the Keyboard Unit for data entry. While the KU is active, the current data entry is boxed. If the KU entry is valid, the new data is displayed once accepted.

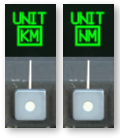


Missing/Invalid Data button

Button labels displayed in white with a question mark indicate data that is missing or currently invalid.

Two-State button

Toggles a mode or option between two states, which are maintained after switching to a different page.

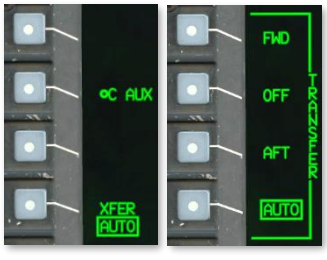


Grouped buttons

Selects a mode or option from a list of grouped buttons. The label along the border of the grouped buttons displays what the options pertain to.

Multi-State button

Displays an expanded list from which to choose a mode or option. Once a selection is made, the expanded list will collapse. If a different option is no longer desired, pressing the currently selected option with the box displayed around its label will collapse the list with no changes made.



Paging buttons

Cycles forward and back through multiple pages of data displayed on the MPD.

Search buttons

Scrolls up and down through a list of grouped button options.

MPD Cursor

Each crewstation may utilize an MPD cursor for accessing MPD commands or interacting with MPD displayed data and symbols. The Cursor Controller on the Collective Mission Grips and TEDAC Left Handgrip is used to slew the cursor on the active MPD. The cursor provides the crewmembers a means to select VAB commands on the MPD without removing their hands from the flight controls or the TEDAC handgrips and pressing the physical button itself. When placed over a VAB label, the label text will be bolded to indicate Cursor-Enter can be pressed.

The cursor can be moved to the opposite MPD using the Cursor Display Select button on the Collective Mission Grip or TEDAC Left Handgrip or by "bumping" the cursor between MPDs. To bump the cursor to the opposite display, move the cursor to the inboard edge of the MPD, release input on the Cursor Controller, and then re-apply pressure input toward the opposite MPD. The cursor may also be utilized on the TDU in the CPG crewstation if the FCR page is displayed on the TDU. However, the cursor can only be moved to the TDU FCR display using the "bump" method.

The MPD cursor may be displayed in several formats, depending on the function that the cursor is performing.

Normal format

The cursor may be used for selecting Variable Action Button commands along the bezel of the MPD.

Crosshairs format

The cursor may be used for selecting symbols or map locations within the central "footprint" of the MPD page.

Symbol Select format

A symbol is identified for cursor selection using Cursor-Enter.

Target Reference Point format

The cursor is being used to place a TRP-shaped Priority Fire Zone on the TSD Battle Area Management page.

Zoom format

The cursor is being used to select an area to enlarge when ZOOM has been enabled on the FCR page.

Opposite Crewmember format

Distinguishes the cursor belonging to the opposite crewmember from the crewmember's own cursor, if enabled for display on the TSD.

MPD Symbology Colors

All MPD pages share a 6-color template for consistent indication of various types of symbology. These colors increase the efficiency of a crewmember's interpretation and prioritization of displayed data within the cockpit.

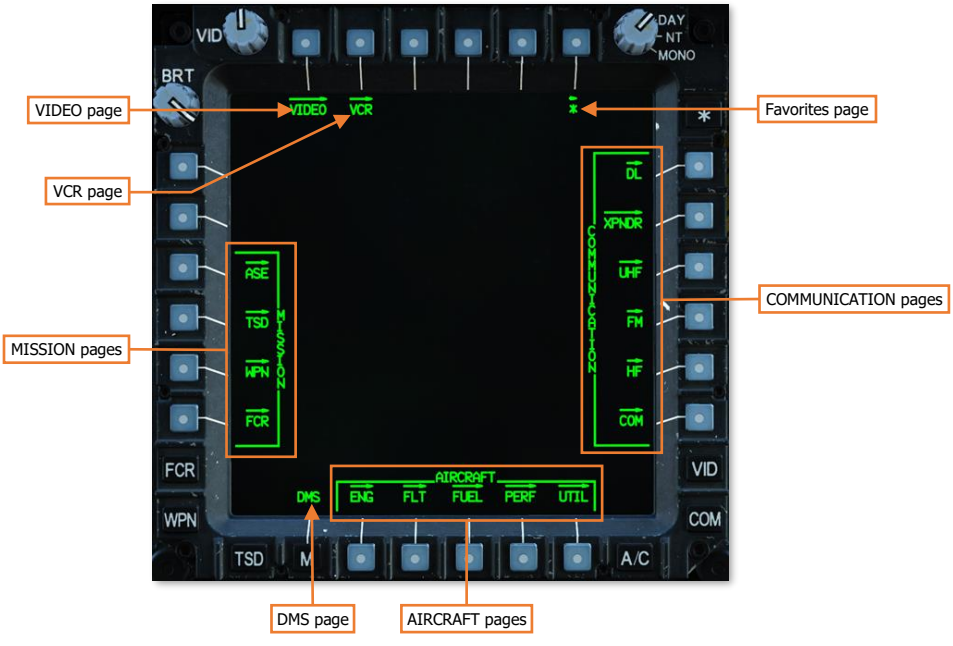
- **Green.** Default symbology color, normal conditions, and Advisory messages.
- **Yellow.** Hazards to flight, intermediate or transient operating conditions, and Caution messages
- **Red.** Targets, enemy threats, conditions exceeding allowable parameters, and Warning messages.
- **White.** Items requiring a crewmember's attention, or invalid selection/data.
- **Blue.** Ownship, friendly units, pitch attitudes above the horizon (sky).
- **Brown.** Pitch attitudes below the horizon (ground).

In addition to colors, the intensity of the symbology itself may also be adjusted to indicate relevance or recency of the information.

- **Full-intensity color.** Relevant or current data.
- **Partial-intensity color.** Less relevant or stale data.

Menu (M) Page

The Menu page provides immediate access to any "top-level" MPD page within the three page categories, as well as the DMS, VIDEO, VCR, and Favorites (*) pages. The Menu page may be accessed at any time by pressing the M button (VAB B1).



Page Categories

Most MPD pages are grouped within one of three categories: AIRCRAFT, COMMUNICATIONS, and MISSION.

AIRCRAFT pages

Aircraft systems.

- **ENG** Engine and drive train information
- **FLT** Flight instruments
- **FUEL** Fuel systems
- **PERF** Performance data
- **UTIL** Utility systems

COMMUNICATION pages

Communication systems.

- **DL** Datalink
- **XPNDR** Transponder
- **UHF** UHF radio
- **FM** FM1/FM2 radios
- **HF** HF radio
- **COM** Comms presets and network management

MISSION pages

Navigation, weapons, radar, and defensive systems.

- **ASE** Aircraft Survivability Equipment
- **TSD** Tactical Situation Display
- **WPN** Weapon systems
- **FCR** Fire Control Radar

Engine (ENG) Page

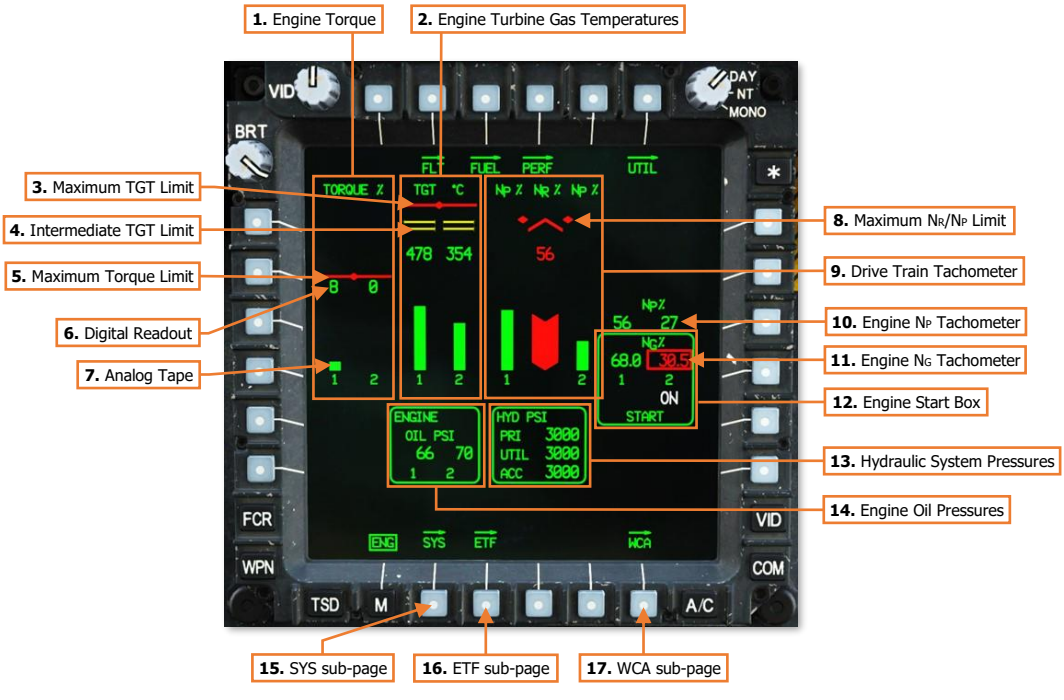
The ENG page displays engine and drive train data and is displayed in either Ground, Flight, or Emergency formats, based on aircraft status. ENG page data may be displayed as digital numerical values and/or analog vertical tapes.

- Values displayed in green represent normal operating parameters.
- Values displayed in yellow represent intermediate or transient operating parameters that will result in component damage or fatigue if maintained continuously.
- Values displayed in red represent maximum operating parameters that have been exceeded that has most likely resulted in component damage or fatigue and may result in imminent failure.

For data that is also displayed as an analog tape, the entire vertical tape is color-coded to indicate operating condition, and the width of the tape will widen when outside of normal operating parameters. The increase in the width of the tape allows crewmembers to recognize when indications are outside normal operating parameters when the MPD is set to MONO (monochromatic) mode.

ENG Ground Format

During initial start-up of the APU, the ENG page will be displayed in Ground format, with engine oil and hydraulic pressure windows displayed in the lower half of the page. The ENG page will return to Ground format any time the ENG START switches are moved to the START or IGN ORIDE positions on the Pilot's Power Quadrant panel.



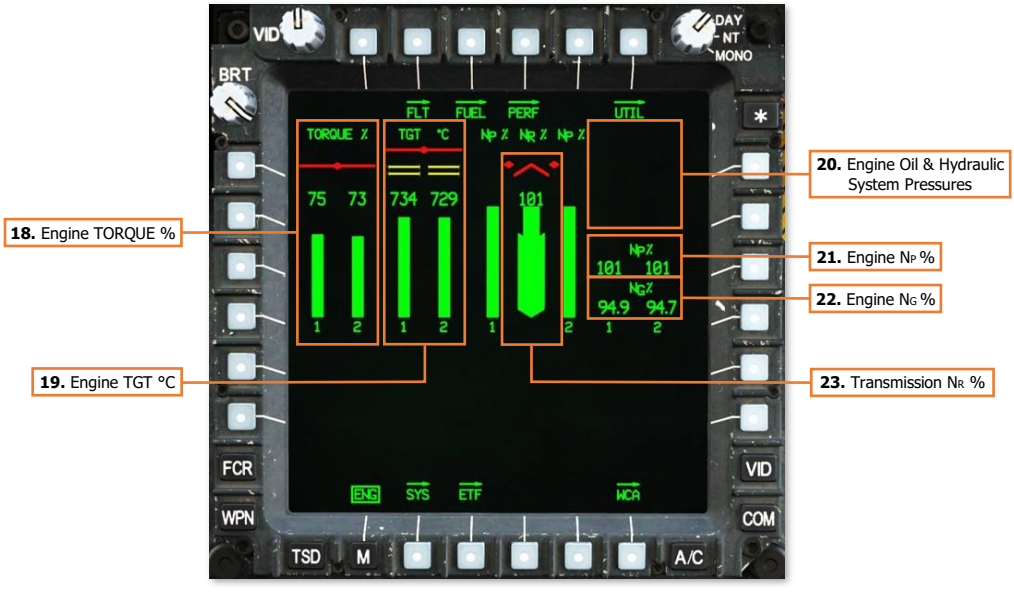
1. **Engine Torque (TQ).** Displays the torque, as a percentage, that is being exerted by engines 1 and 2 on the drive train system as measured at each engines' power turbine output shaft.

2. **Engine Turbine Gas Temperatures (TGT).** Displays the temperature, in degrees Celsius, of the exhaust gases being expelled by the gas generator stages of each engine into the engines' power turbine sections.

3. **Maximum TGT Limit.** Indicates the maximum engine turbine gas temperature (TGT) limit of 949° C.
4. **Intermediate TGT Limit.** Indicates the intermediate engine turbine gas temperature (TGT) limits of 870° C and 878° C.
5. **Maximum Torque Limit.** Indicates the maximum engine torque limit for the current main rotor speed N_R.
6. **Digital Readout.** Digital readouts are displayed to provide precise, numerical values of engine and drive train components.
7. **Analog Tape.** Vertical analog tapes are color-coded and varied in width to provide rapid and intuitive analysis of display normal, intermediate/transient, and maximum operating ranges of the engines and drive train. As the digital readouts of torque, temperature, or speed increase, the analog tapes increase in length.
8. **Maximum N_R Limit.** Indicates the maximum main rotor speed (N_R) limit of 110%.
9. **Drive Train N_R/N_P Tachometer.** Displays the main rotor speed (N_R), as measured at the main transmission, as a percentage. Includes analog tapes for N_R and each engines' N_P speed.
10. **Engine N_P Tachometer.** Displays the power turbine speed of engines 1 and 2, as a percentage.
11. **Engine N_G Tachometer.** Displays the gas generator speed of engines 1 and 2, as a percentage.
12. **Engine Start Box.** Displayed when either Air Turbine Starter (ATS) is engaged in the START or IGN ORIDE modes.
    - If either ENG START switch is positioned to the START position on the Pilot's Power Quadrant panel, "ON" will be displayed under the corresponding N_G digital readout to indicate that a normal start sequence has been initiated for that engine.
    - If the ENG START switch is positioned to the IGN ORIDE position on the Pilot's Power Quadrant panel, "OVRD" will be displayed under the corresponding N_G digital readout to indicate that the engine is being motored by the ATS.
13. **Hydraulic System Pressures (PSI).** Displays the hydraulic pressures of the primary (PRI) and utility (UTIL) hydraulic systems, and the hydraulic accumulator (ACC), in pounds-per-square-inch. The hydraulic system pressures box is removed when the ENG page transitions to In-Flight format.
14. **Engine Oil Pressures (PSI).** Displays the oil pressures of engines 1 and 2, in pounds-per-square-inch. The engine oil pressure box is removed when the ENG page transitions to In-Flight format.
15. **SYS sub-page.** Displays the ENG Systems sub-page.
16. **ETF sub-page.** Not implemented.
17. **WCA sub-page.** Displays the DMS Warning/Caution/Advisory sub-page.

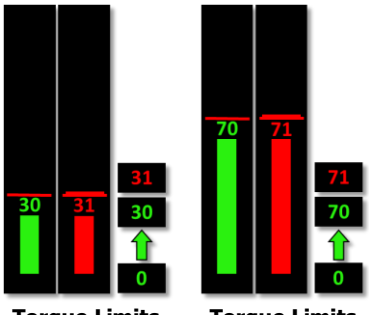
ENG In-Flight Format

When both power levers are brought to FLY, the ENG page will transition from Ground to In-Flight format.



18. Engine TORQUE % (Indications & limits). Displays the torque, as a percentage, that is being exerted by engines 1 and 2 on the drive train system as measured at each engines' power turbine output shaft. The analog tapes and digital readouts will be displayed separately for each engine in red when above these limits under these conditions.

The red maximum limit is dynamic and will re-position based on the maximum allowable torque for the current conditions, which is driven by the main rotor RPMs (N_R) and whether the aircraft is operating under dual- or single-engine power.



Torque Limits (N_R <50%) **Torque Limits (N_R <90%)**

Dual Engine Torque Limits (N_R >90%)

If N_R is <50% the TQ red line will be displayed at 30%.

If N_R is <90% the TQ red line will be displayed at 70%.

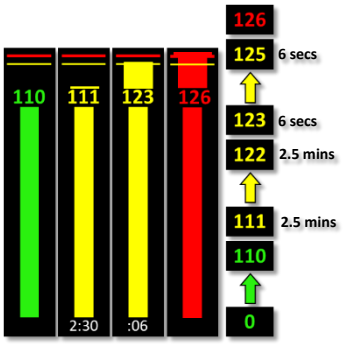
If N_R is >90% the TQ red line will be displayed at 115% under dual engine power and at 125% under single-engine power.

If either TQ indicates <51%, the other engine's TGT limiter is increased to 896 °C, allowing the healthy engine to operate in a single-engine contingency mode. A yellow sub-range limit will be displayed at 123% within both TQ analog tape ranges above the TQ digital readout, delineating between the 2.5-minute single-engine contingency range and the 6-second single-engine transient range.

If either engine TQ enters the dual-engine transient operating range (101-115% when N_R is >90%) a 6-second countdown timer will be displayed instead of the engine numbers below the analog tapes.

If either engine TQ enters a single-engine contingency range (111-122% when N_R is >90%) a 2.5-minute countdown timer will be displayed instead of the engine numbers below the analog tapes.

If either engine TQ enters a single-engine transient operating range (123-125% when N_R is >90%) a 6-second countdown timer will be displayed instead of the engine numbers below the analog tapes.



Single Engine Torque Limits (N_R >90%)

19. Engine TGT °C (Indications & limits). Displays the temperature, in degrees Celsius, of the exhaust gases being expelled by the gas generator sections of engine 1 and 2 into each engines' power turbine sections.

Each engine incorporates a TGT limiter within the Digital Electronic Control that will limit the engine to a maximum TGT of 867±12 °C when under dual engine conditions, or 896±12 °C when under single-engine conditions.

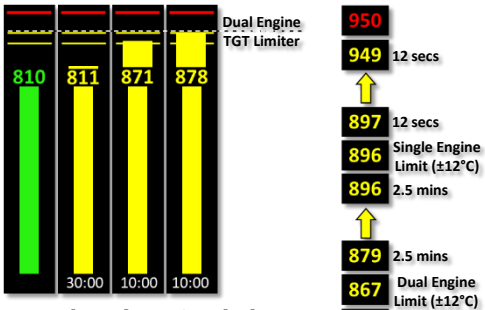
If either engine's torque indicates <51%, the other engine's TGT limiter is increased to 896±12 °C, allowing the healthy engine to operate in a single-engine contingency mode for 2.5 minutes.

TGT timers indicate the maximum acceptable time limit for the intermediate, contingency, and transient operating ranges.

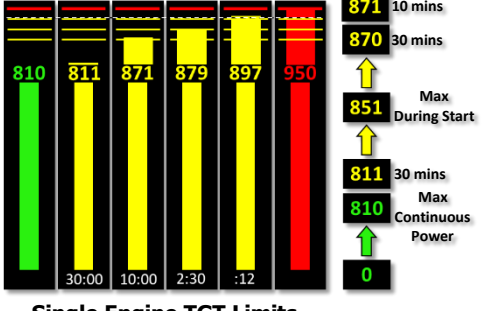
If an engine's TGT enters an intermediate operating range, a 30-minute (811-870 °C) or 10-minute (871-878 °C) countdown timer will be displayed instead of the engine numbers below the analog tapes.

If under single-engine power, a third intermediate sub-range limit will be displayed, delineating between the 2.5-minute single-engine contingency range (879-896 °C) and the 12-second transient range (897-949 °C). When operating within these ranges, a 2.5-minute or 12-second timer will be displayed respectively.

The maximum TGT limit is 949 °C.



Dual Engine TGT Limits



Single Engine TGT Limits and TGT range in Lockout

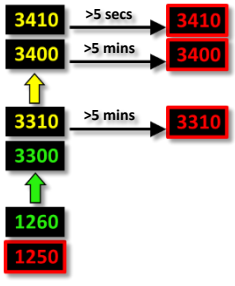
20. Engine Oil & Hydraulic System Pressures (Indications & limits). Displays the oil pressures of engines 1 and 2, in pounds-per-square-inch; or the hydraulic pressures of the primary (PRI) and utility (UTIL) hydraulic systems, and the hydraulic accumulator (ACC), in pounds-per-square-inch. If these systems are outside their normal operating parameters, the applicable box will be displayed above the digital NP readouts when the ENG page is in In-Flight format.

If the oil pressure of an engine is above 120 PSI or below 23 PSI, the digital readout for that engine will be displayed in red and boxed.

Engine Oil Pressure Limits

If the hydraulic pressures of the primary or utility hydraulic systems, or the accumulator, are above 3300 PSI, or if a PSI LOW or LEVEL LOW caution exists for either system, the digital readout for that hydraulic system will be displayed in yellow.

If the hydraulic pressures of the primary or utility hydraulic systems, or the accumulator, are above 3300 for greater than 5 minutes, above 3400 PSI for 5 seconds, or below 1260 PSI, the digital readout for that hydraulic system will be displayed in red and boxed.



Hydraulic System Pressure Limits

21. Engine N_P % (Indications & limits). Displays engine power turbine speed (N_P) as a percentage. N_P is displayed as analog tapes on either side of the main rotor (N_R) analog tape and digitally to the right of the #2 engine N_P analog tape.

If the power turbine speed of an engine is between 106-121%, the analog tape and digital readout for that engine will be displayed in yellow, with the digital readout boxed at 107% and above, and a 12-second countdown timer will be displayed instead of the engine numbers below the analog tapes.

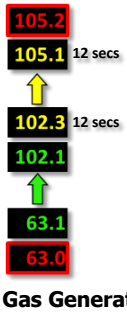
If the power turbine speed of an engine is above 121%, the analog tape and digital readout for that engine will be displayed in red (with the digital readout boxed).

Engine Power Turbine Speed (N_P) Limits

22. Engine N_G % (Indications & limits). Displays engine #1 and #2 gas generator speeds (N_G) as a percentage. N_G is indicated digitally to the right of the #2 engine N_P analog tape, and below the engine N_P digital readouts.

If the gas generator speed of an engine is between 102.3-105.1%, the digital readout for that engine will be displayed in yellow.

If the gas generator speed of an engine is above 105.1% or below 63.1%, the digital readout for that engine will be displayed in red and boxed

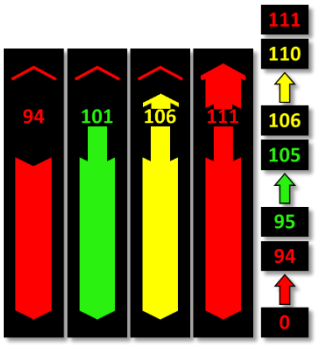


Engine Gas Generator Speed (N_G) Limits

23. Transmission N_R % (Indications & limits). Displays main rotor speed (in percent N_R) as analog vertical tapes with digital readouts and maximum limits. N_R is indicated digitally above the center analog tape.

If the rotor is operating within 106-111% N_R, the analog tape and digital readout will be displayed in yellow.

If the rotor is operating below 95% or above 110%, the analog tape and digital readout will be displayed in red.

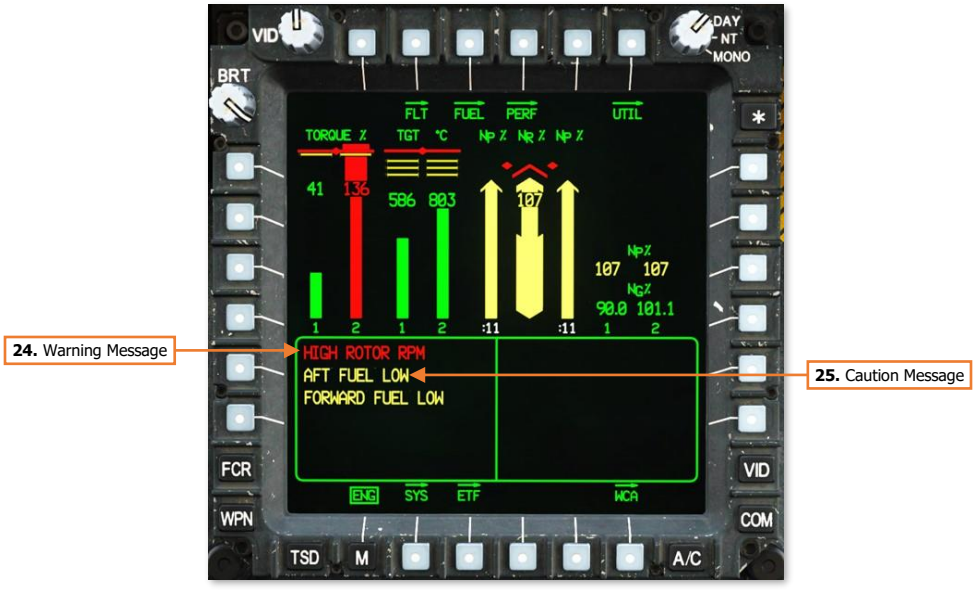


Main Rotor Speed (N_R) Limits

ENG Emergency Format

If Warning or Caution messages are displayed on the EUFD, the ENG page will enter Emergency format and display the Warning or Caution messages in the lower half of the page.

If the hydraulic or engine oil pressures are out of normal operating parameters, the applicable window will be displayed in the top right corner of the ENG page.

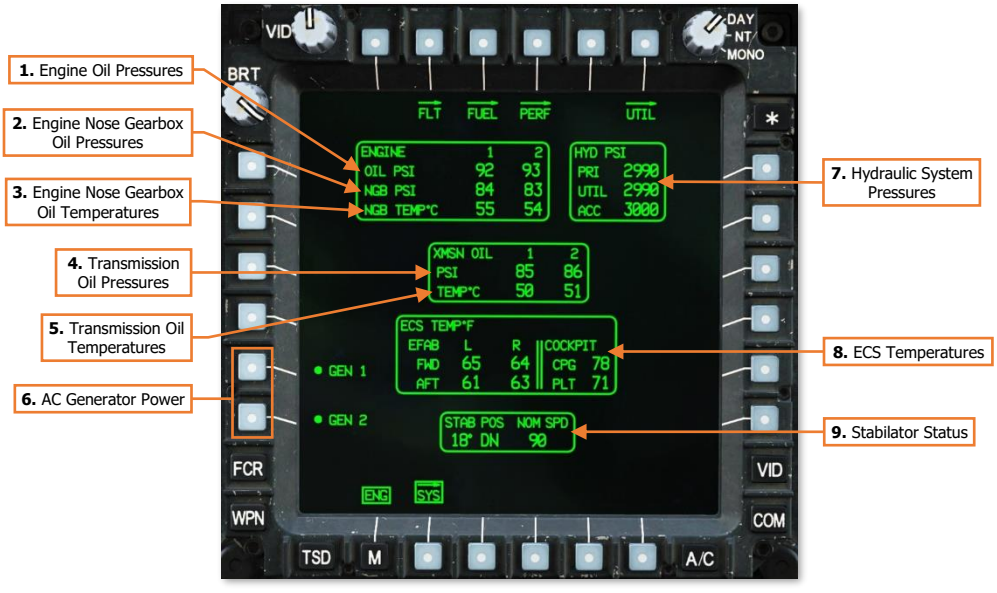


24. Warning Message. Warning messages are displayed in red and alert the crew to critical aircraft emergencies or malfunctions that could result in death to the aircrew and/or catastrophic loss of the aircraft.

25. Caution Message Area. Caution messages are displayed in yellow and alert the crew to less critical but potentially hazardous aircraft malfunctions or conditions that could affect safe flight operations.

ENG Systems (SYS) Sub-page

The SYS page displays drive train pressures and temperatures, hydraulic pressures, environmental temperatures of the Extended Forward Avionics Bays (EFAB) and cockpits, and stabilator angle and nominal speed. Either generator may be disabled from this page.



1. **Engine Oil Pressures (PSI).** Displays the engine oil pressures, in pounds-per-square-inch.

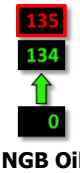
2. **Engine Nose Gearbox (NGB) Oil Pressures (PSI).** Displays the oil pressures of the engine nose gearboxes, in pounds-per-square-inch.

   If the nose gearbox oil pressure is below 30 PSI, the digital readout will be displayed in red and boxed.

NGB Oil Pressure Limits

3. **Engine Nose Gearbox (NGB) Oil Temperatures.** Displays the oil temperatures of the nose gearboxes for engines 1 and 2, in degrees Celsius.

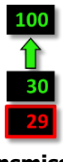
   If the oil temperature of a nose gearbox is above 134°C, the digital readout will be displayed in red and boxed.



NGB Oil Temperature Limits

4. **Transmission (XMSN) Oil Pressures (PSI).** Displays the oil pressures for the main transmission, in pounds-per-square-inch.

   If the transmission oil pressure is below 30 PSI, the digital readout will be displayed in red and boxed.



Transmission Oil Pressure Limits

5. **Transmission (XMSN) Oil Temperatures.** Displays the oil pressures for the main transmission, in degrees Celsius.

   If the transmission oil temperature is above 134 in °C, the digital readout will be displayed in red and boxed.

Transmission Oil Temperature Limits

NOTE: During extended APU operations on the ground without either engine operating, monitor the XMSN OIL TEMP. Do not operate the APU with a XMSN OIL TEMP (1 or 2) between 120°-130° C for greater than 5 minutes. If the temperature exceeds 130° C, shut down the APU and allow the transmission oil to cool for 30 minutes.

6. **AC Generator Power.** Enables/Disables AC Generators 1 and 2. If both generators are disabled, the MPDs will blank and the generators must be reset in the Pilot crewstation to re-enable AC power. (see Pilot's Check Overspeed Test/Generator Reset Panel)

7. **Hydraulic System Pressures.** Displays the hydraulic pressures of the primary (PRI) and utility (UTIL) hydraulic systems, and the hydraulic accumulator (ACC), in pounds-per-square-inch.

8. **ECS Temperatures.** Displays the environmental temperatures inside the forward and aft sections of each Extended Forward Avionics Bay (EFAB) and each cockpit, in degrees Fahrenheit.

9. **Stabilator Status.** Displays the current stabilator angle and nominal airspeed restriction. The angle is referenced to the trailing edge of the stabilator and displays a range of 10° UP to -35° DN.

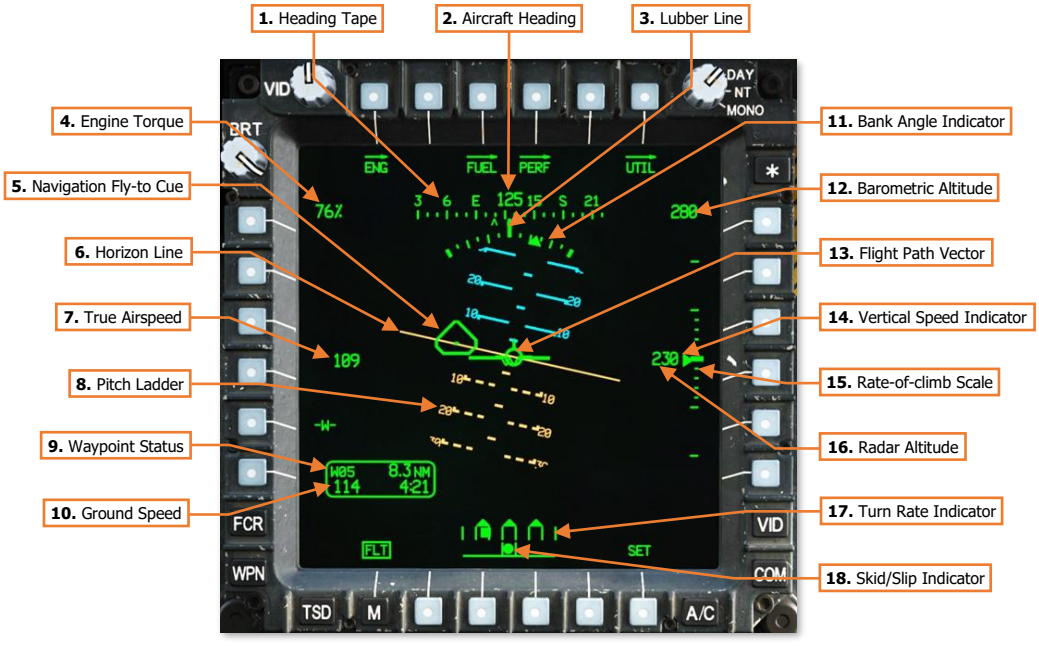
   If the stabilator is in manual mode, the angle and nominal airspeed values are displayed in white.

   If the stabilator is detected as failed, the nominal airspeed value will be displayed in yellow.

   If the position of the stabilator is unknown, the angle indication will be displayed as a white "?" and the nominal airspeed will be displayed in red as the true airspeed equivalent of 90 knots IAS.

Flight (FLT) Page

The FLT page displays flight and basic navigation information; and includes controls for configuring navigation and instrument settings such as altimeter settings, altitude warnings, and units of measurement.



1. **Heading Tape.** Displays a 180° hemisphere of magnetic headings. Major tick marks are displayed in 30° increments and marked by a cardinal direction or heading in the tens value. Minor tick marks are displayed in 10° increments.

2. **Aircraft Heading.** Displays a digital readout of the aircraft's current magnetic heading in 1° increments, superimposed over the Heading Tape.

3. **Lubber Line.** The Lubber Line is aligned to the centerline of the aircraft and serves as a reference for both the aircraft heading and for the Bank Angle Indicator when in Cruise symbology mode.

4. **Engine Torque.** Displays the highest torque value of the two engines, in 1% increments. A box will be displayed around the torque at 98% or greater. If the difference in engine torque values exceeds 12%, the torque digital readout will flash.

5. **Navigation Fly-To Cue.** Indicates the location of the current point selected for navigation. Also called the "homeplate" symbol, the Navigation Fly-To Cue is sized so the Flight Path Vector fits within it for precise 3-dimensional navigation. The Navigation Fly-To Cue is not displayed when the aircraft is weight-on-wheels.

6. **Horizon Line.** Indicates the horizon position and orientation relative to the aircraft nose, which is referenced to the Waterline.

7. **True Airspeed.** Indicates the true airspeed (TAS) of the aircraft in 1 knot increments, from 0 to 210 knots. The airspeed indication is displayed in red and boxed if the airspeed exceeds V_{NE}.

   When Attitude Hold is engaged, a rounded "status window" box is displayed around the TAS digital readout.

8. **Pitch Ladder.** Indicates aircraft pitch attitude. Major pitch ladder increments are displayed at ±10°, ±20°, ±30°, ±45° and ±60° pitch, with minor increments placed at ±5°, ±15°, ±25°, ±37.5°, and ±52.5°.

9. **Waypoint Status.** Displays the point selected for navigation, its distance in kilometers or nautical miles, and estimated time enroute (ETE). The ETE is based on the aircraft's current ground speed, and is presented in HH:MM format when the ETE is ≥5 minutes, or M:SS format when ETE is <5 minutes. The ETE is not displayed when ground speed is <15 knots or ETE is >10 hours. Waypoint Status information is not displayed if there is no active destination point.

10. **Ground Speed.** Indicates the speed across the surface in 1 knot increments. Ground Speed is only displayed when the primary INU is aligned.

11. **Bank Angle Indicator.** Indicates bank angle relative to the horizon, with major tick marks placed at 10° increments and minor tick marks placed at 5° increments. When the Bank Angle Indicator is aligned with the lubber line below the heading tape, the aircraft is in a level attitude.

12. **Barometric Altitude.** Indicates the barometric altitude when Cruise mode symbology is displayed. Barometric Altitude is displayed in 10-foot increments from -2,300 feet to 20,000 feet.

13. **Flight Path Vector.** The Flight Path Vector (FPV) represents the point towards which the helicopter is flying. It is a 3-dimensional representation of the aircraft's velocity vector. The FPV is not displayed if the 3-dimensional velocity is <5 knots ground speed, or if the aircraft is weight-on-wheels.

14. **Vertical Speed Indicator (VSI).** The Vertical Speed Indicator moves up and down the rate-of-climb scale to indicate vertical speed. The VSI becomes saturated at the ±1,000 fpm tick marks at the top or bottom of the Rate-of-climb Scale, augmented by digital readouts of rate-of-climb in 100 fpm increments.

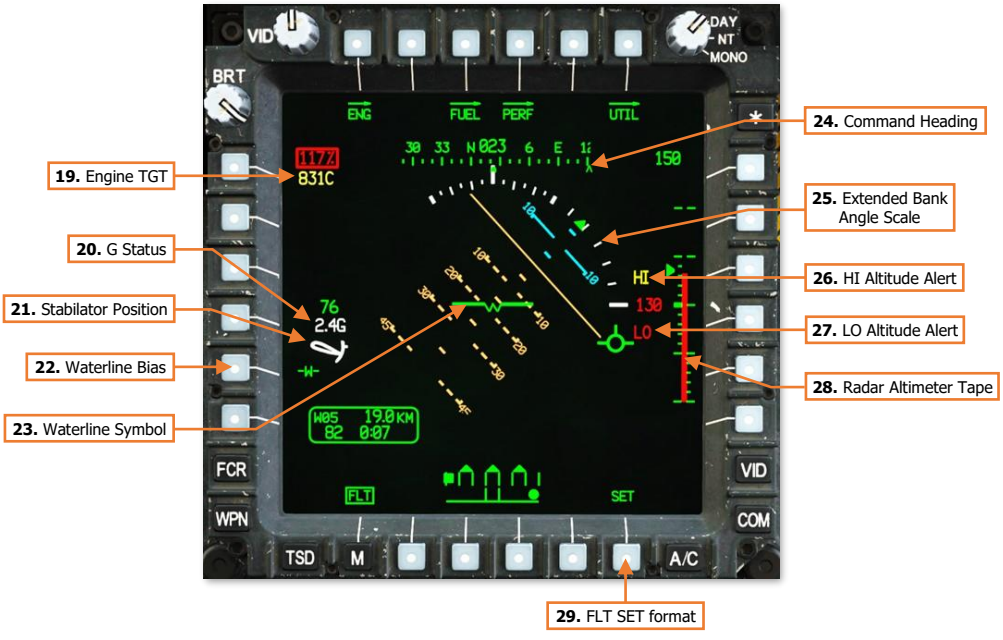
15. **Rate-of-climb Scale.** Major tick marks are placed at 0, ±500 and ±1,000 feet per minute (fpm) rates of climb/descent. Minor tick marks are placed in 100 fpm increments between 0 and ±500 fpm. When the rate-of-climb/descent exceeds ±1,000 fpm, a digital readout to the nearest 100 fpm value is displayed adjacent to the 1,000 fpm major tick marks.

    When Altitude Hold is engaged, a rounded "homeplate" box is displayed next to the Rate-of-climb Scale at 0 fpm.

16. **Radar Altitude.** Indicates the radar-detected altitude above ground level from 0 to 1,428 feet. The Radar Altitude is displayed in increments of 1 foot from 0 to 50 feet in altitude, and increments of 10 feet between 50 feet and 1,428 feet in altitude. The Radar Altitude is not displayed when the altitude exceeds 1,428 feet above ground level.

17. **Turn Rate Indicator.** Indicates the rate of turn as the aircraft enters a bank. The rate of turn is displayed as a solid square moving underneath three "doghouses". The center doghouse cooresponds with no turn (level attitude), and the left and right doghouses coorespond with standard-rate turns to the left and right, respectively. If the indicator is located between the center doghouse and either of the outer doghouses, the aircraft is in a half-standard-rate turn.

18. **Skid/Slip Indicator.** Also called the "trim ball"; indicates whether the aircraft is in coordinated flight (also known as "in aerodynamic trim", or simply "in trim"). With the ball is centered between the tick marks, the aircraft is in coordinated flight, which minimizes drag. If the ball is left of center, applying left pedal will adjust tail rotor thrust to bring the aircraft back into coordinated flight. Likewise, if the ball is right of center, applying right pedal will adjust tail rotor thrust to bring the aircraft back into coordinated flight.



19. Engine TGT. Displays the highest of the two engines' Turbine Gas Temperature (TGT) indications if operating in an intermediate or contingency TGT limit.

When operating under dual engine intermediate power, the TGT (in °C) will be displayed during the final two minutes of either the 30-minute or 10-minute allowable timers.

When operating under single engine contingency power, the TGT (in °C) will be displayed during the entire 2.5 minutes allowable for operating in the contingency power temperature range.

20. G Status. Displays the accelerometer measured G-force on the aircraft when the load factor exceeds 2G's, or if within ¼G of the G load factor limit under the current conditions of velocity, density altitude, and gross weight.

21. Stabilator Position. Displays the position of the stabilator when the stabilator is in Manual mode; the symbol is not shown when the stabilator is in Automatic mode. The position is shown graphically on an arc from 10° trailing edge up to -35° trailing edge down, with a small tick mark at 0°.

The color of the symbol indicates operating mode:

- White: Stabilator is in Manual mode.
- Yellow: Stabilator Manual mode has failed. If the stabilator position is known, it is shown graphically; otherwise, a question mark "?" symbol is shown inside the stabilator symbol. The maximum true airspeed for the current stabilator position is shown below the symbol.
- Red: Stabilator manual mode has failed, and current airspeed exceeds the maximum true airspeed for current stabilator position.

22. Waterline Bias. Toggles the pitch bias of the waterline no bias and -5°. The "-W-" symbol will be boxed when bias is applied.

NOTE: Adjusting the pitch bias on this page adjusts the pitch bias for both crewstations, to include the pitch bias of the horizon line in Transition and Cruise symbology modes.

23. **Waterline Symbol.** The waterline symbol indicates nose position and is a central reference for the pitch ladder. The symbol can be biased (adjusted upward or downward from its normal position) by using the FLT SET format. When the waterline is biased, the symbol will be partially "filled".

Waterline un-biased (Left) & biased (Right)

24. **Command Heading.** Indicates the magnetic heading to the Navigation Fly-To Cue.

25. **Extended Bank Angle Scale.** When the bank angle exceeds 20°, the scale is displayed in white and will be extended in the direction of the current bank.

26. **HI Altitude Alert.** If an altitude value other than 0 is set into the HI Altitude Alert data field on the FLT SET format, and the aircraft is above that altitude as indicated by the radar altimeter, "HI" is displayed in yellow above the radar altimeter digital readout. In addition, the radar altimeter digital readout is displayed in yellow, as is the radar altimeter analog tape if shown.

27. **LO Altitude Alert.** If an altitude value other than 0 is set into the LO Altitude Alert data field on the FLT SET format, and the aircraft is below that altitude as indicated by the radar altimeter, "LO" is displayed in red below the radar altimeter digital readout. In addition, the radar altimeter digital readout is displayed in red, as is the radar altimeter analog tape if shown, and an "ALTITUDE LOW…ALTITUDE LOW" voice message will sound over the ICS.

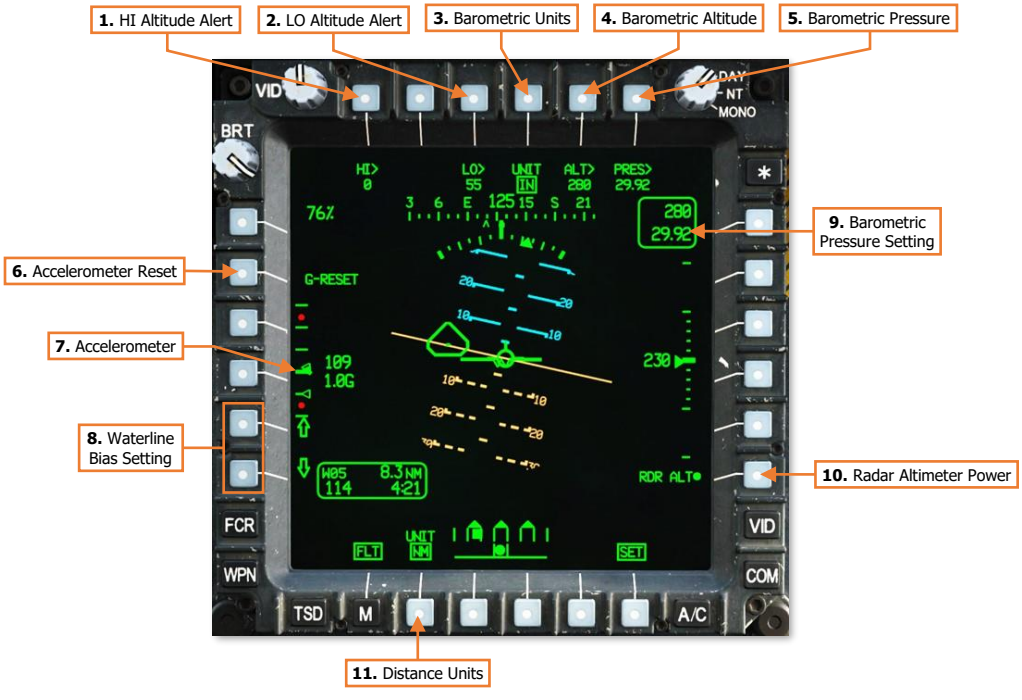
28. **Radar Altimeter Tape.** The Radar Altimeter Tape displays altitude above ground level in an "analog" format. Major tick marks are displayed in 50-foot increments between 0 and 200 feet. Minor tick marks are displayed in 10-foot increments between 0 and 50 feet.

    When the aircraft has exceeded 200 feet AGL, the Radar Altimeter Tape will be removed from the symbology. The Radar Altimeter Tape will not be subsequently displayed until the aircraft descends below 180 feet AGL.

29. **FLT SET format.** Displays the FLT Settings format.

FLT Settings (SET) Format

Pressing the SET button (VAB B6) displays the FLT page in Settings format. Pressing the SET button a second time returns the FLT page to standard format.



1. **HI Altitude Alert.** Activates the KU for inputting a high-altitude alert. When the aircraft is above this altitude as indicated by the radar altimeter, "HI" is displayed in yellow above the radar altimeter digital readout. In addition, the radar altimeter digital readout is displayed in yellow.

   If set to an altitude of "0", the high-altitude alert is disabled.

2. **LO Altitude Alert.** Activates the KU for inputting a low-altitude alert. When the aircraft is below this altitude as indicated by the radar altimeter, "LO" is displayed in red below the radar altimeter digital readout. In addition, the radar altimeter digital readout is displayed in red, as is the radar altimeter analog tape if shown, and an "ALTITUDE LOW…ALTITUDE LOW" voice message will sound over the ICS.

   If set to an altitude of "0", the low-altitude alert is disabled.

3. **Barometric Units.** Toggles the units used to display and edit the barometric pressure setting within the crewstation between inches of mercury (IN) and millibars (MB).

4. **Barometric Altitude.** Activates the KU for inputting the current altitude above sea level (MSL). When this value is changed, the barometric pressure setting is re-calculated based on the pressure altitude detected by the Helicopter Air Data System (HADS) and displayed accordingly.

5. **Barometric Pressure.** Activates the KU for inputting the current barometric pressure setting. When this value is changed, the current altitude above sea level (MSL) is re-calculated based on the pressure altitude detected by the Helicopter Air Data System (HADS) and displayed accordingly.

6. **Accelerometer Reset.** Pressing this button resets the positive and negative accelerometer telltales to 1 G.

7. **Accelerometer.** Displays current load factor (in G-force or G) along a vertical scale. A bolded tick mark indicates 1 G, with non-bolded tick marks every additional G in either direction, for a display range of +4 G to -1 G. Red dots indicate maximum positive and negative load factors for the current environmental conditions, gross weight, and airspeed. The solid green triangle indicates current load factor and is displayed in red if a limit is exceeded. Hollow green triangles are positive and negative telltales, which indicate maximum positive and negative G experienced since the accelerometer was last reset.

8. **Waterline Bias Setting.** Adjusts the pitch bias of the waterline symbol up or down in 1° degree increments for each button press, up to a maximum of 10° in either direction. "BIAS" is displayed if a bias is applied.

   NOTE: Adjusting the pitch bias on this page adjusts the pitch bias for both crewstations, to include the pitch bias of the horizon line in Transition and Cruise symbology modes.

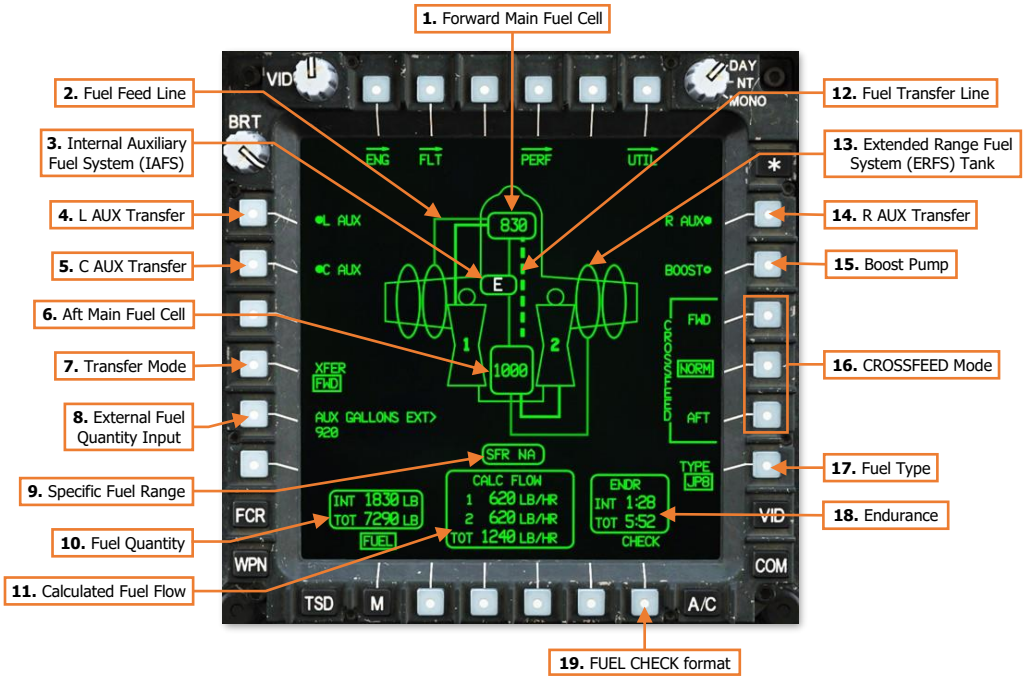
9. **Radar Altimeter Power.** Enables/disables the radar altimeter. When enabled, the radar altimeter will perform a Built-In Test (BIT) for 10 seconds before displaying radar altitude measurements.

10. **Distance Units.** Toggles the units used for distance measurement within the crewstation between kilometers (KM) and nautical miles (NM). The Waypoint Status window on the FLT page, TSD page, and IHADSS Flight Symbology within the crewstation will display the distance to current waypoint based on this selection. The TSD scale and TSD grid lines within the crewstation will also be displayed based on this selection.

    NOTE: The Range Source displayed within the High Action Display is unaffected by this selection and will always be displayed in metric.

Fuel (FUEL) Page

The FUEL page displays fuel quantity and distribution; and includes controls for configuring the crossfeed settings for supplying fuel to engines and transferring fuel between individual fuel tanks.



1. **Forward Main Fuel Cell.** Indicates the quantity of fuel remaining in the forward main fuel cell, in pounds (LB). If the quantity remaining is 240 pounds or less, the digital fuel quantity will be displayed in yellow to indicate a low fuel condition. If the fuel cell is empty, a white "E" will be displayed.

2. **Fuel Feed Line.** When fuel is being transferred between auxiliary fuel tanks and the main fuel cells, a solid line will be displayed between the auxiliary fuel tank and either of the main fuel cells. The Fuel Feed Line will be displayed in white for 3 seconds after transfer has been commanded before reverting to a full intensity green color. If fuel transfer has been commanded but is not occurring, the Fuel Feed Line will be displayed in partial intensity green.

   Fuel supplied from the main fuel cells to either engine are displayed as bolded Fuel Feed Lines.

   NOTE: If fuel is being transferred between the main fuel cells (either automatically or manually), fuel transfer from auxiliary fuel tanks cannot occur and will be paused until the main fuel cells are no longer transferring fuel.

3. **Internal Auxiliary Fuel Cell.** Indicates the quantity of fuel remaining in the Internal Auxiliary Fuel System (IAFS), in pounds (LB). If the fuel cell is empty, a white "E" will be displayed. If the IAFS is not installed, this symbol is not displayed.

4. **L AUX Transfer.** Enables/disables fuel transfer from Extended Range Fuel System (ERFS) tanks mounted on the left wing to the forward main fuel cell. If two ERFS tanks are loaded on the left wing, fuel will be transferred from the outboard ERFS tank to the inboard ERFS tank, and then to the forward main fuel cell in turn. Fuel transfer from wing-mounted ERFS tanks to the main fuel cells cannot occur if bleed air is disabled or unavailable. If no external fuel tanks are loaded on the left wing, this option is not displayed.

5. **C AUX Transfer.** Enables/disables fuel transfer from Internal Auxiliary Fuel System (IAFS) to both main fuel cells. If ERFS tanks are mounted on either wing are also commanded to transfer fuel to the main fuel cells, the IAFS will not transfer fuel until the ERFS tanks are empty. Fuel transfer from the IAFS to the main fuel cells cannot occur if bleed air is disabled or unavailable. If the IAFS is not installed, this option is not displayed.

6. **Aft Main Fuel Cell.** Indicates the quantity of fuel remaining in the aft main fuel cell, in pounds (LB). If the quantity remaining is 260 pounds or less, the digital fuel quantity will be displayed in yellow to indicate a low fuel condition. If the fuel cell is empty, a white "E" will be displayed.

7. **Transfer Mode.** Displays the Transfer selection menu for transferring fuel between the forward and aft main fuel cells. Fuel transfer between the main fuel cells cannot occur if bleed air is disabled or unavailable.

   - **AUTO.** Fuel is automatically transferred between the main fuel cells to maintain leveling. Automatic fuel transfer will only occur if both engines are running.

     Automatic fuel transfer from the aft fuel cell to the forward fuel cell will occur if:

     - The forward fuel cell contains <814 lbs of fuel and the aft fuel contains >240 lbs of fuel.
     - The aft fuel cell contains >500 lbs of fuel and contains >100 lbs more than the forward fuel cell; or the aft fuel cell contains <500 lbs of fuel and contains >50 lbs more than the forward fuel cell.
     - An AFT FUEL LOW caution does not exist.

     Automatic fuel transfer from the forward fuel cell to the aft fuel cell will occur if:

     - The aft fuel cell contains <814 lbs of fuel and the forward fuel contains >280 lbs of fuel.
     - The forward fuel cell contains >500 lbs of fuel and contains >100 lbs more than the aft fuel cell; or the forward fuel cell contains <500 lbs of fuel and contains >50 lbs more than the aft fuel cell.
     - A FWD FUEL LOW caution does not exist.

     Automatic fuel-leveling will be stopped if:

     - The difference between the forward and aft fuel quantities is <20 lbs.
     - A low fuel caution exists from the fuel cell that is being transferred from.

   - **FWD.** Fuel is transferred from the aft main fuel to the forward main fuel cell.
   - **AFT.** Fuel is transferred from the forward main fuel to the aft main fuel cell.
   - **OFF.** Fuel transfer between the main fuel cells is disabled. Automatic fuel transfer to maintain leveling between the main fuel cells will not occur.

8. **External Fuel Quantity Input.** Activates the KU to manually input the total amount of fuel within all external auxiliary fuel tanks loaded on the wing pylons. If ERFS tanks are not installed, this option is not displayed.

   NOTE: Only fuel within the 230-gallon ERFS tanks must be input manually using the KU due to the lack fuel quantity sensing probes. The IAFS is equipped with a fuel quantity probe which provides an indication of fuel quantity.

9. **Specific Fuel Range (SFR).** When ground speed exceeds 10 knots, the SFR window will display an SFR factor that is calculated by dividing the current ground speed by the total fuel flow for the current power setting. This can be used to determine optimum power settings for fuel economy during cruise; higher SFR values indicate better fuel economy.

   When SFR calculation is not being performed, "NA" will be displayed.

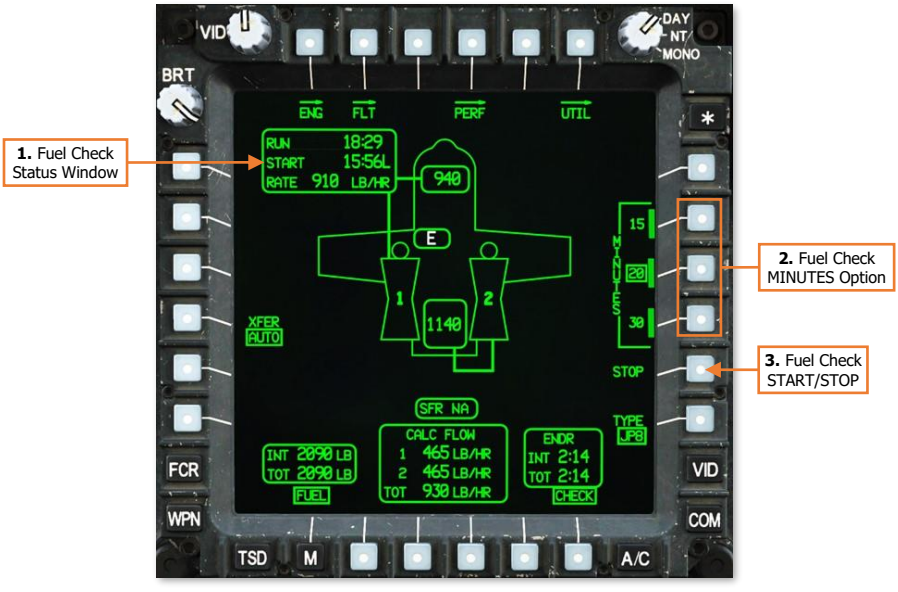
10. **Fuel Quantity.** Displays the fuel quantity onboard the aircraft. INT (Internal) fuel only includes fuel in the forward and aft main fuel cells. The IAFS (if installed) is calculated as an "external" fuel tank and is only included in the TOT (Total) fuel amount.
    - **INT.** Displays the fuel quantity within the forward and aft main fuel cells only. If either main fuel cell is displayed in a "low fuel" status, the internal fuel quantity is displayed in yellow.
    - **TOT.** Displays the total fuel quantity, including internal and external auxiliary fuel tanks. The TOT fuel quantity is not displayed if there are no internal or external auxiliary fuel tanks loaded.
11. **Calculated Fuel Flow.** Displays the fuel consumption rate (in pounds per hour; LB/HR) of each engine (1 and 2) and the total fuel flow (TOT). Fuel consumption by the APU (175 lb/hr) is not included within the calculations.
12. **Fuel Transfer Line.** A bolded, dashed line will marquee between the main fuel cells any time fuel is being transferred between them in either direction. The Fuel Transfer Line will be displayed in white for 3 seconds after transfer has been initiated before reverting to a full intensity green color.
13. **Extended Range Fuel System (ERFS) Tank.** Indicates the presence of a 230-gallon ERFS external auxiliary fuel tank loaded onto a wing pylon. If the external fuel tank is empty, a white "E" will be displayed.
14. **R AUX Transfer.** Enables/disables fuel transfer from Extended Range Fuel System (ERFS) tanks mounted on the right wing to the aft main fuel cell. If two ERFS tanks are loaded on right wing, fuel will be transferred from the outboard ERFS tank to the inboard ERFS tank, and then to the aft main fuel cell in turn. Fuel transfer from wing-mounted ERFS tanks to the main fuel cells cannot occur if bleed air is disabled or unavailable.

    If no external fuel tanks are loaded on the right wing, this option is not displayed.
15. **Boost Pump.** Enables/disables the fuel boost pump. When enabled, the crossfeed valves will automatically be set to their AFT positions, with both engines being fed from the aft main fuel (which is the only fuel cell equipped with a boost pump). When the boost pump is disabled, the crossfeed valves will automatically return to their NORM positions.
16. **Crossfeed Mode.** Controls the sources of fuel supplied from the main fuel cells to the engines.
    - **CROSSFEED – FWD.** Both engines are supplied with fuel from the forward main fuel cell.
    - **CROSSFEED – NORM.** Engine 1 is supplied with fuel from the forward main fuel; engine 2 is supplied with fuel from the aft main fuel cell.
    - **CROSSFEED – AFT.** Both engines are supplied with fuel from the aft main fuel cell.
17. **Fuel Type.** Sets the type of fuel that is loaded into the aircraft for accurate fuel weight calculations. (N/I)
18. **Endurance.** Displays the remaining flight time (endurance) until fuel is depleted. The INT (Internal) fuel only includes fuel in the forward and aft main fuel cells; the IAFS (if installed) is calculated as an "external" fuel tank and is only included in the TOT (Total) endurance calculation.
    - **INT.** Displays the flight time remaining calculated by the fuel quantity within the forward and aft main fuel cells only.
    - **TOT.** Displays the flight time remaining calculated by the total fuel quantity, including internal and external auxiliary fuel tanks. The TOT endurance calculation is not displayed if there are no internal or external auxiliary fuel tanks loaded.

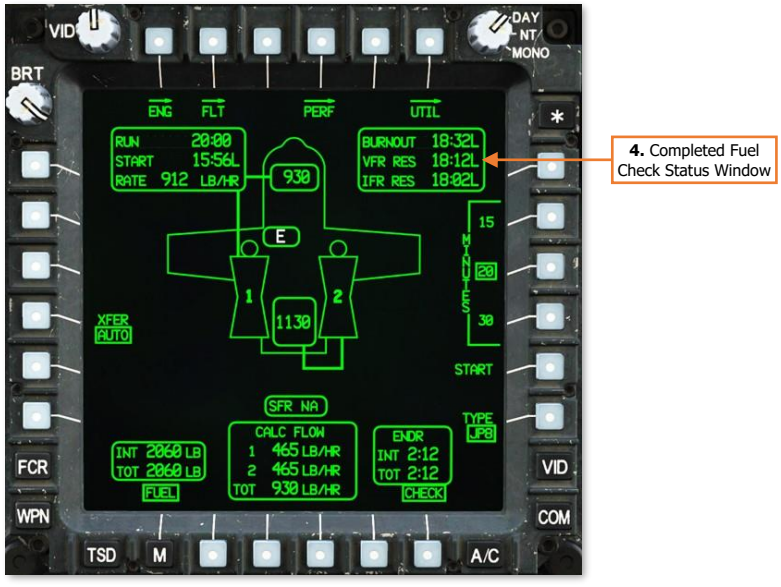
    If the endurance calculation is less than 20 minutes, the time remaining will be displayed in white.
19. **FUEL CHECK format.** Displays the FUEL Check format.

FUEL Check (CHECK) Format

Pressing the CHECK button (VAB B6) displays the FUEL page in Check format. Pressing the CHECK button a second time returns the FUEL page to standard format.



1. **Fuel Check Status Window.** If a fuel consumption check has been started, this status window will appear to display the progress of the fuel check.
   - **RUN.** Displays the amount of time that has elapsed since starting the current fuel consumption check.
   - **START.** Displays the time that the fuel consumption check was started. If the time format is toggled between Local (L) and Zulu (Z) on the TSD Utility sub-page, the fuel consumption check START time will be converted to the selected time format.
   - **RATE.** Displays the average fuel consumption rate (in pounds per hour; LB/HR) as measured since the fuel consumption check START time.
2. **Fuel Check MINUTES Option.** Controls the duration of the fuel consumption check. A "FUEL CHECK COMPLETE" advisory message will be displayed on the EUFD when the fuel consumption check has completed.
   - **15.** The fuel consumption check will run for a duration of 15 minutes.
   - **20.** The fuel consumption check will run for a duration of 20 minutes.
   - **30.** The fuel consumption check will run for a duration of 30 minutes.
3. **Fuel Check START/STOP.** If a fuel consumption check is not being performed, "START" will be displayed to command a fuel consumption check to begin for the duration that is selected above. If a fuel consumption check is in progress, "STOP" will be displayed to command a fuel consumption check to terminate before the selected duration has been reached.

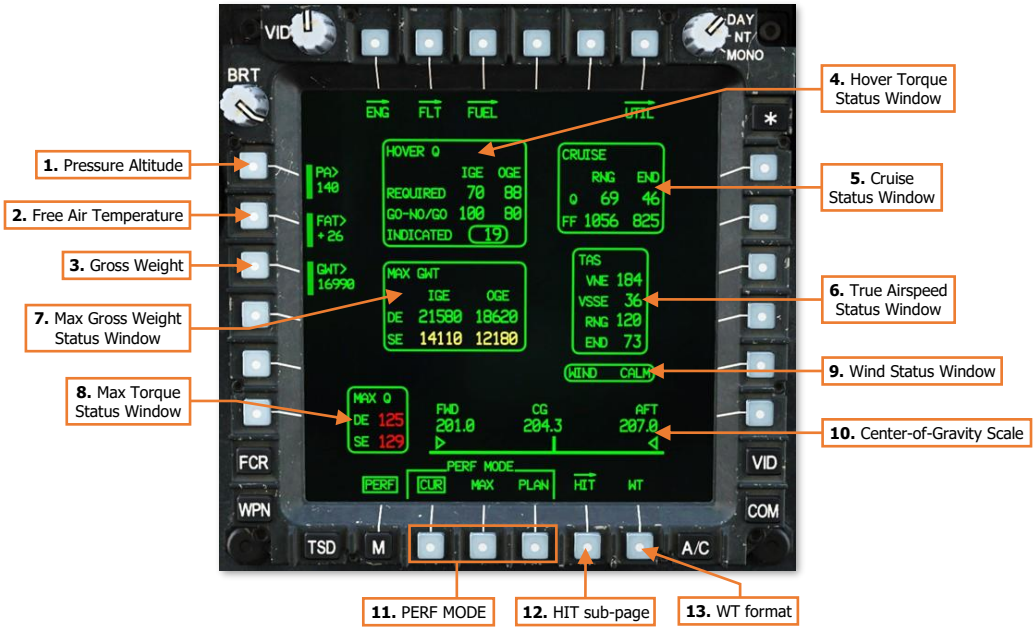


4. **Completed Fuel Check Status Window.** When a fuel consumption check has been completed or stopped, this status window will appear to display the results of the fuel check. If the time format is toggled between Local (L) and Zulu (Z) on the TSD Utility sub-page, the results displayed within the status window will be converted to the selected time format.

- **BURNOUT.** Displays the time the aircraft engines are estimated to flameout due to fuel exhaustion, based on the average consumption rate calculated during the fuel check and the total fuel quantity remaining onboard at the termination of the fuel check.
- **VFR RES.** Displays the time the aircraft will enter the VFR reserve (20 minutes of flight time remaining), based on the average consumption rate calculated during the fuel check and the total fuel quantity remaining onboard at the termination of the fuel check.
- **IFR RES.** Displays the time the aircraft will enter the IFR reserve (30 minutes of flight time remaining), based on the average consumption rate calculated during the fuel check and the total fuel quantity remaining onboard at the termination of the fuel check.

Performance (PERF) Page

The PERF page displays predictive aircraft performance data based on current environmental conditions as measured by the Helicopter Air Data System (HADS). The PERF page includes options for manually inputting conditions for calculating aircraft performance based on predicted changes in air density and/or gross weight.



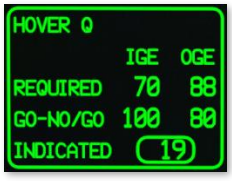
1. **Pressure Altitude (PA).** Displays the pressure altitude (PA) used for performance calculations. When the PERF page is set to CUR mode, the PA will be measured by the HADS. When the PERF page is set to MAX or PLAN modes, the PA may be manually input by the aircrew or uploaded from the DTC.

2. **Free Air Temperature (FAT).** Displays the free air temperature (FAT) used for performance calculations. When the PERF page is set to CUR mode, the FAT will be measured by the HADS. When the PERF page is set to MAX or PLAN modes, the FAT may be manually input by the aircrew or uploaded from the DTC.

3. **Gross Weight (GWT).** Displays the gross weight (GWT) of the aircraft used for performance calculations. When the PERF page is set to CUR mode, the GWT will be calculated by the System Processor (SP). When the PERF page is set to MAX or PLAN modes, the GWT may be manually input by the aircrew or uploaded from the DTC. Current gross weight is calculated by the SP based on the following factors:

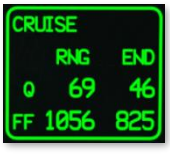
   - Weight values entered on the PERF Weight format.
     - Aircraft basic weight, to include any operational equipment installed (such as the FCR).
     - Payload within the aircraft storage bays, such as survival equipment.
     - Pilot and CPG weights.
     - "Dummy" munitions.
   - Fuel quantity as measured by the fuel system.
   - Auxiliary fuel systems (IAFS/ERFS), weapon stations (M299/M261), and loaded munitions and ammunition as inventoried by the SP.

4. **Hover Torque Status Window.** Displays predicted engine torque (Q) values when performing hovering flight, based on air density and gross weight. The values in this status window are used to assess the aircraft engine performance during a hover power check. (See Hover Power Check for more information.)



- **Hover Torque – REQUIRED IGE.** Displays the predicted hover torque required to hover in-ground-effect (IGE) at 5 feet over the surface, based on the current or predicted gross weight and air density.
- **Hover Torque – REQUIRED OGE.** Displays the predicted hover torque required to hover out-of-ground-effect (OGE) at 80 feet over the surface, based on the current or predicted gross weight and air density.
- **Hover Torque – GO-NO/GO IGE.** Displays the predicted hover torque required to hover in-ground-effect at 5 feet over the surface, at the maximum allowable gross weight specified for dual-engine, in-ground-effect (IGE) hovering flight, based on the air density.
- **Hover Torque – GO-NO/GO OGE.** Displays the predicted hover torque required to hover in-ground-effect at 5 feet over the surface, at the maximum allowable gross weight specified for dual-engine, out-of-ground-effect (OGE) hovering flight, based on the air density.
- **Hover Torque – INDICATED.** Displays the current engine torque value, the highest of the two engines, in 1% increments. If the difference in engine torque values exceeds 12%, the torque value will flash.

5. **Cruise Status Window.** Displays predicted engine torque and fuel flow values at cruise airspeeds, based on air density and gross weight. The values in this status window are used to assess the performance and fuel flow requirements when flying at either Maximum Range or Maximum Endurance airspeeds.



- **CRUISE – Q RNG.** Displays the predicted engine torque (Q) required to maintain level flight at Maximum Range (RNG) airspeed, based on the predicted gross weight and air density.
- **CRUISE – Q END.** Displays the predicted engine torque (Q) required to maintain level flight at Maximum Endurance (END) airspeed, based on the predicted gross weight and air density.
- **CRUISE – FF RNG.** Displays the predicted dual-engine fuel flow (FF) required to maintain level flight at Maximum Range (RNG) airspeed, based on the predicted gross weight and air density.
- **CRUISE – FF END.** Displays the predicted dual-engine fuel flow (FF) required to maintain level flight at Maximum Endurance (END) airspeed, based on the predicted gross weight and air density.

6. **True Airspeed Status Window.** Displays crucial airspeeds within the flight envelope, based on air density and gross weight. The values in this status window are used to maintain the aircraft within safe flight margins or to maximize the performance of the aircraft.

- **TAS – VNE.** Displays the true airspeed Velocity Never Exceed (V_{NE}), based on the predicted gross weight and air density. If the true airspeed exceeds this value, controllability of the aircraft may be negatively affected, or structural damage may occur due to aerodynamic effects on the airframe and/or rotor system.
- **TAS – VSSE.** Displays the true airspeed Velocity Safe Single Engine (V_{SSE}), based on the predicted gross weight, air density, and maximum torque available under single-engine conditions. When operating under single-engine power, level flight at a constant altitude may not be possible below this true airspeed.
- **TAS – RNG.** Displays the true airspeed that will result in the Maximum Range (RNG) of the aircraft, based on the predicted gross weight and air density.
- **TAS – END.** Displays the true airspeed that will result in the Maximum Endurance (END) of the aircraft, based on the predicted gross weight and air density.

7. **Max Gross Weight Status Window.** Displays the maximum gross weight in which hovering flight can be performed, based on air density and gross weight, without exceeding the limitations of the main transmission or engine nose gearboxes. The values in this status window are used to maintain the aircraft within safe flight margins or to evaluate the allowable payload based on the calculated performance of the aircraft.

- **MAX GWT – DE IGE.** Displays the maximum allowable gross weight in which a hover can be maintained in-ground-effect (IGE), at 5 feet over the surface, under dual-engine (DE) power, based on the air density.
- **MAX GWT – DE OGE.** Displays the maximum allowable gross weight in which a hover can be maintained out-of-ground-effect (OGE), at 80 feet over the surface, under dual-engine (DE) power, based on the air density.
- **MAX GWT – SE IGE.** Displays the maximum allowable gross weight in which a hover can be maintained in-ground-effect (IGE), at 5 feet over the surface, under single-engine (SE) power, based on the air density.
- **MAX GWT – SE OGE.** Displays the maximum allowable gross weight in which a hover can be maintained out-of-ground-effect (OGE), at 80 feet over the surface, under single-engine (SE) power, based on the air density.

8. **Max Torque Status Window.** Displays the maximum torque available from the engines, based on air density and engine condition. The values in this status window are used to assess how much torque can be demanded from the engines without causing a decay in rotor RPM (N_R); also known as "rotor droop".

- **MAX Q – DE.** Displays the maximum torque (Q) available under dual-engine (DE) power.
- **MAX Q – SE.** Displays the maximum torque (Q) available under single-engine (SE) power.

NOTE: These values do not take into account the limitations of the engine nose gearboxes or the main transmission. The torques displayed in this window may be used for a short duration in an emergency, but will impart excessive loads into the drive train system, likely incurring post-flight inspection or replacement.

9. **Wind Status Window.** Displays the current wind direction and velocity, as measured by the Helicopter Air Data System (HADS).

10. **Center-of-Gravity Scale.** Displays the calculated longitudinal center-of-gravity (CG) of the aircraft, between a minimum of 201.0 inches and a maximum of 207.0 inches, referenced from the nose of the aircraft. The CG is calculated using the same data used to calculate the current aircraft gross weight.

11. **PERF Mode.** Sets the PERF calculation mode between Current conditions, Maximum conditions, and Planned conditions. The calculations displayed on the PERF page will be based on the conditions displayed (or input) within the selected mode.
    - **CUR.** Calculations performed on the PERF page are based on the current PA and FAT as measured by the HADS, and the current GWT as calculated by the SP.
    - **MAX.** Calculations performed on the PERF page are based on values of PA, FAT, and GWT, as manually input by the aircrew or loaded by the DTC.
    - **PLAN.** Calculations performed on the PERF page are based on values of PA, FAT, and GWT, as manually input by the aircrew or loaded by the DTC.
12. **HIT sub-page.** Displays the PERF Health Indicator Test sub-page. (N/I)
13. **WT format.** Displays the PERF Weight format.

PERF Weight (WT) Format

Pressing the WT button (VAB B6) displays the PERF page in Weight format. Pressing the WT button a second time returns the PERF page to standard format. The Weight format allows either crewmember to enter the weight of the aircrew and other equipment onboard the aircraft for performance and center-of-gravity calculations.

These values are typically configured in advance by maintenance personnel based on the aircraft configuration of installed equipment. The aircrew is only required to update their own personal weights and any additional survival equipment they may have loaded prior to the flight.

1. **Aircraft Basic Weight.** Activates the KU for inputting the basic weight and moment of the aircraft. The basic weight includes the weight of the aircraft itself, permanently installed equipment, hydraulic fluid, engine and transmission oil, and unusable fuel.

   Upon activation, the KU prompt will display "WEIGHT:". After entering the weight into the KU and pressing ENTER, the prompt will display "MOMENT", after which the empty moment (weight × arm) may be input.

2. **Left Aft Bay Weight.** Activates the KU for inputting the weight of any payload loaded within the left aft fuselage storage bay.

3. **Survival Kit Weight.** Activates the KU for inputting the weight of any payload loaded within the survival kit bay in the aft fuselage.

4. **Pilot Weight.** Activates the KU for inputting the weight of the Pilot (including clothing and gear).

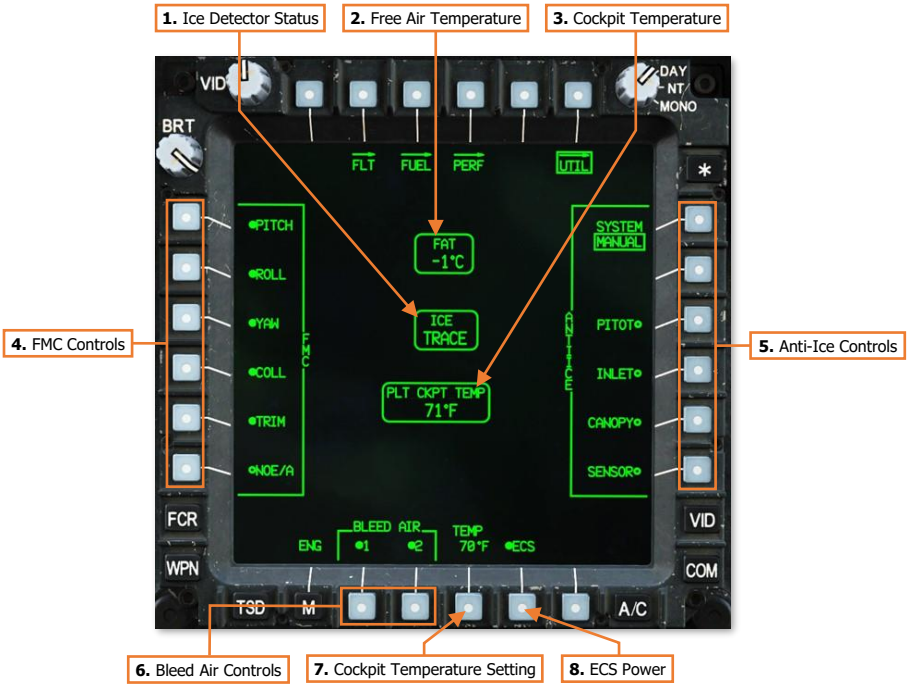
5. **CPG Weight.** Activates the KU for inputting the weight of the Copilot/Gunner (including clothing and gear).

6. **Dummy Missiles Quantity.** Activates the KU for inputting the number of M34 dummy missiles loaded onto the aircraft (0–16). Dummy missiles are not automatically inventoried by the SP and must be input manually.

7. **Dummy Rockets Quantity.** Activates the KU for inputting the number of dummy rockets loaded onto the aircraft (0–76). Dummy rockets are not automatically inventoried by the SP and must be input manually.

Utility (UTIL) Page

The UTIL page displays cockpit and outside air temperatures, and status of the ice detector. The page also includes controls for managing the anti-ice components, environmental systems, and Flight Management Computer (FMC) functions.



1. **Ice Detector Status.** Displays the level of ice accumulation sensed by the external ice detection probe. (N/I)
2. **Free Air Temperature.** Displays free air temperature in °C as sensed by the external HADS temperature probe.
3. **Cockpit Temperature.** Displays the current temperature within the crewstation.
4. **FMC Controls.** Toggles individual Flight Management Computer functions.
   - **PITCH.** Enables/disables the FMC Pitch channel inputs to the longitudinal flight control servo.
   - **ROLL.** Enables/disables the FMC Roll channel inputs to the lateral flight control servo.
   - **YAW.** Enables/disables the FMC Pitch channel inputs to the directional flight control servo.
   - **COLL.** Enables/disables the FMC Pitch channel inputs to the collective flight control servo.
   - **TRIM.** Enables/disables the force trim magnetic brakes on the cyclic and pedals in the Pilot crewstation. Disabling this function will also disable the associated functions of the Force Trim/Hold Mode switch on the cyclic.
   - **NOE/A.** Enables/disables Nap-of-the-Earth/Approach FMC mode. In NOE/A mode, the stabilator is commanded to 25° trailing edge down when airspeed is below 80 knots, but will revert to automatic mode when airspeed is 80 knots or greater. This improves "over-the-nose visibility" for low-altitude flight or during approach to landing.

5. **Anti-Ice Controls.** Toggles individual anti-ice elements. (N/I)
   - **SYSTEM.** Toggles the anti-ice system between Automatic and Manual modes of operation.
     - **AUTO.** Anti-ice systems are automatically enabled if ice is detected by the ice detect probe. When ice is no longer detected, anti-ice systems will remain enabled but may be manually disabled by the aircrew.
     - **MANUAL.** Anti-ice systems must be manually enabled by the aircrew.
   - **PITOT.** Enables/disables the electrical heating elements within the pitot and air data sensors.
   - **INLET.** Enables/disables the engine inlet and nose gearbox electrical heating elements.
     - **NOTE:** The engine inlet fairings and inlet guide vanes are heated using bleed air from the engine compressor's 5th stage. Activation of the INLET anti-ice heating will cause an increase in turbine gas temperatures (TGT), which may incur TGT temperature limiting and loss of rotor RPMs when operating at high power settings.
   - **CANOPY.** Enables/disables the electrical heating elements embedded in the forward canopy windscreens for the Pilot and CPG.
   - **SENSOR.** Enables/disables the electrical heating of the TADS/PNVS turret shrouds and sensor windows. The sensor anti-ice will be disabled with aircraft weight-on-wheels and will be inhibited from selection.
6. **Bleed Air Controls.** Enables/Disables the bleed air supply from engines 1 and 2.
7. **Cockpit Temperature Setting.** Activates the KU for inputting the desired crewstation temperature. Each crewstation is set independently.
8. **ECS Power.** Enables/Disables the Environmental Control System (ECS).

Tactical Situation Display (TSD) Page

The Tactical Situation Display presents a top-down overview of the battlespace around the aircraft. The TSD is a versatile, full color, moving map that fuses pre-planned mission data with real-time information and symbology received from the various onboard sensors, or received from offboard platforms through the datalink modem.

The TSD in each crewstation can be independently customized by each crewmember to tailor the information displayed based on the mission, changes in the tactical environment, and personal preferences. The TSD is also used as the aircrew's primary navigational display, whether performing a simple training flight in the local airspace, using the ADF receiver for radio-based navigation in low-visibility conditions, or navigating to an tactical objective within a combat area.

The Point (POINT), Route (RTE), and Instrument (INST) sub-pages are described in the Navigation chapter.

The Report (RPT), Shot (SHOT), Fuel/Ammo/Rockets/Missiles (FARM), and Battle Area Management (BAM) sub-pages are described in the Datalink chapter.

1. **PAN sub-page.** Displays the TSD Pan sub-page.
2. **SHOW sub-page.** Displays the TSD Show sub-page.
3. **Aircraft Heading.** Displays a digital readout of the aircraft's current magnetic heading in 1° increments.
4. **COORD sub-page.** Displays the TSD Coordinates sub-page.
5. **RPT sub-page.** Displays the TSD Report sub-page.
6. **UTIL sub-page.** Displays the TSD Utility sub-page.
7. **INST sub-page.** Displays the TSD Instruments sub-page.
8. **Message Receive (REC).** Displays the Receive selection menu for receiving datalink messages.
9. **Ownship.** Indicates the present location of the aircraft.

10. **Waypoint Status.** Displays the point selected for navigation, its distance in kilometers or nautical miles, and estimated time enroute (ETE). The ETE is based on the aircraft's current ground speed, and is presented in HH:MM format when the ETE is ≥5 minutes, or M:SS format when ETE is <5 minutes. The ETE is not displayed when ground speed is <15 knots or ETE is >10 hours. Waypoint Status information is not displayed if there is no active destination point.

    NOTE: The Waypoint Status window is not displayed when the TSD is set to Attack (ATK) Phase.

11. **SA Overlay.** Not implemented.

12. **Command Heading.** Indicates the magnetic heading to the point selected for navigation.

13. **Grid Status.** Displays the distance between each TSD grid line in kilometers or nautical miles. If GRID is disabled on the MAP sub-page, the Grid Status window will not be displayed.

14. **Scale Setting.** Adjusts the scale of the TSD up or down. The current setting is shown between the arrow buttons and is scaled based on the UNIT (KM/NM) selection within the crewstation on the FLT Settings page. The available TSD scales are shown below:

    - 400 KM/216 NM
    - 150 KM/81 NM
    - 100 KM/54 NM
    - 75 KM/40.5 NM
    - 50 KM/27 NM
    - 25 KM/13.5 NM
    - 15 KM/8.1 NM
    - 10 KM/5.4 NM
    - 5 KM/2.7 NM
    - 2 KM/1.1 NM
    - 1 KM/0.5 N

    When either of the scale buttons are depressed for more than 1 second, the TSD scale will become bolded and will smoothly zoom in/out while retaining the current chart scale. If neither scale button is pressed for 1 second, the zoom function will be disabled and the TSD scale buttons will revert to normal function.

15. **Freeze Mode (FRZ).** When enabled, sets the TSD to Freeze mode. All TSD symbology and navigation data will continue to update as normal, but the focal point of the TSD "footprint" will be the white Ghostship symbol. The blue Ownship symbol will continue to move across the map independently of the TSD footprint to display the actual aircraft position. (See TSD Pan sub-page for more information.)

    Ghostship

    FRZ mode may also be enabled by cursor-selecting any location within the TSD footprint when no other MPD cursor action is available, such as CAQ or point-select.

16. **Cursor Acquisition (CAQ).** Enables the cursor to designate a point on the TSD as the acquisition source. After pressing the CAQ button, the TSD will enter Freeze mode and enable any points displayed within the TSD footprint to be selected by the MPD cursor. Pressing Cursor-Enter when over a point symbol designates that point as the acquisition source.

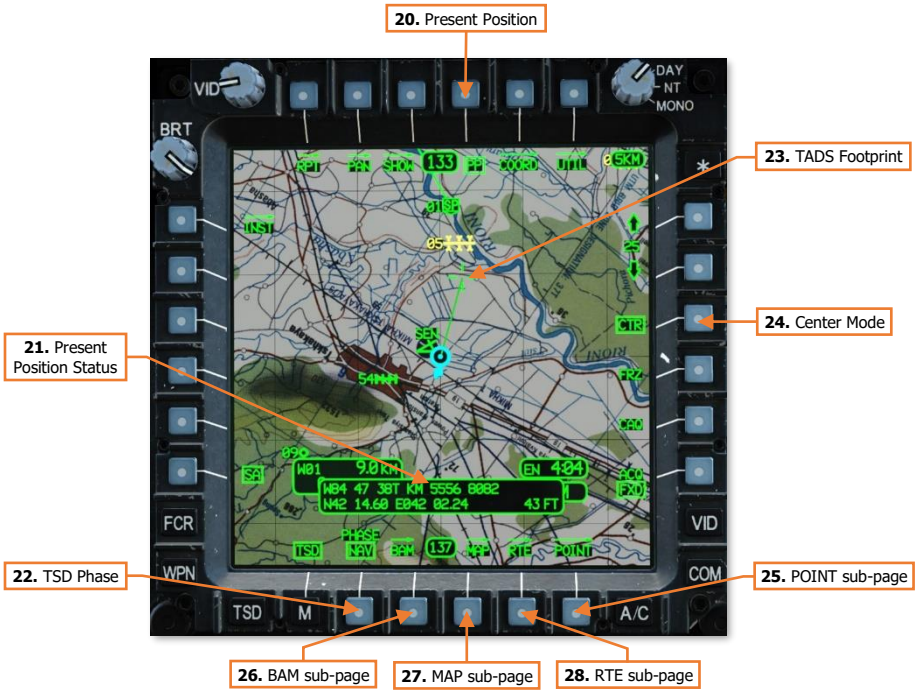
    Acquisition selection may be a Waypoint, Hazard, Control Measure, pre-planned or stored Target/Threat, an FCR detected target. If a map location on the TSD is selected instead of a point, a Terrain point (TRN PT) is created at that location. If a Terrain point is designated, the location is stored as Target/Threat points T55 (PLT) or T56 (CPG) in the COORD file (see TSD Coordinates sub-page). A white cross labeled "PLT" or "CPG" will appear on the map.

17. **Acquisition Source (ACQ).** Displays the acquisition source selection menu. (See Acquisition Sources in the Tactical Employment chapter for more information.)

18. **Endurance Status (EN).** Displays the remaining flight time (endurance) until fuel is depleted, based on the TOT (Total) endurance calculation. If the endurance calculation equals 20 minutes or less, the time remaining will be displayed in white and "EN" will flash.

    NOTE: If the calculated fuel flow to the engines is "0" (when the engines are off), the Endurance Status window is not displayed.

19. **Wind Status.** Displays the wind speed and direction of origin as computed by the aircraft Helicopter Air Data System (HADS). If wind speed is computed as <5 knots, the Wind Status will display "CALM". If the N_R is <50% and wind speed is >45 knots, the Wind Status will display the wind speed in yellow.



20. Present Position. When enabled, displays the Present Position Status window below the Ownship.

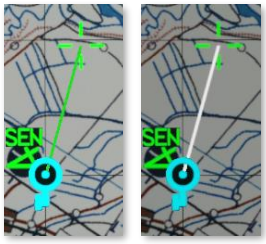
21. Present Position Status. Displays the Ownship aircraft's MGRS coordinates, Latitude/Longitude coordinates, and the aircraft's altitude in feet above mean sea level (MSL).

22. TSD Phase. Sets the TSD Phase to Navigation (NAV) or Attack (ATK). The TSD will display different elements of information relevant to the corresponding phase of the mission. Many of these elements may be configured within each crewstation based on crewmember preferences or mission requirements. (See TSD Show sub-page and TSD Coordinates Show sub-pages for more information.)

- **NAV.** The Navigation phase is used for flights to and from the combat area. As such, its default Show settings are configured with a focus on navigation, routing, and avoidance of obstacles. However, most Show settings can be enabled/disabled similar to the Attack phase, with a few exceptions:
  - Waypoint symbols and the current Route cannot be hidden.
  - Low-priority FCR target symbols cannot be seen.
  - SHOT symbols cannot be seen.
- **ATK.** The Attack phase is used for operations within the combat area or in the vicinity of the objective. As such, its default Show settings are configured with a focus on pre-planned targets and threats, FCR targeting data, and avoidance of obstacles. However, most Show settings can be enabled/disabled similar to the Navigation phase, with a few exceptions:
  - Waypoint Status window cannot be seen.
  - Only waypoints that are part of the current Route can be seen if CURRENT ROUTE is enabled. In addition, waypoints set as the crewmember's acquisition source can also be seen.
  - Low-priority FCR target symbols can be seen, if enabled.
  - SHOT symbols can be seen.

23. **TADS Footprint.** Displays a top-down representation of the TADS line-of-sight and range when the CPG's selected sight is set to TADS. The distance between the Ownship and the crosshairs represent the CPG's current range value and may not directly represent the true range to the location seen through the TADS line-of-sight itself.

    When the TADS Laser Rangefinder/Designator (LRFD) is firing, the solid green line projected between the Ownship and the TADS Footprint will be displayed in white.



TADS Footprint

24. **Center Mode (CTR).** When enabled, sets the TSD to Center mode, in which the TSD is centered on the Ownship. When disabled, the TSD is focused forward of the Ownship in a depressed mode.
25. **POINT sub-page.** Displays the TSD Point sub-page.
26. **BAM sub-page.** Displays the TSD Battle Area Management sub-page.
27. **MAP sub-page.** Displays the TSD Map sub-page.
28. **RTE sub-page.** Displays the TSD Route sub-page.

TSD Pan (PAN) Sub-page

The PAN sub-page allows the crewmember to move and rotate the map independently of the Ownship location and orientation. When using the PAN sub-page, the TSD is automatically set to Freeze mode, indicated by a dashed border displayed around the "TSD footprint".

The PAN sub-page not only allows the aircrew to view areas of the battlespace from a different perspective, it also allows them to more effectively plan, modify, or preview different aspects of the mission from within the aircraft itself, which may become necessary due to changes on the battlefield. As such, the PAN sub-page is a critical extension of other TSD functions on the Point (POINT), Route (RTE), or Battle Area Management (BAM) sub-pages.

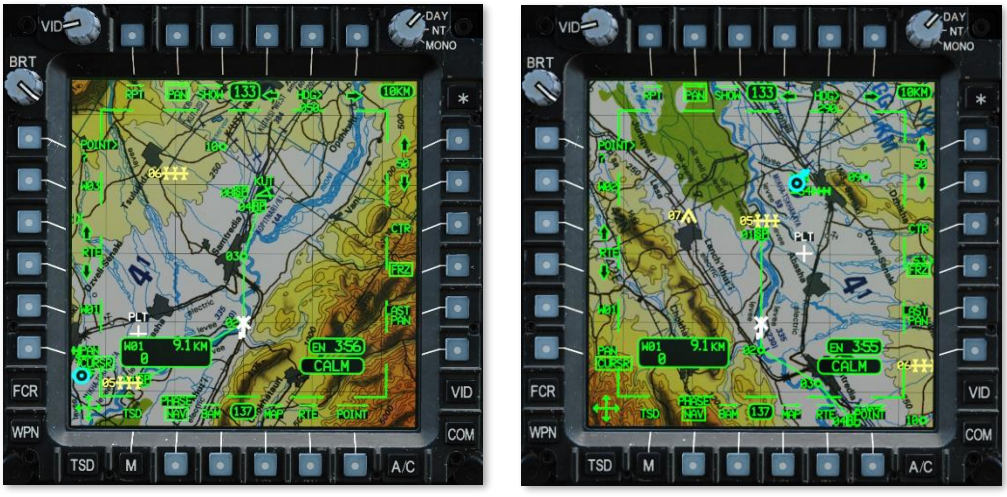
1. **TSD Heading.** Adjusts the heading of the TSD footprint independently of the aircraft heading. Pressing the left arrow (VAB T4) or right arrow (VAB T6) rotates the map in 1° increments for each momentary press, or 40° each second when pressed and held. Alternatively, HDG> (VAB T5) can be used to activate the KU for directly inputting the desired TSD heading.

2. **Pan to Point.** Activates the KU for inputting a point within the navigational database. After entry, the TSD will pan to the location of the point so that it is centered within the TSD footprint.

3. **Pan to next Route Point.** The Ghostship will pan to the corresponding point along the currently selected route and will orient toward the required heading on course to the subsequent route point. This can be used to preview the current route as if it were being flown in a sequential order as planned.

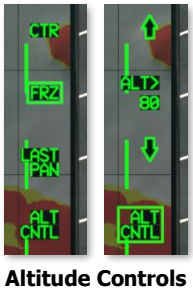
4. **Route Pan.** The Ghostship will pan along the route. Pressing the up arrow (VAB L3) or down arrow (VAB L4) will advance the Ghostship along the route a distance equal to one TSD grid square. When the up or down arrows are pressed and held, the TSD footprint will smoothly pan along the route in a continuous motion.

5. **Pan to previous Route Point.** The TSD footprint will pan to the corresponding point along the currently selected route and will orient toward the required heading on course to the subsequent route point. This can be used to preview the current route as if it were being flown in a reversed sequential order as planned.



Panning to each subsequent Route Point (Left) and continuously in reverse (Right)

6. **Pan Mode.** Sets the PAN mode to either CURSR (default mode) or NORM mode.
   - **CURSR.** The TSD footprint may be moved in any direction using the Cursor Controller on the Collective Mission Grip or the TEDAC Left Handgrip in the CPG crewstation. Pressing Cursor-Enter will switch the mode to NORM.
   - **NORM.** The TSD footprint is re-centered on the MPD cursor location each time Cursor-Enter is pressed on the Collective Mission Grip or the TEDAC Left Handgrip, or the Alternate Cursor Enter Trigger is pulled on the Collective Mission Grip or the Alternate Cursor Enter button is pressed on the TEDAC Right Handgrip.
7. **Pan Cursor.** When the MPD cursor is assigned to an MPD that is displaying the TSD PAN sub-page while the PAN mode is set to CURSR, the cursor is placed in the bottom left corner of the MPD. The TSD footprint is slaved to the MPD cursor and will move with it until PAN mode is toggled to NORM, PAN sub-page is exited, or the MPD cursor is re-assigned to the opposite MPD using the Cursor Display Select button on the Collective Mission Grip or the TEDAC Left Handgrip.
8. **Freeze Footprint.** Indicates the TSD is in Freeze mode. All TSD symbology and navigation data will continue to update as normal, but the focal point of the TSD footprint will be the white Ghostship symbol. The blue Ownship symbol will continue to move across the map independently of the TSD footprint to display the actual aircraft position.
9. **Ghostship.** Indicates the focal point of the TSD footprint any time the TSD is in Freeze mode.
10. **Last Pan.** Resets the TSD to the previous location and heading prior to the most recent Pan action.
11. **Altitude Control.** Enables/disables the Ghostship altitude controls. This option is only displayed when COLOR BAND is set to A/C or ELEV on the MAP sub-page.
12. **Altitude Controls.** Adjusts the Ghostship's altitude above ground level (AGL) independently of the Ownship. Pressing the up arrow (VAB R3) or down arrow (VAB R5) adjusts the altitude in 10 foot increments for each momentary press, or 10 feet each second when pressed and held. Alternatively, ATL> (VAB R4) can be used to activate the KU for directly inputting the desired Ghostship altitude.



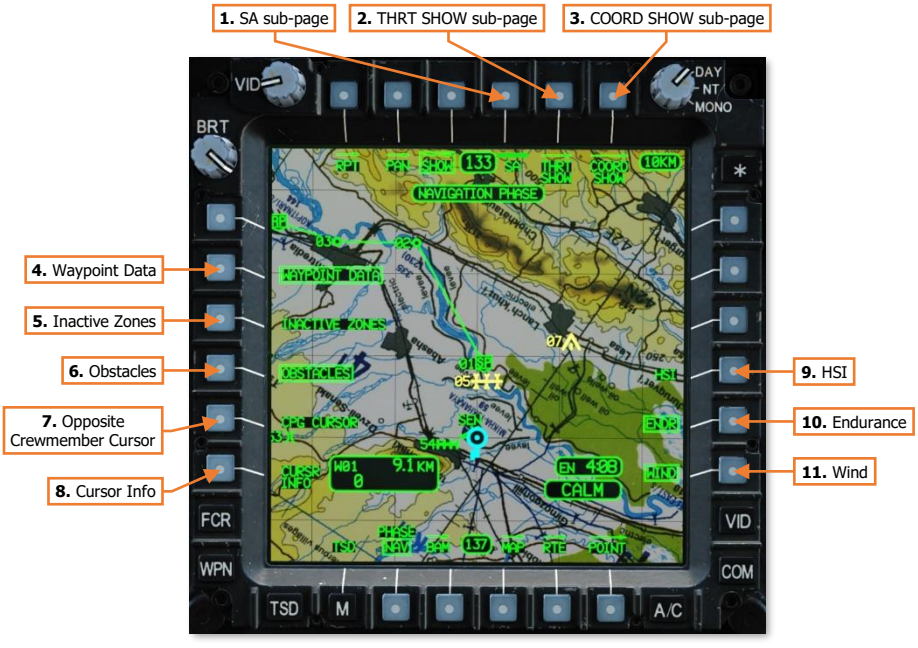
Altitude Controls

TSD Show (SHOW) Sub-page

The SHOW sub-page allows each crewmember to configure their TSD to suit the mission, tactical situation, or personal preferences. In addition, independent SHOW options are available for the Navigation and Attack phases.

NAV Phase

The Navigation Phase is used for flights to and from the combat area. As such, the default SHOW settings (shown below) are configured with a focus on navigation, routing, and avoidance of obstacles.



1. **SA sub-page.** Not implemented.
2. **THRT SHOW sub-page.** Displays the TSD Threat Show sub-page.
3. **COORD SHOW sub-page.** Displays the TSD Coordinate Show sub-page.
4. **Waypoint Data.** Enables/disables the display of the Waypoint Status window when the TSD is set to NAV phase. The Waypoint Status window cannot be displayed in ATK phase.
5. **Inactive Zones.** Enables/disables the display inactive Priority Fire Zones or No Fire Zones.
6. **Obstacles.** Enables/disables the display FCR-detected obstacles when the TSD is set to NAV phase. (N/I)
7. **Opposite Crewmember Cursor.** Enables/disables the display of the opposite crewmember's MPD cursor when being used on their respective TSD.
8. **Cursor Info Status.** Enables/disables the display the Cursor Info Status window.
9. **Horizontal Situation Indicator (HIS).** Enables/disables the display Horizontal Situation Indicator around the Ownship. When the TSD is set to Freeze mode, the HSI will be referenced to the Ghostship. (See TSD Pan sub-page for more information.)
10. **Endurance Status (ENDR).** Enables/disables the display the Endurance Status window.
11. **Wind Status (WIND).** Enables/disables the display of the Wind Status window.

12. Cursor Info Status. Displays the aircraft's selected Earth datum, the MGRS coordinates of the MPD cursor position within the TSD "footprint" in 8-digit grid format, the elevation of the terrain under the MPD cursor position in feet (FT) above mean sea level (MSL), and the distance from the Ownship to the cursor position.

13. HSI Compass. Displays the magnetic heading reference around the Ownship or Ghostship symbols. Cardinal directions and numerals to the nearest tens value are placed every 30° of azimuth, major tick marks are placed at every 10° of azimuth, and minor tick marks are placed at every 5° of azimuth. Quadrant lines indicate relative azimuths around the aircraft in relation to the aircraft's heading independently of the HSI compass itself, in 45° increments.

If the ADF is powered and is receiving a radio signal over the frequency to which it is tuned, the ADF Bearing Pointer will be displayed within the HSI Compass any time the HSI itself is shown, even if the TSD is not set to the Instruments (INST) sub-page. (See TSD Instruments sub-page for more information.)

ATK Phase

The Attack phase is used for operations within the combat area or in the vicinity of the objective. As such, the default SHOW settings (shown below) are configured with a focus on fires distribution, FCR targeting data, avoidance of obstacles, and operations within a battle position.

14. Current Route. Enables/disables the display of the waypoints and route lines of the current Route when the TSD is set to Attack phase. All waypoints are displayed on the TSD in NAV phase.

15. FCR Targets/Obstacles. Enables/disables the display of low-priority FCR targets and FCR-detected obstacles when the TSD is set to ATK phase. Low-priority FCR targets cannot be displayed on the TSD in NAV phase.

TSD Threat Show (THRT SHOW) Sub-page

The THRT SHOW sub-page allows each crewmember to configure hostile threat and intervisibility information on the TSD. Unlike the SHOW and COORD SHOW sub-pages, options on the THRT SHOW sub-page are used for both TSD phases, and will remain the same if the phase is toggled between NAV and ATK.

1. **ASE Threats.** Enables/disables the display of the ASE "footprint" around the outer edge of the TSD. When enabled, the ASE footprint will be displayed on the TSD if any threats are detected by the ASE system. When disabled, the ASE will still provide voice message alerts of detected threats, but the ASE footprint will not be displayed on the TSD.

   NOTE: The ASE Autopage setting overrides the ASE Threats THRT SHOW setting. If a threat meets or exceeds the threshold corresponding with the ASE Autopage setting, the ASE footprint will be displayed on the TSD even if the ASE THREATS option is disabled.

   (See Aircraft Survivability Equipment (ASE) page for more information.)

2. **Visibility Shading (VIS SHADE).** Not implemented.

3. **Visibility Source (VIS).** Selects the visibility source for displaying threat rings and visibility shading.

   - **THRT.** Yellow shading is drawn within yellow and red threat rings to display areas in which the Ownship will be visible to, and likely detected by, hostile threats based on the current aircraft altitude.
   - **OWN.** Blue shading is drawn within the Ownship ring to display areas of terrain that are currently visible to the Ownship at its current location and altitude.

THRT Visibility

Threat detection and lethality rings are displayed on the TSD to indicate areas in which the aircraft is likely to be detected and/or engaged by hostile threats.

4. **Threat Detection Ring.** Yellow rings indicate the estimated range at which hostile threats are able to detect the aircraft. If VIS SHADE (VAB L6) is enabled, yellow visibility shading is drawn within the ring to display areas in which the Ownship will be visible to, and likely detected by, hostile threats based on the current aircraft altitude.

5. **Threat Lethality Ring.** Red rings indicate the estimated range at which hostile threats are able to engage the aircraft with weapon systems. If VIS SHADE (VAB L6) is enabled, yellow visibility shading is drawn within the ring to display areas in which the Ownship will be visible to, and likely engaged by, hostile threats based on the current aircraft altitude.

6. **Terrain Point.** Terrain points (TRN) are displayed as white crosses and labeled by the crewstation that set them onto the TSD; PLT for the Pilot crewstation and CPG for the Copilot/Gunner crewstation. Only one Terrain point can be stored in each crewstation at any given time, with the Pilot's Terrain point stored in the Target/Threat database at T55, and the CPG's Terrain point stored in the Target/Threat database at T56.

7. **Terrain Point Altitude.** When TRN PT (VAB R3) is enabled, three options will be displayed at VAB L3, L4 and L5. These options allow the crewmember to adjust the visibility shading altitude of the Terrain point corresponding with their crewstation. (N/I)

   Pressing the up arrow (VAB L3) or down arrow (VAB L5) increases or decreases the altitude in 5-foot increments for each momentary press, or continuously when pressed and held. Alternatively, ALT> (VAB L4) can be used to activate the KU for directly inputting the desired visibility altitude.

8. **Threat Point.** Threat points are displayed as red, hostile air defense symbols with a two-digit alphanumeric label corresponding with the threat type. (See Appendix C for more information.)

9. **Target Point.** Target points are displayed as red "T" symbols with a two-digit numeric label corresponding with the point index within the Target/Threat database (T01-T50). (See the Navigation chapter for more information.)

10. **Rings/Visibility Point Selections.** Enables/disables the display of threat rings and visibility shading for selected point types.

- **ACQ.** If a Target, Threat, or Terrain point is set as the acquisition source within the crewstation, the corresponding threat ring(s) for that point will be displayed, regardless of the threat ring selections below. If a different acquisition source is selected, the threat ring(s) for that point will be removed unless enabled by the threat ring selections below.
- **TRN PT.** Terrain points set by the Pilot and/or CPG will display a yellow threat ring with a radius of 8 kilometers, regardless of whether those points are set as the current acquisition source within the crewstation.
- **FCR/RFI.** Not implemented.
- **THREATS.** All threat points will display yellow and/or red threat rings, based on the type of threat corresponding with that point type, regardless of whether the point is set as the current acquisition source within the crewstation.
- **TARGETS.** All Target (TG) points will display red threat rings with a radius of 3 kilometers, regardless of whether those points are set as the current acquisition source within the crewstation.

OWN Visibility

Blue shading is drawn within the Ownship ring to display areas of terrain that are currently visible to the Ownship at its current location and altitude.

11. Visibility Ring. Blue rings are displayed around the Ownship, Terrain Points, and Ghostship, if enabled by the corresponding point selections (VAB R2, R3 and R4 respectively) and the RINGS option (VAB R6).

12. Ownship Rings/Visibility Point Selections. Enables/disables the display of Ownship visibility rings (VAB R6) and/or visibility shading (VAB L6) for selected point types.

- **OWN.** Visibility rings and/or visibility shading is displayed around the Ownship with a radius of 8 kilometers.
- **TRN PT.** Terrain points set by the Pilot and/or CPG will display blue visibility rings and/or visibility shading with a radius of 8 kilometers, regardless of whether those points are set as the current acquisition source within the crewstation.
- **GHOST.** Visibility rings and/or visibility shading is displayed around the Ghostship with a radius of 8 kilometers any time the Ghostship is displayed. (See TSD Pan sub-page for more information.)

13. Ownship Point Rings. Enables/disables the display of blue visibility rings for point types enabled by the corresponding point selections (VAB R2, R3 and R4).

TSD Coordinate Show (COORD SHOW) Sub-page

The COORD SHOW sub-page allows each crewmember to configure what tactical graphics are displayed on the TSD. In addition, independent COORD SHOW options are available for the Navigation and Attack phases.

NAV Phase

That Navigation Phase is used for flights to and from the combat area. As such, the default COORD SHOW settings (shown below) are configured with a focus on navigation and control of the flight within the battlespace.

1. **Control Measures.** Enables/disables the display of general control measures. General control measures that are part of the current route, the navigation destination, or set as the acquisition source will be shown on the TSD regardless of this option.

2. **Friendly Units.** Enables/disables the display of friendly unit control measures. Friendly control measures that are part of the current route, the navigation destination, or set as the acquisition source will be shown on the TSD regardless of this option.

3. **Enemy Units.** Enables/disables the display of enemy unit control measures. Enemy control measures that are part of the current route, the navigation destination, or set as the acquisition source will be shown on the TSD regardless of this option.

4. **Planned Targets/Threats.** Enables/disables the display of targets and threats, to include targets/threats that are added by the crew during the mission. Targets and threats cannot be part of a route, but they can be set as the navigation destination or set as the acquisition source; in which case they will be shown on the TSD regardless of this option.

5. **Tactical Lines.** Not implemented.

6. **Engagement Areas.** Not implemented.

ATK Phase

The Attack phase is used for operations within the combat area or in the vicinity of the objective. As such, the default COORD SHOW settings are configured with a focus on the prevention of fratricide ("friendly fire"), pre-planned targets and threats, battle damage assessment, and control of the flight within the battlespace.

7. SHOT Locations. Enables/disables the display of missile engagement locations as green X symbols. Ownship missile engagement locations are displayed in full-intensity green. Missile engagement locations received via the datalink are displayed in partial-intensity green.

SHOT symbols represent locations to which an AGM-114 missile has been fired for the purposes of post-attack battle damage assessment (BDA). These symbols do not indicate whether the AGM-114 successfully hit a target nor what target was actually struck by the missile.

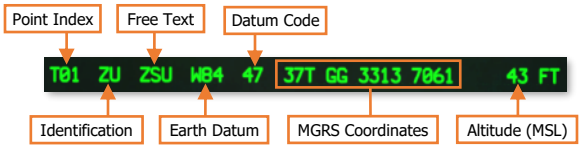
See TSD SHOT sub-page in the Datalink chapter for more information.

TSD Coordinate (COORD) Sub-page

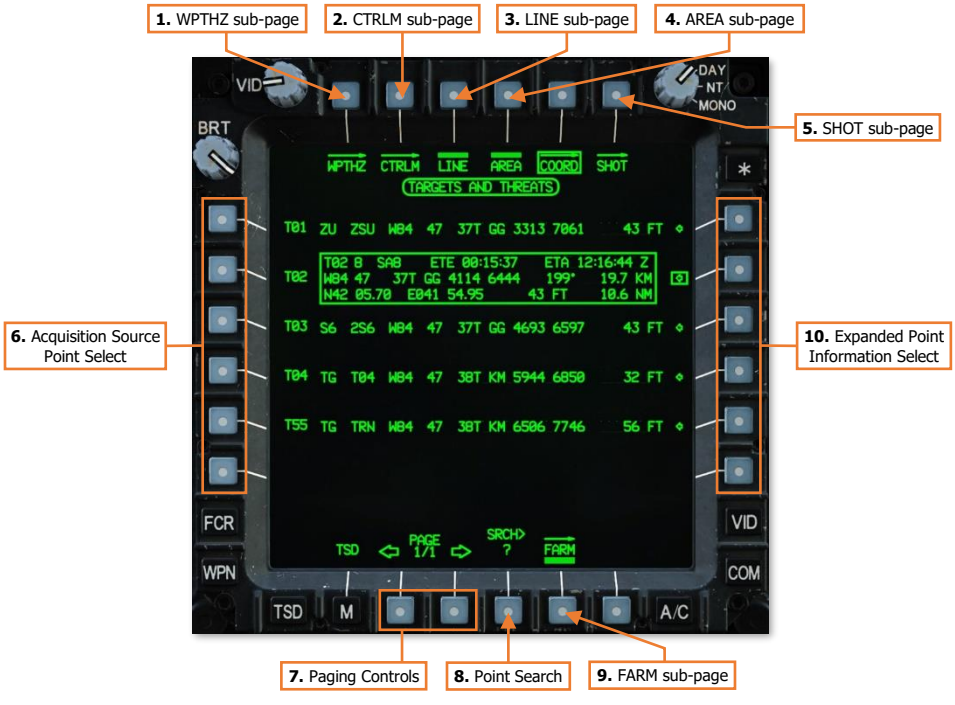
The COORD sub-page displays a list of all Target and Threat points residing within the database.

Each point entry within the list may be selected to view additional information regarding the point itself or selected as the crewmember's acquisition source.

(See Acquisition Sources for more information.)



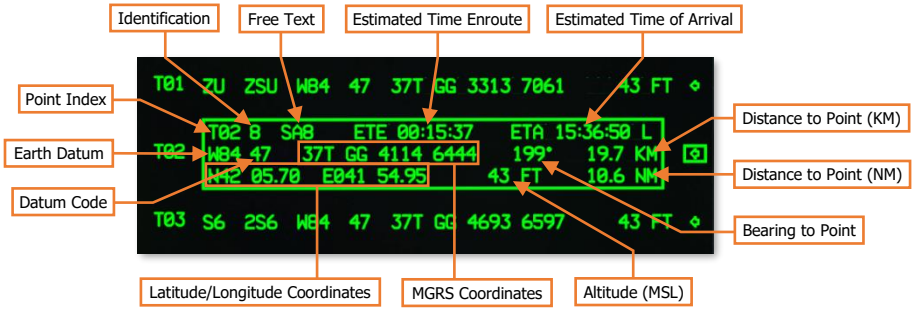
Additional sub-pages may be accessed from the COORD sub-page that allow the crewmembers to review other portions of the database within the aircraft memory. The COORD sub-page also allows the crewmembers to review SHOT files and FARM reports received from other aircraft within the team.



1. **WPTHZ sub-page.** Displays the TSD Waypoint/Hazard sub-page.
2. **CTRLM sub-page.** Displays the TSD Control Measure sub-page.
3. **LINE sub-page.** Not implemented.
4. **AREA sub-page.** Not implemented.
5. **SHOT sub-page.** Displays the TSD Shot sub-page.
6. **Acquisition Source Point Select.** Selecting a VAB to the left of a Target/Threat point will set that point as the acquisition source and return the MPD to the main TSD page.
7. **Paging Controls.** Cycles forward and back through multiple pages of Target/Threat points.
8. **Point Search.** Activates the KU for inputting alphanumeric characters to search for a specific Target/Threat point within the database. Displayed points will be filtered accordingly based on the results.

9. **FARM sub-page.** Displays the TSD Fuel/Ammunition/Rockets/Missiles sub-page.

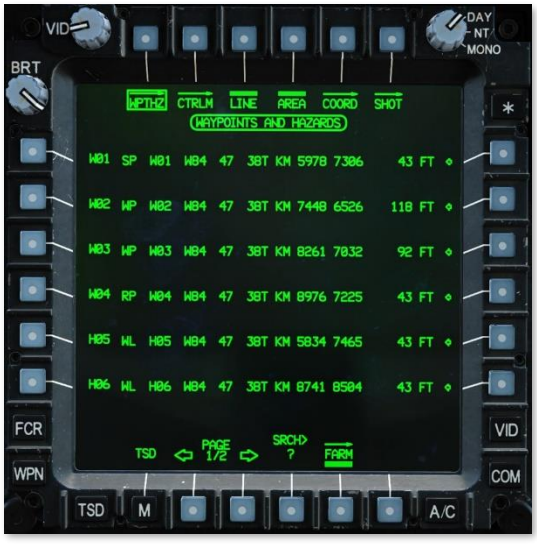
10. **Expanded Point Information Select.** Selecting a VAB to the right of a Target/Threat point will display an information window with expanded details regarding that Target/Threat point.



- **Point Index.** The database partition and location within which the point resides. (see the Navigation chapter for more information.)
- **Identification.** The one- or two-character abbreviated code of the point, which determines its specific symbol and color.
- **Free Text.** The one-, two-, or three-character text that may be added to the point for additional context as to the nature of the location.
- **Estimated Time Enroute (ETE).** The estimated elapsed time to travel to the point, based on the distance to the point from the ownship's current position and the ownship's current ground speed.
- **Estimated Time of Arrival (ETA).** The estimated time of arrival at the point, based on the current system time and the estimated time enroute (ETE). The ETA time format (Local or Zulu) is based on the system time format selected on the TSD Utility sub-page.
- **Earth Datum.** The geodetic system used to determine the point's location on the Earth.
- **Datum Code.** The one- or two-character abbreviated code of the point's Earth datum.
- **Distance to Point (KM).** The distance from the ownship position to the point's location, in kilometers.
- **Distance to Point (NM).** The distance from the ownship position to the point's location, in nautical miles.
- **Bearing to Point.** The magnetic heading from the ownship position to the point's location.
- **MGRS Coordinates.** The location of the point, in Military Grid Reference System 8-digit grid format.
- **Latitude/Longitude Coordinates.** The location of the point, in Latitude/Longitude Degrees, Minutes, Minute-Decimals format (DD°MM.MM' DDD°MM.MM').
- **Altitude.** The altitude of the point above mean sea level (MSL).

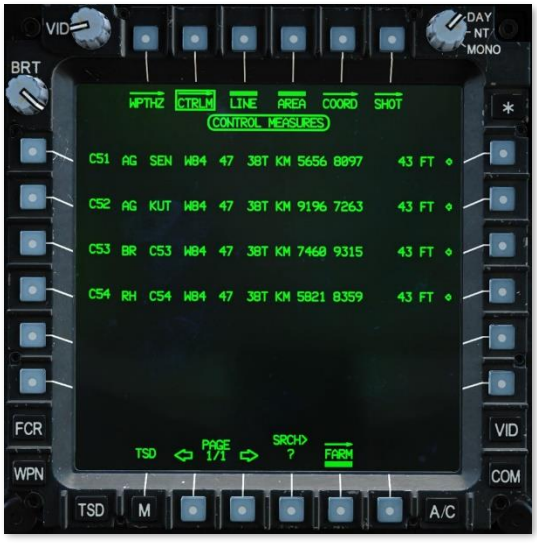
TSD Waypoint/Hazard (WPTHZ) Sub-page

The WPTHZ sub-page displays a list of all Waypoint and Hazard points residing within the database. This page functions identically to the TSD Coordinate sub-page.



TSD Control Measure (CTRLM) Sub-page

The CTRLM sub-page displays a list of all Control Measure points residing within the database. This page functions identically to the TSD Coordinate sub-page.



TSD Map (MAP) Sub-page

The MAP sub-page allows the crewmember to configure the map underlays and enhancements displayed on the TSD, as well as the TSD orientation around the Ownship symbol.

Chart Underlay

The CHART selection (VAB L2) displays a color moving map underlay on the TSD using map image tiles loaded within the database.

1. **Grid Overlay.** Enables/disables the grid overlay on the TSD.
2. **Slope Shading.** Not implemented.
3. **Grid Status.** Displays the distance between each TSD grid line in kilometers or nautical miles. If GRID (VAB T5) is disabled, the Grid Status window will not be displayed.
4. **TSD Underlay Type.** Selects the type of moving map to be underlaid on the TSD.
   - **CHART.** Displays a tactical navigation chart underlaid beneath all TSD symbology, generated by chart tiles of various scales stored within the aircraft database.
   - **DIG.** Displays an elevation relief map underlaid beneath all TSD symbology, generated by Digital Terrain Elevation Database (DTED) information stored within the aircraft database.
   - **SAT.** Displays satellite-based photo imagery beneath all TSD symbology, generated by Controlled Image Base (CIB) imagery stored within the aircraft database.
   - **STICK.** No map underlay is displayed on the TSD. A video source may be selected as a TSD underlay from the Video (VID) page.

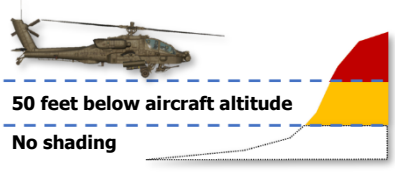
5. **Chart Underlay Scale.** Manually selects a chart scale for display as the moving map underlay. This option is only displayed if the TYPE (VAB L2) is set to CHART. The available chart scale selections are shown below:

- 1:5M (1:5,000,000)
- 1:2M (1:2,000,000)
- 1:1M (1:1,000,000)
- 1:500K (1:500,000)
- 1:250K (1:250,000)
- 1:100K (1:100,000)
- 1:50K (1:50,000)
- 1:12.5K (1:12,500)

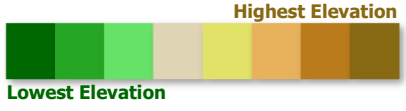
Chart rasters may not be available for all scale selections or may be limited to certain areas.

6. **Color Band Shading.** Selects the altitude reference for applying color shading to the map underlay, based on terrain elevation. This option is only displayed if the TYPE (VAB L2) is set to CHART, DIG, or SAT.

- **NONE.** No color shading is applied.
- **A/C.** Color shading is applied based on the aircraft altitude above mean sea level (MSL). Color shading is dynamically updated as the aircraft altitude changes.
  - **Red shading.** Terrain with an elevation that is at or above the current aircraft altitude.
  - **Yellow shading.** Terrain with an elevation that is within 50 feet below the aircraft altitude.
  - **No shading.** Terrain that is more than 50 feet below the aircraft altitude.



- **ELEV.** Color shading is applied based on the terrain elevation above mean sea level (MSL). The shading scale will be from green to brown if the MPD mode is set to DAY or NIGHT, or from green to black if the MPD mode is set to MONO.



Color Band set to A/C (Left) or set to ELEV (Right)

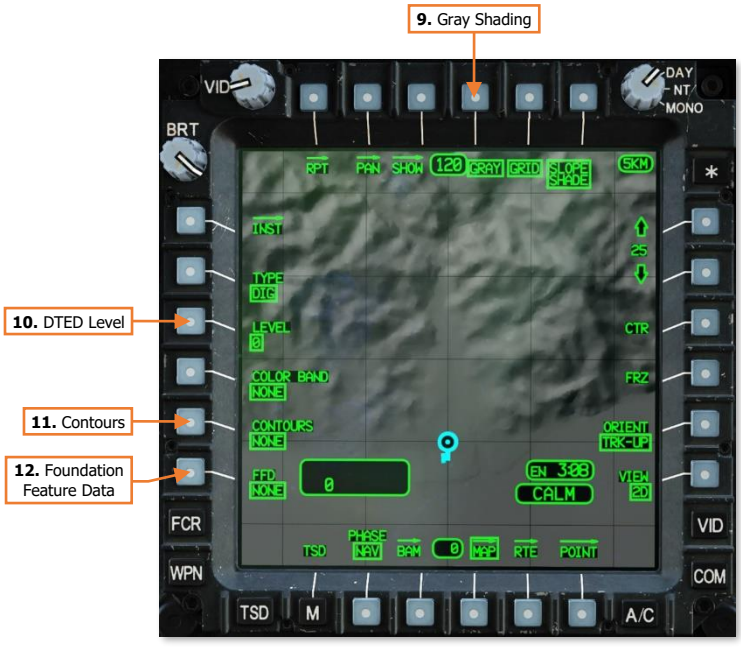
7. **TSD Orientation.** Sets the orientation of the TSD.
   - **HDG-UP.** The TSD will be aligned to the aircraft's heading.
   - **TRK-UP.** The TSD will be aligned to the aircraft's ground track across the surface. If the ground speed is 30 knots or less, or if the difference between the aircraft's heading and ground track is >30°, the TSD orientation will temporarily revert to HDG-UP.
   - **N-UP**. The TSD will be aligned to true North. Note that if Center mode (VAB R3) is disabled, the TSD footprint will shift in an angular fashion around the Ownship as the aircraft heading changes.

TSD Orientation set to N-UP with CTR disabled

8. **TSD View Angle.** Not implemented.

Digital Terrain Underlay

The DIG selection (VAB L2) displays an elevation relief map underlay on the TSD using Digital Terrain Elevation Database (DTED) information.



9. **Gray Shading.** Enables/disables gray terrain shading. This option is only displayed if the TYPE (VAB L2) is set to DIG, and is enabled by default. When disabled, digital terrain will be displayed with a green shading.

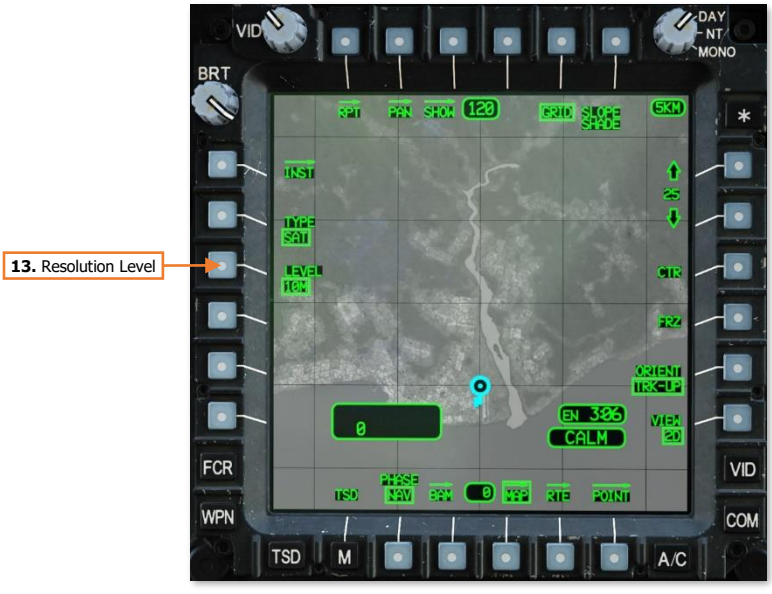
10. **DTED Level.** Not implemented.

11. **Contours.** Not implemented.

12. **FFD Display.** Not implemented.

Satellite Photo Underlay

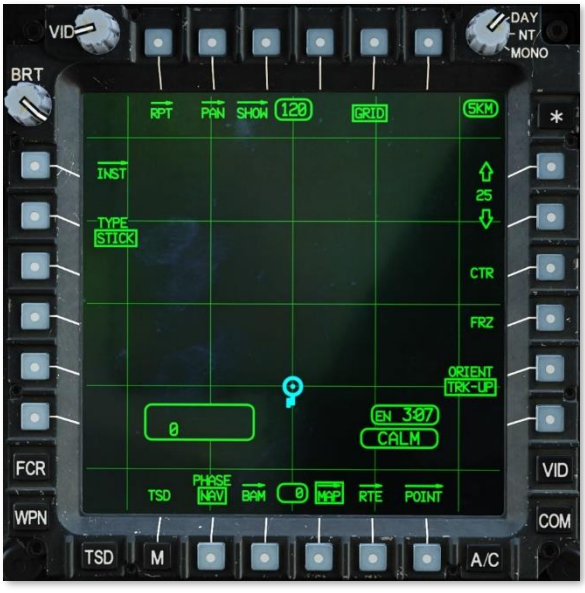
The SAT selection (VAB L2) displays a black and white satellite photo underlay on the TSD using Controlled Image Base (CIB) imagery.



13. Resolution Level. Not implemented.

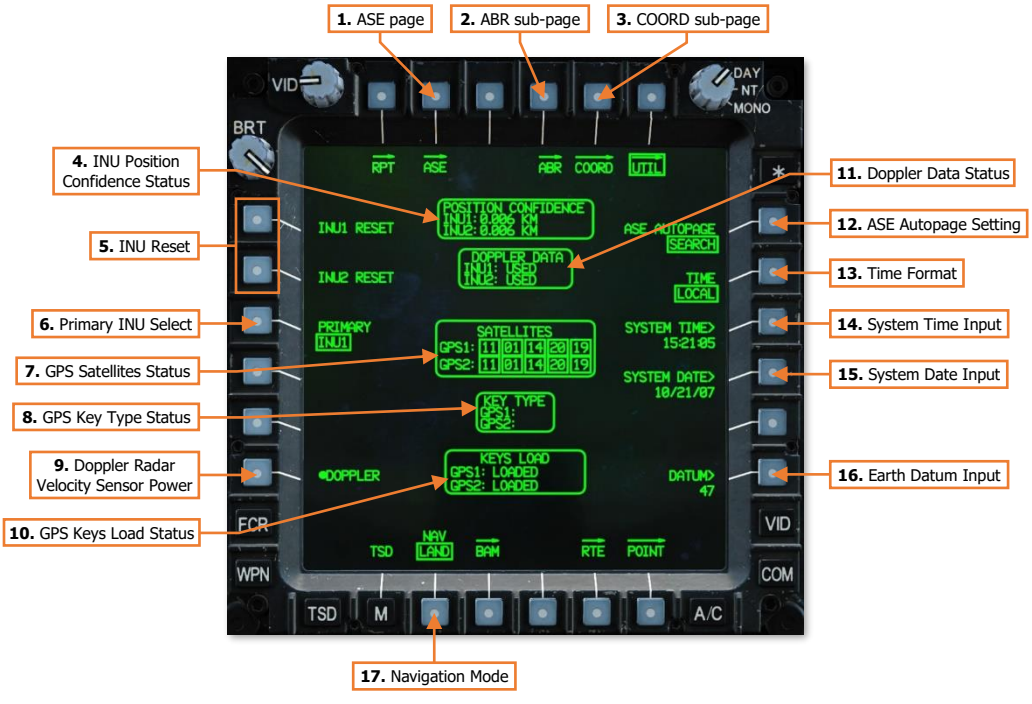
"Stick Map" (no underlay)

The STICK selection (VAB L2) displays TSD symbology only in a "stick map" format, with no moving map underlay. However, this selection allows a video underlay to be displayed under TSD symbology, based on video source underlays selected on the Video (VID) page.



TSD Utility (UTIL) Sub-page

The UTIL sub-page allows the aircrew to monitor the status of the navigation system components, configure the system time format between Local and Zulu times zones, modify the system time or date, and set the ASE autopage setting.



1. **ASE page.** Displays the Aircraft Survivability Equipment (ASE) page.
2. **ABR sub-page.** Displays the TSD Abbreviation sub-page.
3. **COORD sub-page.** Displays the TSD Coordinate sub-page.
4. **INU Position Confidence Status.** Displays the estimated radial position error for INU1 and INU2. If the radial position error is 0.050 km (50 meters) or greater, the position error will be displayed in white.
5. **INU Reset.** Resets INU1 and INU2. If the INU data becomes invalid or unreliable, a reset is used to command the corresponding INU to attempt a re-alignment and update.
6. **Primary INU Select.** Sets the primary INU used by the aircraft avionics to INU1 or INU2, with the other used as a backup. The System Processor (SP) will automatically select the primary INU, but the aircrew may manually select either INU as primary as long as both INU's are providing valid and reliable data. If the backup INU is detected as unreliable or in a reset/re-alignment state, this option will be unavailable and "barriered"
    - **INU1.** Sets INU1 as the primary INU; sets INU2 as the backup INU.
    - **INU2.** Sets INU2 as the primary INU; sets INU1 as the backup INU.
7. **GPS Satellites Status.** Displays the ID's of GPS satellites that are visible to the GPS antenna. If a signal from a satellite is being received and utilized by the EGI's, the satellite ID will be boxed.
8. **GPS Key Type.** Displays the type cryptographic keys loaded into each GPS receiver. (N/I)

9. **Doppler Radar Velocity Sensor Power.** Enables/disables power to the Doppler navigation sensor.
10. **GPS Keys Load Status.** Displays the state of the cryptographic keys loaded into each GPS receiver. (N/I)
11. **Doppler Data Status.** Displays the status of Doppler data utilization by each INU.
    - **USED.** INU is using Doppler-aided navigation.
    - **MEMORY.** INU is using Doppler-aided navigation in dead-reckoning mode.
    - **REJECTED.** INU is not using Doppler-aided navigation.
12. **ASE Autopage Setting.** Displays the ASE autopage setting for the crewstation. Pressing VAB R1 will display an expanded selection of autopage options.
    - **SEARCH.** If a new threat is detected, the TSD will be autopaged if the ASE or TSD pages are not already displayed within the crewstation.
    - **ACQUISITION.** If a detected threat elevates to ACQUISITION, the TSD will be autopaged if the ASE or TSD pages are not already displayed within the crewstation.
    - **TRACK.** If a detected threat elevates to TRACK, the TSD will be autopaged if the ASE or TSD pages are not already displayed within the crewstation.
    - **OFF.** ASE autopaging is disabled.
13. **Time Format.** Sets the system time format to Local or Zulu (UTC) time zones.

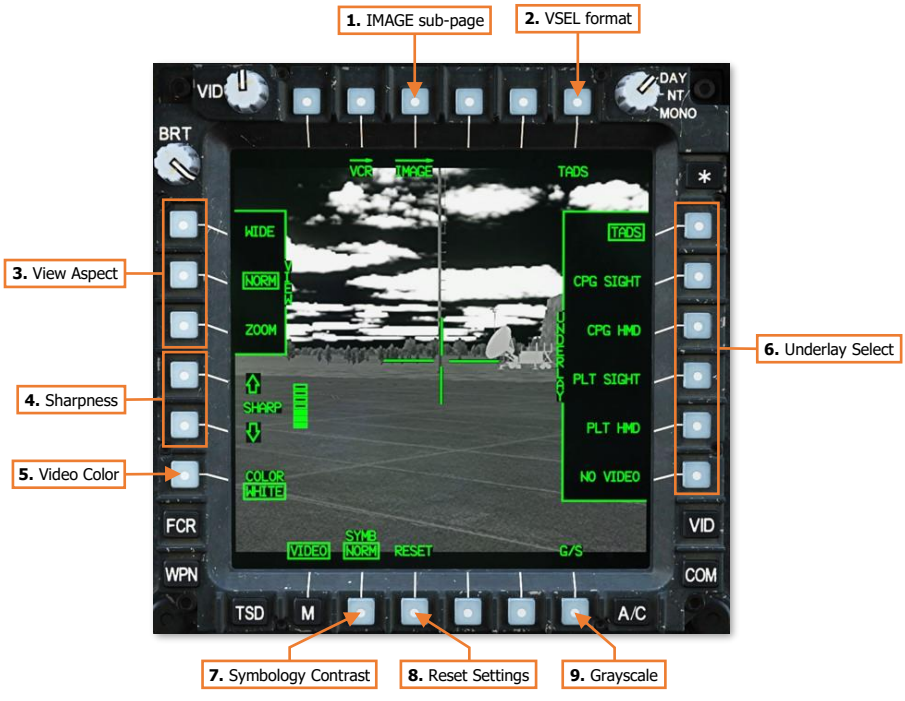
    NOTE: The selected time format is common between crewstations, in that selecting a different format in one crewstation changes it for both crewstations.
14. **System Time Input.** Activates the KU for inputting the system time. Each time format may be independently modified, and the time that will receive the input is based on the time format selected by VAB R2.

    NOTE: The Zulu time is normally based on timing signals received by GPS satellites and should only be modified if absolutely necessary
15. **System Date Input.** Activates the KU for inputting the system date.

    NOTE: The system date is referenced to the Zulu time, and is normally based on timing signals received by GPS satellites and should only be modified if absolutely necessary
16. **Earth Datum Input.** Activates the KU for inputting the geodetic system to be used for navigation. The default datum is "47" (WGS-84). A list of available datums is shown on the TSD Abbreviation sub-page.
17. **Navigation Mode.** Sets the navigation mode to LAND or SEA. During start-up, the selected mode will control the method of INU alignment. In flight, the selected mode changes the weighting of the data received by the Doppler Radar Velocity Sensor to provide the best navigational accuracy.
    - **LAND.** Sets the INU alignment to land-based operations, and Doppler-aided navigation to overland flight operations.
    - **SEA.** Sets the INU alignment to sea-based operations, and Doppler-aided navigation to overwater flight operations.

Video (VID) Page

The VIDEO page allows the crewmembers to view video and symbology from aircraft sensors. Video sources may be set as independent underlays on each MPD in either crewstation while other MPD pages are displayed.



1. **IMAGE sub-page.** Not implemented.
2. **VSEL format.** Displays the VID Video Select format. Displays the selected video underlay in a decluttered video/symbology format. The text label under VAB B6 will dynamically change based on the selected video underlay and the video source of the underlay selection.
   - **TADS.** Displays TADS Weapon symbology and TADS sensor video.
   - **C-FLT.** Displays CPG Flight symbology. If the CPG's NVS Mode switch is set to NORM or FIXED, the CPG's selected NVS sensor video will also be displayed.
   - **P-FLT.** Displays Pilot Flight symbology. If the Pilot's NVS Mode switch is set to NORM or FIXED, the Pilot's selected NVS sensor video will also be displayed.
3. **View Aspect.** Sets the video aspect for any video underlay displayed on the MPD.
   - **VIEW – WIDE.** Video underlay will be displayed in Wide aspect. All video will be seen but with significant blank space above and below the video boundaries.
   - **VIEW – NORM.** Video underlay will be displayed in Normal aspect. Some video area will not be seen beyond the left and right MPD boundaries.
   - **VIEW – ZOOM.** Video underlay will be displayed in Zoom aspect. Enlarges the source video but does not increase resolution. Some video area will not be seen beyond the MPD boundaries.

4. **Sharpness.** Adjusts the sharpness of the video underlay. Increasing the sharpness improves detection of fine details but also increases the intensity of video noise.

5. **Video Color.** Sets the color scale of the video underlay.

   - **WHITE.** Video underlay is displayed in a grayscale, with brighter shades increasing in white intensity and darker shades decreasing in intensity to black.
   - **GREEN.** Video underlay is displayed in a greenscale, with brighter shades increasing in green intensity and darker shades decreasing in intensity to black.

     This may be used to set the video underlay to a greenscale independently of the symbology overlay. This allows the crewmember to retain full MPD brightness and color symbology without setting the MPD mode to MONO.

6. **Underlay Select.** Selects the video source for display as an underlay on the MPD.

   - **UNDERLAY – TADS.** Displays TADS sensor video.

     NOTE: The TADS Weapon symbology crosshair is incorporated as part of the video underlay and will be displayed even if the VID page is not set to VSEL format.
   - **UNDERLAY – CPG SIGHT.** Displays video from the CPG's selected sight. If the MPD is not showing a video underlay when the CPG displays the VID page, this video underlay option is automatically selected.
   - **UNDERLAY – CPG HMD.** Displays video from the CPG's helmet-mounted display.
   - **UNDERLAY – PLT SIGHT.** Displays video from the Pilot's selected sight.
   - **UNDERLAY – PLT HMD.** Displays video from the Pilot's helmet-mounted display. If the MPD is not showing a video underlay when the Pilot displays the VID page, this video underlay option is automatically selected.
   - **UNDERLAY – NO VIDEO.** No video underlay will be displayed on the MPD. VSEL format selection (VAB B6) is blanked.

7. **Symbology Contrast.** Sets the relative brightness of the video underlay compared to the remainder of the symbology displayed on the MPD.

   - **NORM.** Displays video using the normal video brightness scale.
   - **BOOST.** Displays video using a reduced brightness scale in order to boost the apparent brightness of the symbology in contrast to the video underlay.

8. **Reset Settings.** Resets the VID page options to their default settings.
   - **View Aspect:** NORM
   - **Sharpness:** Level 3 of 7
   - **Video Color:** WHITE

9. **Grayscale.** Displays grayscale calibration images along the top and bottom of the MPD for ensuring all shades of the video underlay are easily visible with the current VID page options and MPD brightness/mode settings.

Video Select (VSEL) Format

Pressing the VSEL button (VAB T6) displays the VID page in Video Select format. Pressing the VSEL button a second time returns the VID page to standard format. The Video Select format allows the crewmember to view the selected video underlay in a decluttered video/symbology format.

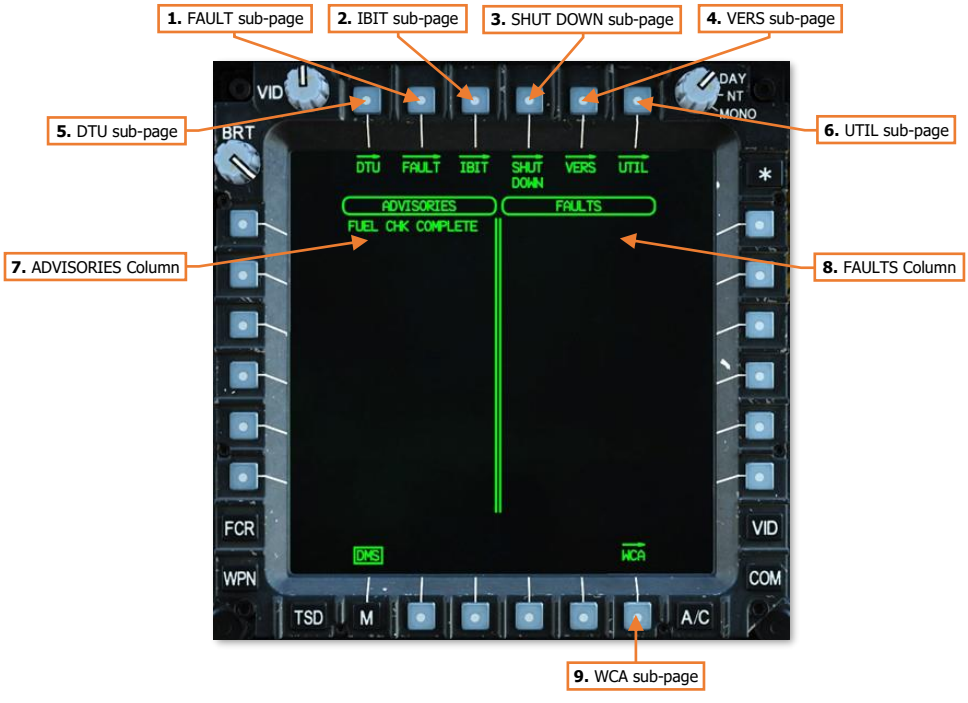
1. **View Aspect.** Sets the video aspect for any video underlay displayed on the MPD.
   - **VIEW – W.** Video underlay will be displayed in Wide aspect. All video will be seen but with significant blank space above and below the video boundaries.
   - **VIEW – N.** Video underlay will be displayed in Normal aspect. Some video area will not be seen beyond the left and right MPD boundaries.
   - **VIEW – Z.** Video underlay will be displayed in Zoom aspect. Enlarges the source video but does not increase resolution. Some video area will not be seen beyond the MPD boundaries.
2. **Sharpness.** Adjusts the sharpness of the video underlay. Increasing the sharpness improves detection of fine details but also increases the intensity of video noise.

Video Cassette Recorder (VCR) Page

The VCR page is not implemented.

Data Management System (DMS) Page

The DMS page allows the aircrew to view advisory messages and system faults. Additional DMS sub-pages may be accessed from this page for diagnostic and maintenance functions.

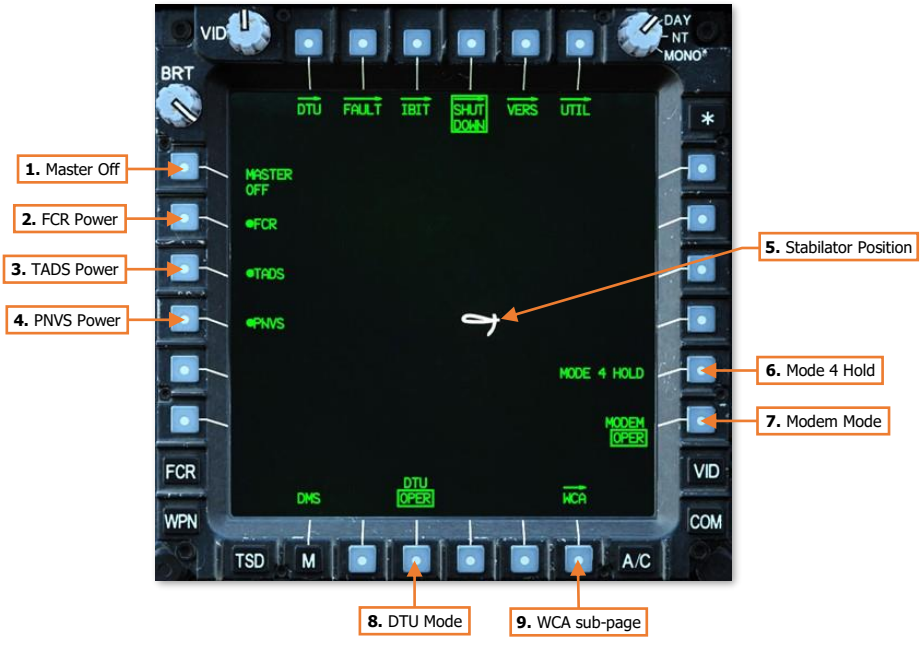


1. **FAULT sub-page.** Not implemented.
2. **IBIT sub-page.** Not implemented.
3. **SHUT DOWN sub-page.** Displays the DMS Shutdown sub-page.
4. **VERS sub-page.** Displays the DMS Version sub-page.
5. **DTU sub-page.** Not implemented.
6. **UTIL sub-page.** Displays the DMS Utility sub-page.
7. **ADVISORIES Column.** Displays current advisory messages.
8. **FAULTS Column.** Displays active system faults reported by the System Processor (SP).
9. **WCA sub-page.** Displays the DMS Warnings/Cautions/Advisories sub-page.

DMS Shutdown (SHUT DOWN) Sub-page

The SHUT DOWN sub-page is used to ensure critical aircraft systems are properly powered down prior to removing aircraft power altogether.

The Stabilator Position symbol is displayed on the SHUT DOWN sub-page in the same manner as the FLT page, to allow the aircrew to determine when the stabilator has been properly zeroized prior to shutting down the aircraft.



1. **Master Off.** Commands the FCR (if installed), TADS, and PNVS to shut down, and switches the DTU and modem to STBY mode.
2. **FCR Power.** Enables/disables the FCR system components. Not shown if the FCR is not installed.
3. **TADS Power.** Enables/disables the TADS system components.
4. **PNVS Power.** Enables/disables the PNVS system components.
5. **Stabilator Position.** Displays the position of the stabilator when the stabilator is in Manual mode; the symbol is not shown when the stabilator is in Automatic mode. The position is shown graphically on an arc from 10° trailing edge up to -35° trailing edge down, with a small tick mark at 0°.
6. **Mode 4 Hold.** Prevents Mode 4 IFF codes from being zeroized following aircraft shutdown. (N/I)
7. **Modem Mode.** Toggles the modem between standby (STBY) and operational (OPER) mode.
8. **DTU Mode.** Toggles DTU between standby (STBY) and operational (OPER) mode. (N/I)
9. **WCA sub-page.** Displays the DMS Warnings/Cautions/Advisories sub-page.

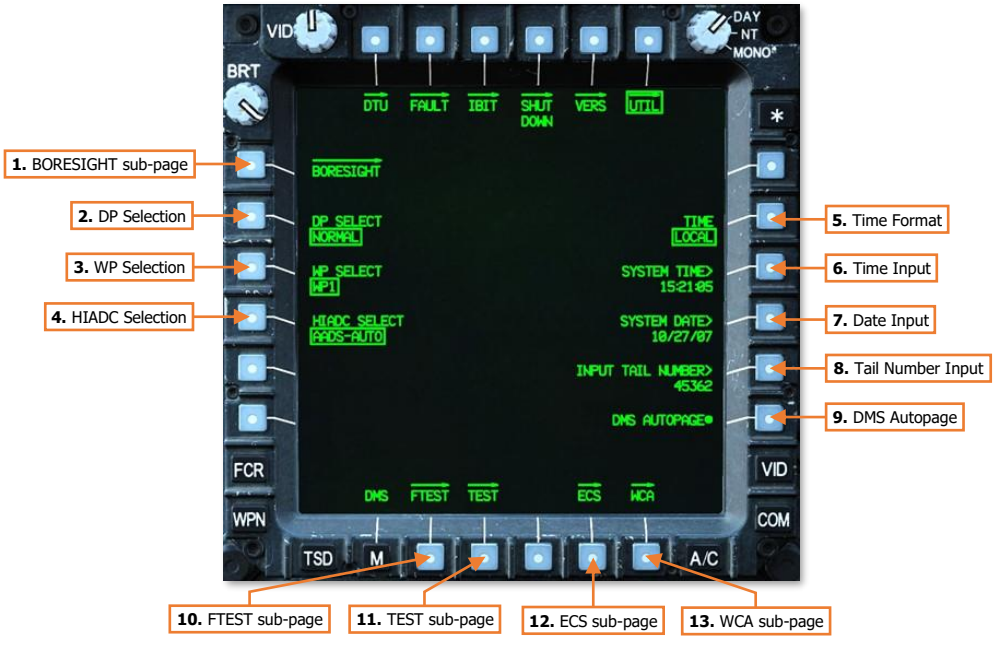
DMS Version (VERS) Sub-page

The Versions sub-page displays the current software versions within the various aircraft avionics systems.

1. **Software Versions Columns.** Displays the Line Replaceable Units (LRU) relevant to the selected subsystems category along the bottom of the page.
   - **LRU.** Displays the applicable LRU component.
   - **1.** Displays the software version of the corresponding LRU component.
   - **2.** Displays the software version of redundant LRU components, if applicable.
2. **Subsystems Selection.** Sets the avionics subsystems category for viewing relevant LRU software.
   - **SUBSYSTEMS – ACFT/COMM.** Displays the software versions of environmental, electrical, and communication systems.
   - **SUBSYSTEMS – WPN/SIGHT.** Displays the software versions of weapon and sensor systems.
   - **SUBSYSTEMS – PROC/DMS.** Displays the software versions of the aircraft processors.
   - **SUBSYSTEMS – NAV/ASE.** Displays the software versions of the Flight Management Computer (FMC) and the air data and defensive systems.

DMS Utility (UTIL) Sub-page

The Utility sub-page allows the aircrew to configure basic aircraft settings and access diagnostic functions. Most functions on this page are not implemented.



1. **BORESIGHT sub-page.** Not implemented.
2. **DP Select.** Allows maintenance personnel to select the Display Processor mode of operation. Inhibited when in the air (not weight on wheels). (N/I)
3. **WP Select.** Allows maintenance personnel to select the Weapon Processor mode of operation. Inhibited when in the air (not weight on wheels). (N/I)
4. **HIADC Select.** Allows maintenance personnel to select the Airspeed and Direction Sensor (AADS) mode of operation within the High Integrated Air Data Computer (HIADC). Inhibited when in the air (not weight on wheels) or if the ENG POWER levers are not set to OFF. (N/I)
5. **Time Format.** Toggles the time format between LOCAL or ZULU (UTC) time.
6. **System Time.** Activates the KU for inputting the current Local or Zulu (UTC) time.
7. **System Date.** Activates the KU for inputting the current date (UTC).
8. **Input Tail Number.** Activates the KU for inputting the aircraft's registration number. This number is used when interfacing with diagnostic and maintenance equipment.
9. **DMS Autopage (CPG only).** Enables/disables autopaging by the Data Management System. This option is only displayed within the CPG crewstation. DMS Autopaging cannot be disabled in the Pilot crewstation. (See MPD Auto-paging for more information.)
10. **FTEST sub-page.** Not implemented.
11. **TEST sub-page.** Not implemented.

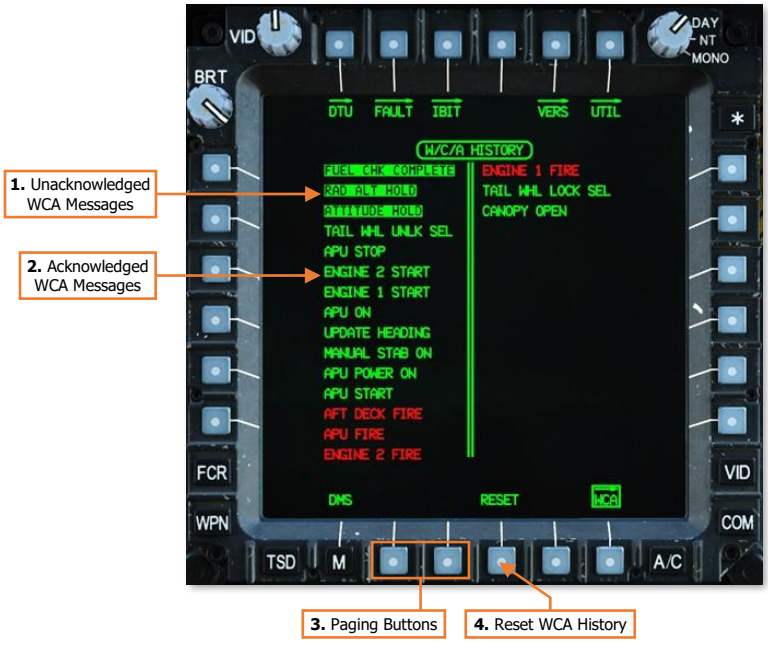
12. **ECS sub-page.** Not implemented.

13. **WCA sub-page.** Displays the DMS Warnings/Cautions/Advisories sub-page.

DMS Warning/Caution/Advisory (WCA) Sub-page

The Warning/Caution/Advisory sub-page displays a list of all current and previous Warnings, Cautions and Advisories that have occurred since the aircraft was powered on. Warnings are displayed in Red, Cautions are displayed in Yellow, and Advisories are displayed in Green.

(See Enhanced Up-Front Display for more information.)



1. **Unacknowledged WCA Messages.** WCA messages that have occurred (or re-occurred) since the WCA history has been reset (VAB B4) are displayed in inverse video. This allows a crewmember to review messages that may have been displayed on the EUFD very briefly or intermittently but were not seen prior to their removal.

2. **Acknowledged WCA Messages.** WCA messages that have been acknowledged by resetting the WCA history (VAB B4) are displayed in normal video.

3. **Paging Buttons.** If the WCA history exceeds 30 messages (up to a maximum of 128), additional pages will be available for selection using paging buttons (VAB B2 and B3). If the WCA history is less than 30, the paging buttons will not be displayed.

4. **Reset.** Resets the WCA history and sets all messages currently displayed in inverse video to normal video.

FLIGHT MANAGEMENT COMPUTER (FMC)

The AH-64D incorporates a Flight Management Computer (FMC) that can electronically command movement to the flight control servo-actuators for reduced pilot workload and accurate weapons delivery. The FMC also provides stabilator scheduling based on collective position and longitudinal calibrated airspeed; and Back-Up Control System (BUCS) functionality in case of jams or severances within the cockpit flight controls.

The FMC's three primary functions regarding aircraft control are Stability Augmentation, Command Augmentation, and Hold mode functionality. The Stability and Command Augmentation Systems (collectively referred to as "SCAS") are always active within the FMC channels, however each FMC channel may be individually enabled/disabled via the Aircraft Utility (UTIL) page. Alternatively, all FMC channels may be disabled immediately using the FMC Release "pinkie" button on the Cyclic Grip in either crewstation.

The cyclic, collective, and pedals in each cockpit utilize a collection of sensors called Linear Variable Differential Transducers (LVDT) to measure the position and movement of each flight control axis and relay these movements to the FMC. These movements are used by the FMC to process SCAS commands to the flight controls during normal operations, or to provide full "fly-by-wire" flight control functions during an emergency when in BUCS mode.

Each FMC channel corresponds to an individual hydromechanical servo-actuator that manipulates the main or tail rotor swashplate assemblies; and each of these servo-actuators includes an electronically commanded hydraulic valve. This valve can be commanded by the FMC to initiate movement of the servo-actuator control linkage to the swashplate independently of, or in conjunction with, direct mechanical inputs from the flight controls within the crewstations. The component within each servo-actuator that initiates these control movements is referred to as the "SAS sleeve", and each possesses a limited range of motion to provide SCAS and hold mode functionality (±10% authority in all axes except the pitch axis, which is +20% forward and -10% aft authority).

The FMC commands the flight control servo-actuators based on the following:

- Flight control inputs as reported through the Linear Variable Differential Transducers (LVDT)
- Aircraft rate information from the EGI's
- Helicopter Air Data System (HADS)
- Radar altimeter
- Pitot and static port pressure sensors

The FMC can only command movement to the servo-actuators via the SAS sleeves through the Primary hydraulic system. Therefore, if the Primary hydraulic system fails or loses pressure, the aircraft can still be flown using the Utility hydraulic system, but without the stability and augmentation the FMC provides; nor will hold modes or BUCS be available.

When flying from the cockpit, the Controls Indicator may be displayed by pressing **[RCtrl]+[Enter]** to view a visual representation of the flight control positions and their behavior, as commanded by the FMC. (See the DCS Fundamentals chapter for more information.)

Stability Augmentation System

The Stability Augmentation System (SAS) function of the FMC provides a stable aircraft for reduced pilot workload and increased weapons delivery accuracy. SAS is active in each FMC control axis that is enabled via the Utility (UTIL) page any time the force trim release on the Cyclic Grip is not pressed. SAS inputs are limited by the authority of the SAS sleeves within each flight control servo-actuator (±10% authority in all axes except the pitch axis, which is +20% forward and -10% aft authority).

When necessary, the FMC commands movement of the SAS sleeves within the applicable flight control servo-actuator(s) to provide the following:

- Yaw rate damping <40 knots ground speed. When accelerating, yaw rate damping will be present until ground speed is ≥40 knots. When decelerating from ground speeds ≥40 knots, yaw rate damping won't return until ground speed is <30 knots.
- Turn coordination ≥40 knots ground speed. When decelerating from ground speeds ≥40 knots, turn coordination will be present until ground speed is <30 knots. When accelerating, turn coordination won't return until ground speed is ≥40 knots.
- Lateral (roll) and Longitudinal (pitch) rate damping at all speeds.
- Atmospheric upset damping.

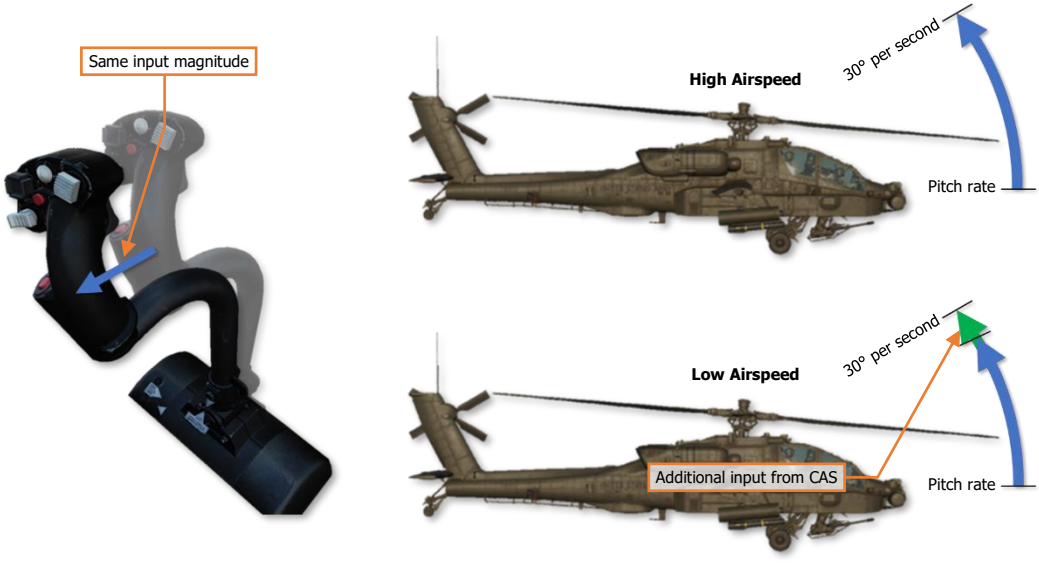
Rate damping minimizes attitude oscillations within the respective pitch, roll and yaw axes, but will not prevent attitude drift from the force trimmed positions of the flight controls. Atmospheric upset damping reduces the effect of atmospheric disturbances (such as turbulence) from affecting the aircraft's flight path.

The EGI inertial measurements provide airframe movements/rates to the FMC, which compares the EGI data to the flight control LVDTs. If there are no changes in the flight control positions, the FMC commands the respective servo-actuator SAS sleeves to counter the un-commanded movements.

Command Augmentation System

The Command Augmentation System (CAS) function of the FMC provides an immediate and uniform aircraft response at all longitudinal airspeeds. CAS is active in each FMC control axis that is enabled via the Utility (UTIL) page. CAS input limitations are the same as SAS (±10% authority in all axes except the pitch axis, which is +20% forward and -10% aft authority).

When a control input is made, the FMC detects the flight control movement in the respective LVDT axis (or axes) and will command movement of the SAS sleeve within the applicable flight control servo-actuator(s). This provides a "power steering" response to remove the lag effect of mechanical inputs into the flight control servo-actuators. At lower longitudinal airspeeds, the amount of CAS input is proportionally increased to ensure the aircraft handling remains consistent with flight at higher airspeeds.



Command Augmentation at different airspeeds

CAS is disabled in the FMC Yaw channel when the aircraft is on the ground (determined by the weight-on-wheels or "squat" switch). This prevents over-steering during ground taxi.

Force Trim & "Breakout" Values

The Cyclic Grip includes the Force Trim/Hold Mode switch. When this 4-way switch is pressed to the forward **R** (Release) position, the force trim magnetic brakes on the cyclic and pedals are released. This position is analogous to pressing the "force trim interrupt" button in other helicopters. The force trim release in the AH-64D serves three purposes in flight:

- Disengages the magnetic brakes of the force trim system on the cyclic and pedals.
- Temporarily disengages any active hold modes that are currently engaged in the pitch, roll, and yaw axes and (while pressed) allows the SAS sleeves to re-center within the respective servo-actuators.
- Sets new reference values of pitch, roll, heading, sideslip, velocity, or position; depending on what Attitude Hold modes/sub-modes are active at any given time.

Force Trim/Hold Mode Switch

When the Force Trim/Hold Mode switch is pressed to the left **AT** position, Attitude Hold is enabled, and will enter one of three sub-modes based on current ground speed (see Attitude Hold for more information). A subsequent press to the left AT position will disable the Attitude Hold.

When the Force Trim/Hold Mode switch is pressed to the right **AL** position, Altitude Hold is enabled (if within vertical speed parameters), and will enter one of two sub-modes based on current ground speed and altitude above ground level (see Altitude Hold for more information). A subsequent press to the right AL position will disable the Altitude Hold.

When the Force Trim/Hold Mode switch is pressed to the aft **D** position, Attitude Hold and Altitude Hold modes will be disabled.

Any time the force trim release is pressed, Attitude Hold (if enabled) and Heading Hold (always enabled) will be temporarily disengaged. When the force trim release is no longer pressed, these hold modes will attempt to re-engage and "capture" new reference values to hold, based on the sub-mode within which they are operating. Even if the force trim release is not pressed, a "breakout" value within each flight control axis of the cyclic and pedals allows the pilot to "fly through" the hold modes. These breakout values do not disable the hold modes altogether but will temporarily disengage their function, and the SAS sleeves in the corresponding flight control servo-actuators will no longer hold the commanded reference value(s) until the conditions for hold mode re-engagement are met.

Hold Modes

The hold modes are designed to provide limited hands-off flight and decrease pilot workload. Like the SAS and CAS functions of the FMC, the hold modes utilize the same SAS sleeves within the servo-actuators to affect the aircraft flight controls. As such, they are subject to the same limited control authorities (±10% in roll, yaw and collective; +20% and -10% in pitch) and are not autopilot functions.

To best utilize the FMC hold mode functionality, the pilot should first fly the aircraft to a stable, force-trimmed state. Once the aircraft is set at the desired flight condition, engage the desired hold mode(s).

Although there are only two Hold mode selections that can be made by the pilot (enabling/disabling the Attitude Hold or the Altitude Hold), the Hold modes themselves include multiple sub-modes within each flight control axis that are contextually selected by the FMC based on the specific flight conditions within which the aircraft is being operated. As a whole, this can be considered a "task"-based approach to sub-mode selection, in which the FMC selects the best sub-modes in the applicable flight control axes to achieve the level of flight control assistance requested by the pilot. This is distinct from manual selection of hold sub-modes, which would require additional

interaction by the pilot to manage the hold modes themselves as flight conditions changed, counter to the original purpose of *reducing* pilot workload.

Each sub-mode within the corresponding flight control axis is mutually exclusive, meaning that only one sub-mode can be active within a flight control axis at any given time. The applicable hold sub-modes within each FMC axis are shown below.

Attitude (AT) Hold sub-modes
Pitch and Roll axes.

- **Attitude Hold**
- **Velocity Hold**
- **Position Hold**

Heading Hold sub-modes
Yaw axis only.

- **Heading Hold**
- **Turn Coordination** (SAS function)

Altitude Hold (AL) sub-modes
Collective axis only.

- **Barometric Altitude Hold**
- **Radar Altitude Hold**

Heading Hold is distinct in that it is always active and cannot be enabled/disabled independently of the yaw axis itself. In addition, Turn Coordination, although it is a SAS function and not a hold sub-mode, is always enabled along with Heading Hold, and will be referenced in the following sections. However, like the sub-modes in the other axes, Heading Hold and Turn Coordination are mutually exclusive and are automatically selected by the FMC based on flight conditions.

With regard to sub-mode selection, the pilot should not adjust the flight conditions to force the FMC to utilize one hold mode over the other. Rather, the pilot should understand the unique flight control requirements that exist under various flight conditions which lead to the FMC's logic in selecting the most appropriate sub-mode that should be utilized at any given time. The pilot only needs to enable hold mode assistance using the Force Trim/Hold Mode switch, and the appropriate hold sub-mode will assist the pilot in performing the current task, provided the force trim is not being depressed and the flight controls are within their respective breakout values.

As an example of this concept, the Attitude Hold will enter one of its three sub-modes based on the ground speed of the aircraft.

- If the aircraft is ≤5 knots ground speed, the FMC will select Position Hold. The FMC will attempt to hold a hover over a fixed position on the ground since such a flight condition would most likely only exist if the pilot was attempting to do so.

- If the aircraft is >5 knots but <40 knots ground speed, the FMC will select Velocity Hold sub-mode. In this instance, the FMC will attempt to maintain the current velocity and direction across the surface since such a flight condition would most likely only exist if the pilot was attempting to perform low-speed flight at a constant speed and direction (possibly even sideways or backwards) between battle positions or when maneuvering near obstacles at low altitude.

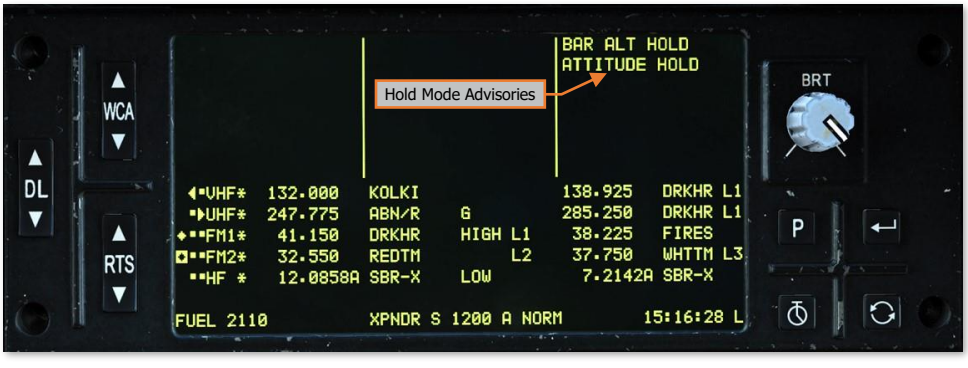
  As a helicopter's attitude directly affects its velocity and direction, maintaining a constant attitude will result in a constant velocity and direction; however, when operating at speeds below 40 knots the main rotor wash and flight direction may produce different airflow effects across different portions of the airframe, which may be exacerbated by local surface winds. As a result of these influences and flight maneuver requirements, the FMC uses the velocity and direction as its reference instead of simply the pitch/bank attitude.

- If the aircraft is ≥40 knots ground speed, the FMC will select Attitude Hold sub-mode. When performing flight above 40 knots, the pilot is most likely performing forward "cruise" flight since sideways flight with excessive sideslip at such speeds would be quite hazardous for safe aircraft operation. As such, the FMC will attempt to maintain the pitch and roll attitudes to maintain the cruise flight condition.

  If in a turn, the FMC will maintain the current bank angle to continue the turn. If the bank angle is <3°, the FMC assumes the pilot intends to maintain level flight and will auto-level the aircraft to 0° bank angle. The pitch angle will also be maintained by the FMC, which in turn will maintain the aircraft velocity since a helicopter's pitch attitude directly affects its velocity in forward flight, but is not subject to the same airflow disturbances when compared to low speeds.

When Attitude Hold is enabled, a box will be placed around the airspeed indicator in the HDU Flight symbology and on the FLT page; and the "ATTITUDE HOLD" advisory will be displayed on the EUFD.

When Altitude Hold is enabled, a "home plate" box will be placed around the VSI indicator in the HDU Flight symbology and on the FLT page; and either the "RAD ALT HOLD" or the "BAR ALT HOLD" advisory will be displayed on the EUFD, depending on what Altitude Hold sub-mode is entered.



Any time the Attitude Hold or Altitude Hold are disabled using the Force Trim/Hold Mode switch, the hold mode indicators within the HMD symbology and on the FLT page will flash and an audio tone will alert the crew that a hold mode has been deactivated.

Heading Hold & Turn Coordination Sub-modes

The FMC Yaw channel operates within two SAS sub-modes: Yaw Damping and Turn Coordination. Either of these sub-modes are enabled any time FMC Yaw channel is turned on, depending on the measured ground speed of the aircraft. In addition, the FMC Yaw channel may also operate in a Heading Hold mode. None of these modes may be disabled; however, condition-based logic will determine within which sub-mode the Yaw channel is operating, and whether that sub-mode is engaged or disengaged from affecting the flight control servo-actuators at any given time.

The primary condition that determines which sub-mode is enabled is the helicopter's ground speed, and in addition whether Attitude Hold is enabled. If the ground speed is <40 knots, Heading Hold or Yaw Damping sub-mode is enabled. If the ground speed is ≥40 knots, Turn Coordination is enabled. If the ground speed is ≥40 knots and Attitude Hold is enabled, the sub-mode may switch between Heading Hold and Turn Coordination, based on criteria described below.

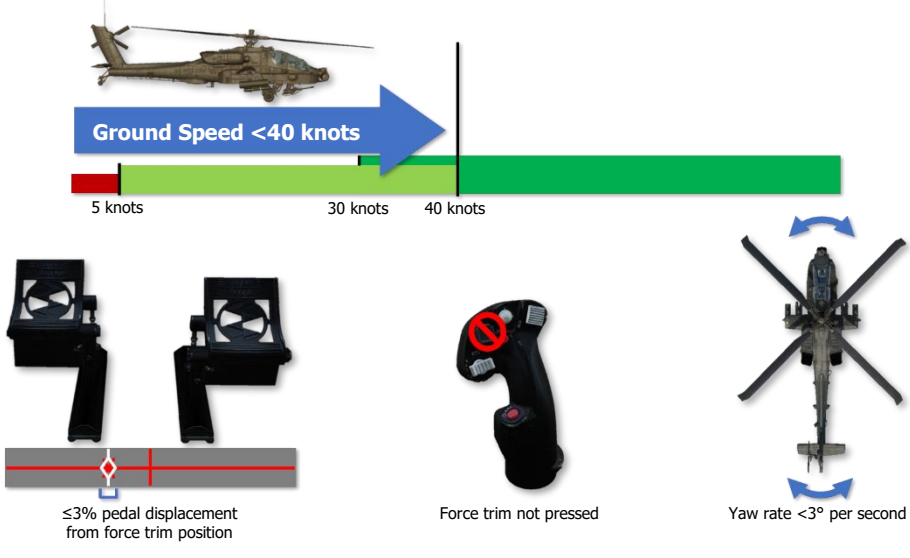
The "breakout values" within the Yaw channel become incrementally larger with forward speed. The purpose behind this is to desensitize the pedals to prevent disengaging the Heading Hold during cruise flight.

Heading Hold

Heading Hold assists the pilot in maintaining the magnetic heading reference. If the force trim release is pressed, Heading Hold is disengaged and the FMC Yaw channel will only provide command augmentation. When the pilot stops pressing the force trim release and the parameters for Heading Hold engagement are met, the FMC will update the Heading Hold reference to the current magnetic heading and engage Heading Hold.

If Attitude Hold is **disabled**, Heading Hold will engage when **all** of the following conditions are true:

- One second has elapsed since Heading Hold was disengaged.
- The helicopter is off the weight-on-wheels ("squat") switch.
- Ground speed <40 knots.
- Pedal displacement ≤3% in yaw axis from the force trim reference position.
- Force trim is not pressed.
- Yaw rate <3° per second.



Heading Hold engagement (Attitude Hold disabled)

If Attitude Hold is **enabled** in Position or Velocity sub-modes, Heading Hold will engage when **all** of the following conditions are true:

- Pedal displacement ≤3% in yaw axis from the force trim reference position in Position Hold sub-mode or ≤6% in yaw axis from the force trim reference position in Velocity Hold sub-mode.
- Force trim is not pressed.
- Yaw rate <3° per second.

Heading Hold engagement (Position Hold enabled)

Heading Hold engagement (Velocity Hold enabled)

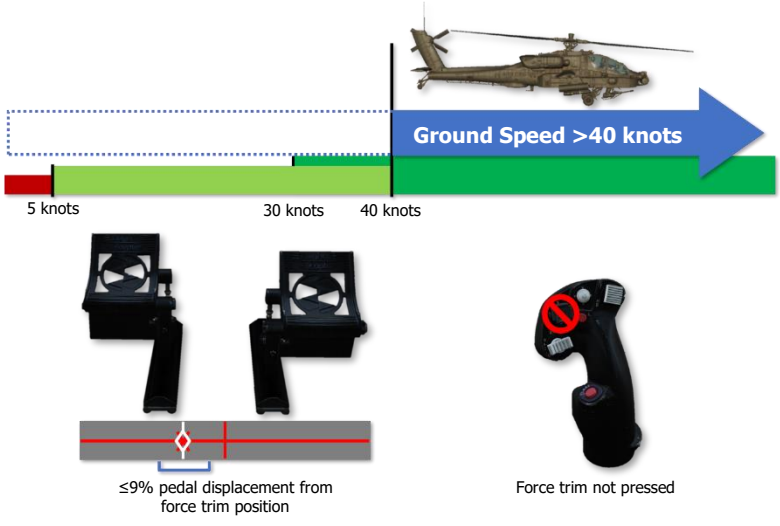
Heading Hold will engage under certain conditions if Attitude Hold is enabled and in Attitude Hold sub-mode, but this logic is inter-woven along with Turn Coordination and is described below.

Turn Coordination Sub-mode

Turn Coordination sub-mode assists the pilot in maintaining the sideslip angle, and is a function of roll attitude, airspeed, and sideslip. Sideslip angle is a derived quantity based on inertial velocity as opposed to air data. This method of determining sideslip angle provides more stable and reliable sideslip information than can be obtained from an air data sensor. If the force trim release switch is pressed, Turn Coordination is disengaged, and the FMC Yaw channel will only provide command augmentation and rate damping. When the pilot stops pressing the force trim release switch, the FMC will update the Turn Coordination sideslip angle reference to the current trim ball position.

If Attitude Hold is **disabled**, Turn Coordination will engage when **all** of the following conditions are true:

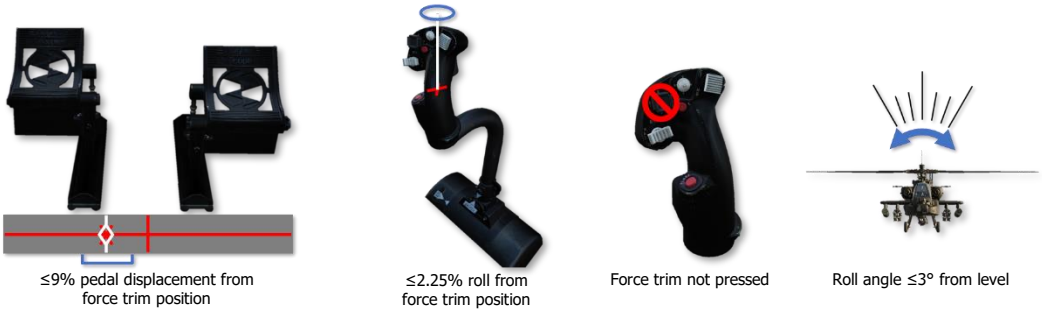
- Ground speed ≥40 knots.
- Pedal displacement ≤9% in yaw axis from the force trim reference position.
- Force trim is not pressed.



Turn Coordination engagement (Attitude Hold disabled)

If Attitude Hold is **enabled** with ground speed ≥40 knots, Turn Coordination will switch to Heading Hold when **all** of the following conditions are true:

- Pedal displacement ≤9% in yaw axis from the force trim reference position.
- Cyclic displacement ≤2.25% in roll axis from the force trim position.
- Roll (bank) angle is ≤3° from level attitude.
- Force trim is not pressed.



Turn Coordination switches to Heading Hold (Attitude Hold enabled)

If Attitude Hold is **enabled** with ground speed ≥40 knots, Heading Hold will revert to Turn Coordination if **any** of the following conditions are true:

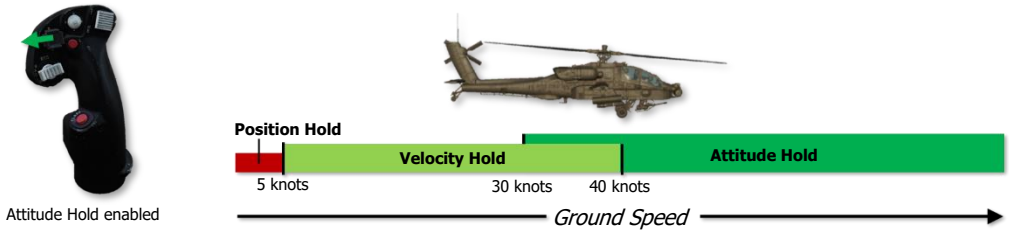
- Pedal displacement >9% in yaw axis from the force trim reference position.
- Cyclic displacement >2.25% in roll axis from the force trim position.
- Roll (bank) angle is >7° from level attitude.
- Force Trim is pressed.

Heading Hold reverts to Turn Coordination (Attitude Hold enabled)

Attitude Hold & Position/Velocity Hold Sub-modes

The FMC Pitch and Roll channels operate with Attitude Hold and two additional sub-modes: Position Hold and Velocity Hold. Only one of these three sub-modes can be activated at any given time, only when the Attitude Hold is activated using the Force Trim/Hold Mode switch when pressed to the Left/AT position, and only when the FMC Pitch and Roll channels are turned on. Condition-based logic will determine which sub-mode the Pitch/Roll channels are using, and whether that sub-mode is engaged or disengaged from affecting the flight control servo-actuators at any given time.

The condition that determines which Attitude Hold sub-mode the Pitch/Roll channels operate within is the helicopter's ground speed. If the ground speed is ≤5 knots, Position Hold sub-mode is activated. If the ground speed is >5 knots but <40 knots, Velocity Hold sub-mode is activated. If ground speed is ≥40 knots, Attitude Hold sub-mode will be activated.



Attitude Hold Sub-modes

Attitude Hold may be activated while still on the ground, however it will not engage in any sub-mode until the helicopter is off the weight-on-wheels ("squat") switch.

Position Hold Sub-mode

When Position Hold sub-mode is engaged, the FMC will use velocities provided by the EGI to approximate and maintain its position. If the pilot presses the force trim, or displaces the cyclic beyond the breakout values in pitch or roll (2.5% in the pitch axis or 2.25% in the roll axis) without pressing the force trim, Position Hold will disengage and the SAS will revert to rate damping only. Once the cyclic is returned within the breakout values and the force trim is no longer pressed, the aircraft's current position will be captured as the new reference position, Position Hold will re-engage, and the FMC will command SAS sleeve inputs into the Pitch and Roll servo-actuators to maintain the aircraft over the reference position.

To re-position the helicopter and set a new position reference, the pilot should press and hold the force trim release switch, translate the helicopter to the desired location, and then stop pressing the force trim release switch when a stable hover has been established. Pressing the force trim release switch is not necessary if the cyclic position exceeds the breakout values, however pressing and holding the force trim will allow the SAS sleeves to center themselves within their respective axes, ensuring maximum authority in each direction when Position Hold is re-engaged. If the pilot accelerates the aircraft above 5 knots ground speed and then returns the cyclic within the breakout values and stops pressing the force trim, Velocity Hold sub-mode will be entered.

Since Position Hold is only engaged when ground speed is ≤5 knots while the force trim release switch is not pressed, Heading Hold will also be active in the FMC Yaw axis while operating in this sub-mode. However, if the pedals are displaced ≥3% from the force trim reference position, Heading Hold will disengage and will only re-engage given the conditions listed in the Heading Hold & Turn Coordination Sub-modes description.

Velocity Hold Sub-mode

When Velocity Hold sub-mode is engaged, the FMC will use inertial velocities provided by the EGI to maintain a 2-dimensional velocity and in the horizontal plane. If the pilot presses the force trim, or displaces the cyclic beyond the breakout values in pitch or roll (2.5% in the pitch axis or 2.25% in the roll axis) without pressing the force trim, Velocity Hold will disengage and the SAS will revert to rate damping only. Once the cyclic is returned within the breakout values and the force trim is no longer pressed, the aircraft's current velocity and vector will be captured as the new reference velocity, Velocity Hold will re-engage, and the FMC will command SAS sleeve inputs into the Pitch and Roll servo-actuators to maintain the current velocity and relative direction over the ground.

To establish a new velocity and/or vector reference, the pilot should press and hold the force trim release switch, adjust the flight controls to attain the desired velocity and vector, and then stop pressing the force trim release switch when a stable flight condition has been established. Pressing the force trim release switch is not necessary if the cyclic position exceeds the breakout values, however pressing and holding the force trim will allow the SAS sleeves to center themselves within their respective axes, ensuring maximum authority in each direction when Velocity Hold is re-engaged. If the pilot accelerates the aircraft to 40 knots ground speed or greater and then returns the cyclic within the breakout values and stops pressing the force trim, Attitude Hold sub-mode will be entered. If the pilot decelerates the aircraft to 5 knots ground speed or less and then returns the cyclic within the breakout values and stops pressing the force trim, Position Hold sub-mode will be entered.

Since Velocity Hold is only engaged when ground speed is >5 knots and <40 knots while the force trim release switch is not pressed, Heading Hold will also be active in the FMC Yaw axis while operating in this sub-mode. However, if pedals are displaced ≥6% from the force trim reference position, Heading Hold will disengage and will only re-engage given the conditions listed in the Heading Hold & Turn Coordination Sub-modes description.

Attitude Hold

When Attitude Hold sub-mode is engaged, the FMC will use rates and attitudes provided by the EGI to maintain a pitch and roll attitude. If the pilot presses the force trim, or displaces the cyclic beyond the breakout values in pitch or roll (2.5% in the pitch axis or 2.25% in the roll axis) without pressing the force trim, Attitude Hold will disengage and the SAS will revert to rate damping only. However, unlike Position or Velocity Hold submodes, Attitude Hold will only disengage in the respective axis in which a breakout value has been exceeded.

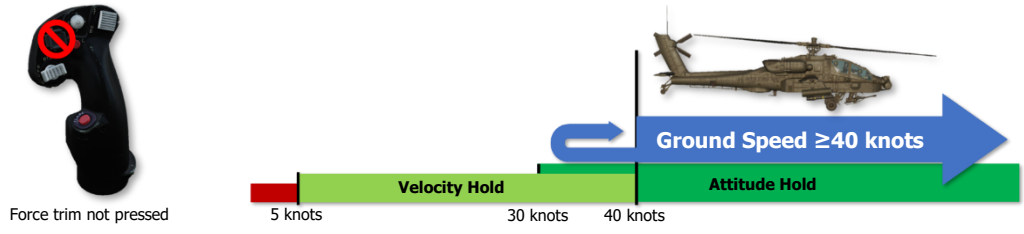
As an example, if the pilot displaces the cyclic >2.25% in the Roll axis only, the FMC will disengage Attitude Hold in the Roll servo-actuator only, but still provide SAS rate damping functions for that actuator. The FMC will continue to maintain the referenced pitch attitude by commanding movement to the SAS sleeve within the Pitch servo-actuator. Once the cyclic is returned within the breakout values, the aircraft's current pitch and/or roll

attitude will be captured as the new reference attitude, Attitude Hold will re-engage in the respective axis, and the FMC will command SAS sleeve inputs into the Pitch and Roll servo-actuators to maintain the current pitch and roll attitude. However, if the roll reference is <3° from a level roll attitude, the bank angle will be commanded to 0° and the aircraft will auto-level.

This axis-specific breakout logic allows a pilot to adjust the airspeed or bank angle without disengaging the other axis being commanded by the FMC in Attitude Hold sub-mode, or by pressing the force trim. This can be convenient for flying an orbit or navigating a route at cruise speeds.

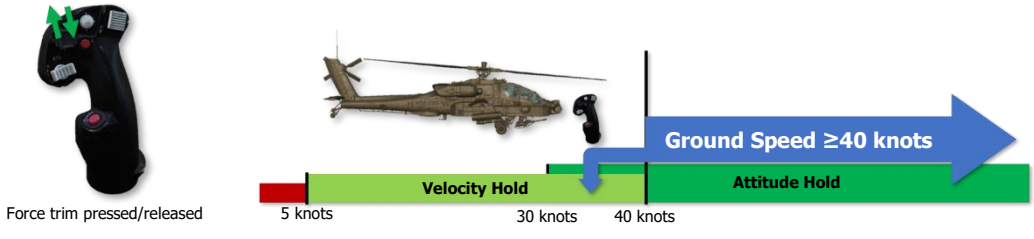
To establish a new attitude reference, the pilot should press and hold the force trim release switch, adjust the flight controls to attain the desired attitude, and then stop pressing the force trim release switch when a stable flight condition has been established. Pressing the force trim release switch is not necessary if the cyclic position exceeds the breakout values, however pressing and holding the force trim will allow the SAS sleeves to center themselves within their respective axes, ensuring maximum authority in each direction when Attitude Hold is re-engaged.

If the ground speed decreases below 40 knots but remains above 30 knots, and the pilot does not displace the cyclic beyond its breakout values nor press the force trim, Attitude Hold will be maintained and will not enter Velocity Hold sub-mode.



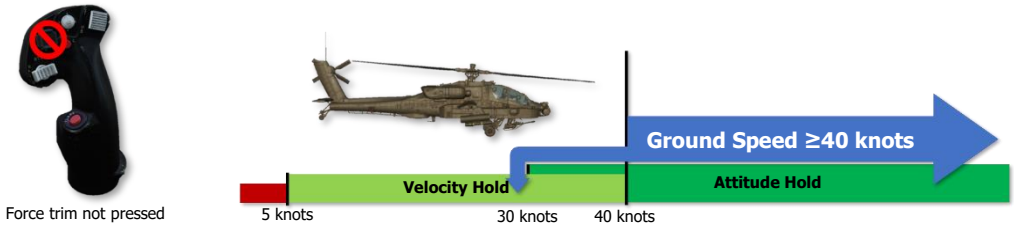
Attitude Hold Sub-mode maintained if force trim is not pressed

However, if the pilot displaces the cyclic beyond its breakout values and then returns the cyclic within the breakout values while still below 40 knots ground speed, Velocity Hold sub-mode will be entered. Likewise, if the ground speed decreases below 40 knots but above 30 knots and the pilot presses the force trim prior to accelerating back to 40 knots ground speed or greater, Velocity Hold will be entered.



Velocity Hold Sub-mode entered if force trim is pressed <40 knots

If the ground speed decreases below 30 knots ground speed, Velocity Hold will be entered regardless of whether the pilot has displaced the cyclic beyond its breakout values or pressed the force trim.

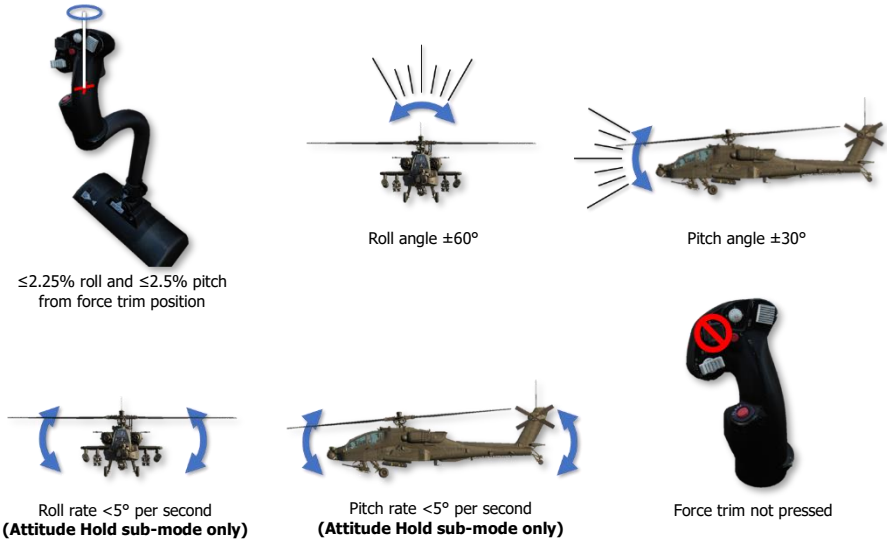


Velocity Hold Sub-mode entered <30 knots

Heading Hold or Turn Coordination will also be active in the FMC Yaw axis while operating in Attitude Hold sub-mode, subject to the logic described in the Heading Hold & Turn Coordination Sub-modes description.

Attitude Hold will engage when all the following conditions are true:

- The helicopter is off the weight-on-wheels ("squat") switch.
- Cyclic displacement ≤2.25% in roll and ≤2.5% in pitch from the force trim reference position.
- Roll attitude <±60° and Pitch attitude <±30°.
- Pitch and Roll rates <5° per second. **(Attitude Hold sub-mode only)**
- Force trim is not pressed.



Attitude Hold Engagement

Altitude Hold Modes

The FMC Collective channel operates within two hold sub-modes: Radar Altitude Hold and Barometric Altitude Hold. Only one of these sub-modes can be engaged at any given time, and only when the Altitude Hold is activated using the Force Trim/Hold Mode switch when pressed to the Right/AL position, and only when the FMC Collective channel is turned on. Condition-based logic will determine which sub-mode the Collective channel is using, and whether that sub-mode is engaged or disengaged from affecting the flight control servo-actuators at any given time.

Altitude Hold enabled

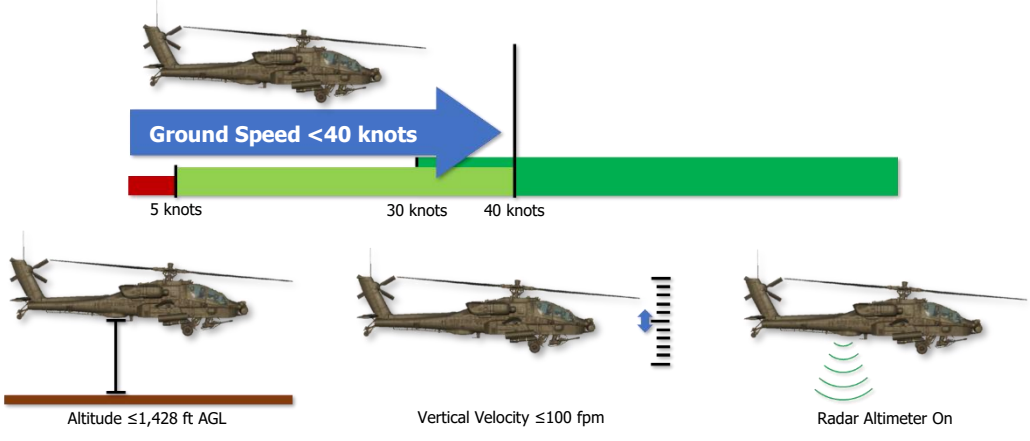
The conditions that primarily determine which Altitude Hold sub-mode the Collective channel operates within is the helicopter's ground speed and the radar altimeter. If the ground speed is <40 knots and the radar altitude is ≤1,428 feet AGL, Radar Altitude Hold sub-mode will be activated. If the ground speed is ≥ 40 knots or the radar altitude is >1,428 feet AGL, Barometric Altitude Hold sub-mode is activated. Additional logic governing the activation or de-activation of these sub-modes are listed below.

Radar Altitude Hold Sub-Mode

Radar Altitude Hold is not a terrain following mode. It provides distance from the ground directly below the aircraft and does not provide any approaching terrain variation information.

Radar Altitude Hold may only be engaged when **all** of the following conditions are true:

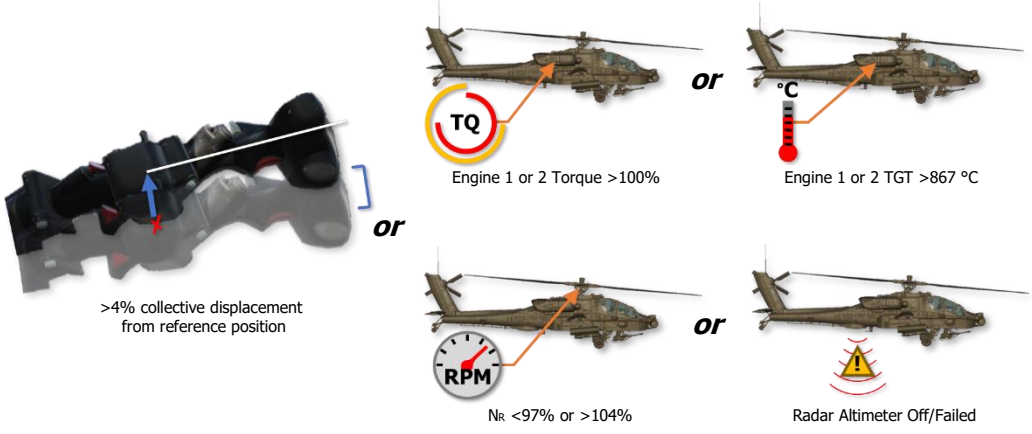
- Ground speed <40 knots.
- Altitude is ≤1,428 feet above ground level (AGL).
- Vertical velocity is ≤100 feet per minute.
- The radar altimeter is powered on and operational.



Radar Altitude Hold Engagement

Radar Altitude Hold is automatically disengaged when **any** of the following conditions are true:

- Pilot displaces the collective >4% from the reference position (collective position at the time Radar Altitude Hold mode is activated).
- Either engine torque (TQ) >100%.
- Either engine Turbine Gas Temperature (TGT) >867° C.
- Rotor speed (N_R) is <97% or >104%.
- The radar altimeter is turned off or has failed.

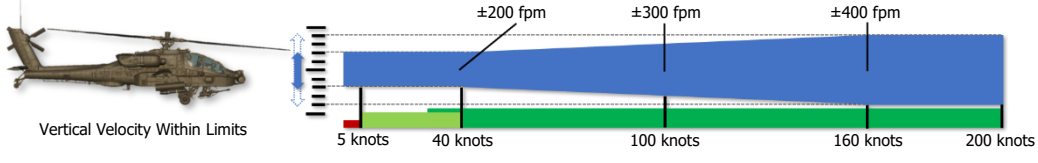


Radar Altitude Hold

Barometric Altitude Hold Sub-Mode

Barometric Altitude Hold can only be activated when **both** of the following conditions are true:

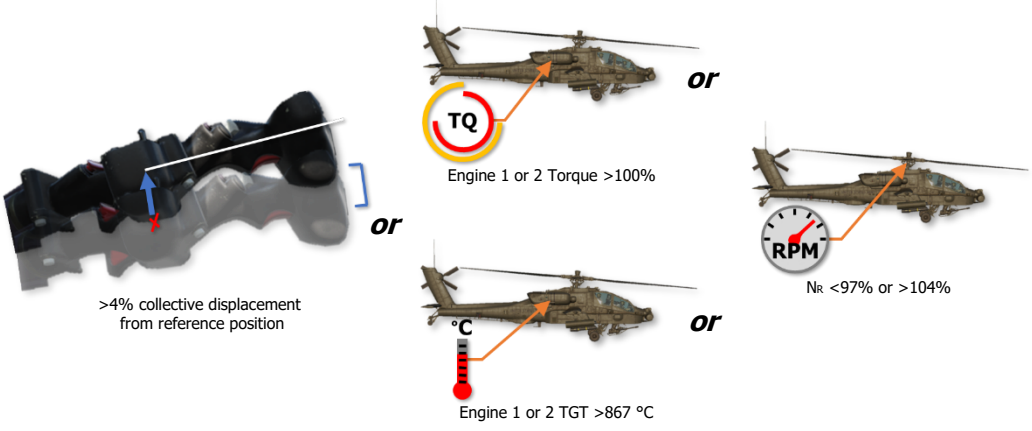
- If conditions for Radar Altitude Hold sub-mode activation cannot be met.
- Vertical velocity is within the limits below as determined by aircraft ground speed:
  - If ground speed is <40 knots, vertical velocity is ≤200 feet per minute.
  - From 40 to 160 knots ground speed, the vertical velocity rate limit increases linearly from ±200 feet per minute at 40 knots to ±400 feet per minute at 160 knots. (Example: at 100 knots ground speed, the vertical velocity rate limit must be ≤300 feet per minute)



Barometric Altitude Hold Engagement

Barometric Altitude Hold is automatically disengaged when **any** of the following conditions are true:

- Pilot displaces the collective >4% from the reference position (collective position at the time Radar Altitude Hold mode is activated).
- Either engine torque (TQ) >100%.
- Either engine Turbine Gas Temperature (TGT) >867° C.
- Rotor speed (N_R) is <97% or >104%.



Barometric Altitude Hold Disengagement

Flight Control Advisories

Since the SAS sleeve within each servo-actuator possesses a limited authority to affect the flight controls (±10% authority in all axes except the pitch axis, which is +20% forward and -10% aft authority), if a hold mode is engaged and the SAS sleeve has reached the limit of its authority, the SAS sleeve is described as "saturated". If the saturation condition persists, the FMC's ability to maintain the reference values of pitch, roll, heading, sideslip, velocity, or position will be degraded. Any time one or more servo-actuator has become saturated, a brief Flight Control audio tone will be heard and an advisory will be displayed on the EUFD to alert the crew.

The Flight Control audio tone will sound with an associated EUFD advisory when the criteria listed below is met for each respective sub-mode:

- If in Attitude Hold sub-mode, the SAS SATURATED advisory will be presented to the crew after 90 seconds of continuous saturation within the Pitch, Roll or Collective axes or 10 seconds of continuous saturation within the Yaw axis.
- If in Velocity Hold sub-mode, the SAS SATURATED advisory will be presented to the crew after 2 seconds of continuous saturation within the Pitch, Roll or Collective axes or 7 seconds of continuous saturation within the Yaw axis.
- If in Position Hold sub-mode, the SAS SATURATED advisory will be presented to the crew after 1 second of continuous saturation within the Pitch, Roll or Collective axes or 5 seconds of continuous saturation within the Yaw axis.
- If in Position Hold sub-mode, the HOVER DRIFT advisory will be presented to the crew if the aircraft drifts greater than 48 feet (one rotor diameter) from the reference position.
- If in Barometric Altitude Hold, the ALTITUDE DRIFT advisory will be presented to the crew if the aircraft drifts greater than ±100 feet from the reference altitude.
- If in Radar Altitude Hold, the ALTITUDE DRIFT advisory will be presented to the crew if the aircraft drifts greater than ±5 feet from the reference altitude at 10 feet, increasing to ±100 feet at 1,400 feet altitude.

When the pilot presses the force trim release (which also interrupts any hold modes that are enabled in the FMC Pitch, Roll and/or Yaw channels), the SAS sleeves within the Pitch, Roll, and Yaw servo-actuators will return to center within 3 to 5 seconds. While the SAS sleeve is moving to center, it will continue to provide command augmentation to ensure an immediate and uniform flight control response.

During sideward flight or hovering flight with high crosswinds without the force trim pressed, a SAS SATURATED advisory and Flight Control audio tone may be presented to the crew. Under these conditions, the relative wind from sideward flight or high crosswinds will apply force to the vertical tail, creating a weathervane effect in which the nose will turn into the wind. The FMC will attempt to compensate for this weathervane effect while in Heading Hold sub-mode, which may result in saturation of the SAS sleeve within the Yaw servo-actuator.

PROCEDURES

US Army photo
by SGT Daniel Schroeder

It is recommended that the Flight Management Computer (FMC) section within the AH-64D chapter is reviewed prior to reading through the various flight maneuvers within this chapter.

Throughout this chapter, attitude references within the maneuver descriptions will be based on the assumption that the pitch ladder has remained un-biased. (see MPD Flight (FLT) page for more information.)

When describing cockpit controls or specific tasks performed in each crewstation, the following symbols will be used to denote each crewstation or cockpit control effects between the crewstations.

PLT	Denotes a task that is performed by the Pilot.
CPG	Denotes a task that is performed by the Copilot/Gunner.
PLT / CPG	Denotes a task that may be performed by either crewmember.
PLT & CPG	Denotes a task that is performed by both crewmembers.
©	Denotes a cockpit control, option, or setting that is "common" between crewstations. A change performed in one crewstation will affect both crewstations. Any item that does not have this symbol is "independent" between crewstations.
"Pilot"	Denotes the crewmember occupying the aft crewstation.
"pilot"	Denotes the crewmember manipulating the aircraft flight controls in the conduct of performing a specific flight maneuver.

AIRCRAFT START

The AH-64 was designed to be operated from a "field environment" away from established ground support infrastructure or airfield facilities. Although it is equipped with external power and pneumatic air receptacles, allowing it to be supported by Aviation Ground Power Units (AGPU) or other ground support equipment, the primary method of starting the aircraft is via its integrated GTCP36-155 Auxiliary Power Unit (the same gas turbine engine that powers the AGPU).

Once the APU is up to operating speed, the APU drive shaft mechanically engages the main transmission's accessory gearbox, which in turn powers the primary and utility hydraulic pumps and both AC generators. This pressurizes the flight control servo-actuators and enables AC electrical power to be delivered to some aircraft systems, including both Transformer Rectifier Units (TRU) which converts AC power to DC power. Once DC power is supplied to the remainder of the electrical busses, all aircraft systems may be configured as necessary, and the aircraft battery will be charged.

Prior to Starting APU

After an external preflight inspection and walk-around has been performed by the aircrew to ensure the aircraft is flightworthy and all gear and equipment is properly secured within the storage bays, the aircrew enters their respective crewstations. The seat harness restraints are secured and the crewmembers secure intercom cables and electrical connectors that supply power to the IHU helmet-tracking sensors.

If not already performed during the preflight inspection, the aircrew inspects their crewstation to ensure all switches and knobs are set appropriately prior to enabling electrical power and starting the APU.

Interior Checks (Pilot crewstation) PLT

1. Canopy door – Set as desired (open or intermediate position).

Check the following on the Left Console:

2. EXT LT/INTR LT panel – Set NAV switch in accordance with local procedures, ANTI-COL switch to OFF, and interior lighting knobs as desired.
3. Power levers – OFF.
4. ENG START switches – OFF.
5. RTR BRK switch – OFF.
6. NVS MODE switch – OFF.

Check the following on the Keyboard Unit:

7. KU brightness knob – As desired.

Check the following on the Instrument Panel:

8. EUFD brightness knob – As desired.
9. MPD brightness and Mode knobs – As desired.
10. PARK BRAKE – Brakes set; PARK BRAKE handle is pulled outward.
11. Standby flight instruments – Check:
    - Standby Attitude Indicator – Caged.

Check the following on the CMWS Control Panel:

12. CMWS Control Indicator PWR knob – OFF.
13. CMWS Control Panel – Set switches as follows:
    - ARM/SAFE switch – SAFE.
    - CMWS/NAV switch – As appropriate.
    - BYPASS/AUTO switch – As appropriate.
    - JETTISON guarded switch – Down (cover closed).

Check the following on the Right Console:

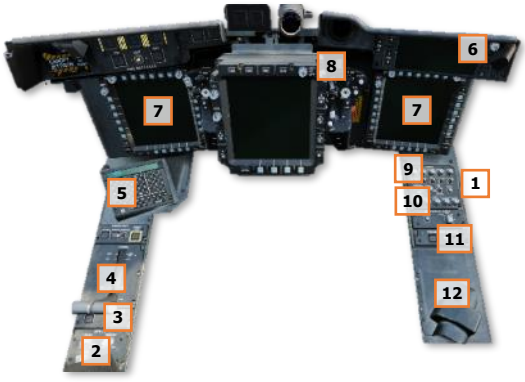
14. COMM panel audio volume knobs – As desired.
15. COMM panel ICS switch and SENS knob – As desired.
16. Helmet Display Unit (HDU) – As desired.

Interior Checks (Copilot/Gunner crewstation) CPG

1. Canopy door – Set as desired (open or intermediate position).

Check the following on the Left Console:

2. INTR LT panel – As desired.



3. NVS MODE switch – OFF.
4. Power levers – OFF.

Check the following on the Keyboard Unit:

5. KU brightness knob – As desired.

Check the following on the Instrument Panel:

6. EUFD brightness knob – As desired.
7. MPD brightness and Mode knobs – As desired.

Check the following on the TEDAC handgrips:

8. TEDAC Right Handgrip LT switch – OFF.

Check the following on the Right Console:

9. COMM panel audio volume knobs – As desired.
10. COMM panel ICS switch and SENS knob – As desired.
11. PROCESSOR SELECT switch – AUTO.
12. Helmet Display Unit (HDU) – As desired.

Battery Checks

Once the interior checks are complete, perform the following:

1. PLT MSTR IGN switch – BATT (or EXT PWR if external power is to be used).
2. PLT TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
3. PLT & CPG ICS system – Check to verify communications between crewstations.
4. PLT & CPG INTR LT PRESS-TO-TEST button – Press and hold; verify all signal lights illuminate.
5. PLT / CPG MSTR WARN, MSTR CAUT, and EUFD – Check for any malfunction indications.
6. PLT TEST switch held to position 1 – Both crewmembers check the following:
   - "MSTR WARN" light – Flashing.
   - ENG 1 FIRE, APU FIRE, and ENG 2 FIRE buttons – "FIRE" lights are illuminated.
   - EUFD – "AFT DECK FIRE" warning message is displayed.
   - Audio Warnings – "ENG 1 FIRE", "APU FIRE", "ENG 2 FIRE" and "AFT DECK FIRE" voice warning messages are heard in sequence.
7. CPG TEST switch held to position 2 – Both crewmembers check the following:
   - "MSTR WARN" light – Flashing.
   - ENG 1 FIRE, APU FIRE, and ENG 2 FIRE buttons – "FIRE" lights are illuminated.
   - PRI and RES buttons – "DISCH" lights are illuminated.
   - EUFD – "AFT DECK FIRE" warning message is displayed.
   - Audio Warnings – "ENG 1 FIRE", "APU FIRE", "ENG 2 FIRE" and "AFT DECK FIRE" voice warning messages are heard in sequence.

APU Start

When the APU button is pressed, a nitrogen pre-charge will force hydraulic fluid from the accumulator cylinder to discharge through the APU starter, allowing the APU compressor to spool up to sufficient speed for combustion. Once the APU has reached a sufficient speed for the gas generator to become self-sustaining, the APU starter will disengage.

The APU start sequence is fully automatic and requires no additional action by the crew.

1. PLT APU button – Press and release to initiate APU start sequence.
2. PLT EUFD advisory column – Verify "APU ON" message is displayed.
3. PLT MSTR IGN switch – BATT (if external power was used prior to APU start).

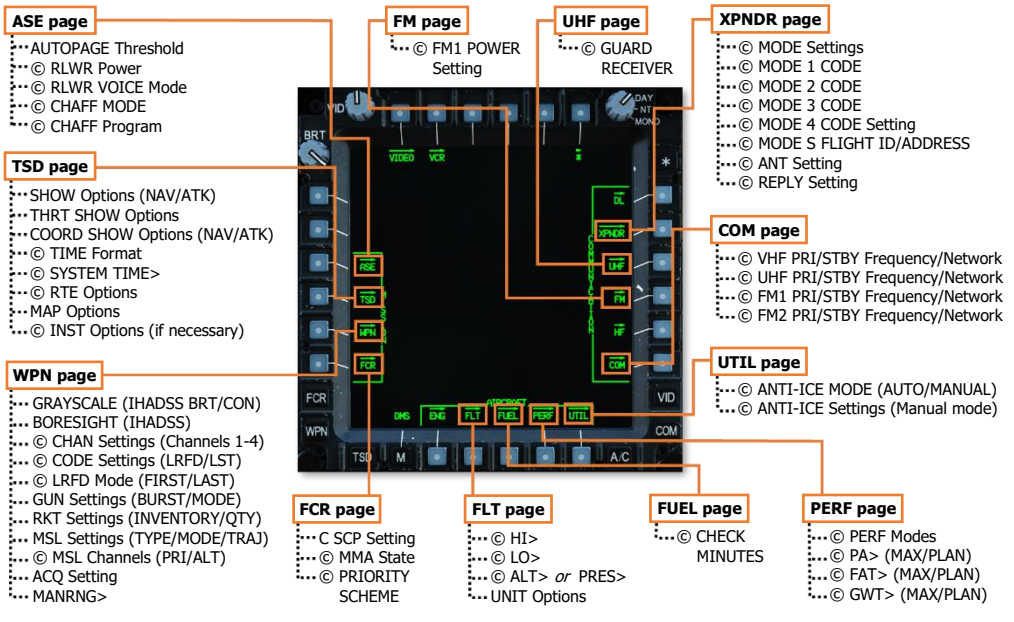
After Starting APU

Once the APU has been started and the MPDs have initialized, perform the following:

1. PLT & CPG Canopy door – Close.
2. PLT / CPG DTU page – Select MASTER LOAD to upload DTC data to the aircraft systems. (N/I)
3. PLT & CPG Aircraft systems – Initialize and configure remaining options as appropriate for mission.

Initialize Aircraft Systems

After a Master Load has been completed on the DTU page, remaining options within each cockpit are configured for the mission. This process is commonly referred to as a "DMS sweep". A DMS sweep may be conducted in accordance with crewmember preferences, but it is important to be consistent and coordinate with the other crewmember to ensure any settings that are common between crewstations are agreed upon and the start-up process is conducted in an efficient manner. (© Denotes "common" options or settings)



An example DMS sweep is shown as follows (settings that are common between crewstations will be annotated by a © symbol):

1. PLT & CPG M (Menu) button – Press.
2. PLT & CPG ASE (VAB L3) – Select.
   - AUTOPAGE (VAB R1) – Set as desired.
   - UTIL (VAB T6) – Select.
     - © RLWR Power (VAB R4) – Press.
     - © RLWR VOICE (VAB R5) – Set as desired.
     - © CHAFF MODE (VAB L1) – Set as desired.
     - © CHAFF Program (VAB L2-L5) – Set as desired.
3. PLT & CPG TSD Fixed Action Button – Press.
   - SHOW (VAB T3) – Select and configure NAV SHOW options.
     - PHASE (VAB B2) – Select ATK and configure ATK phase SHOW options.
     - THRT SHOW (VAB T5) – Select and configure THRT SHOW options.
     - COORD SHOW (VAB T6) – Select and configure ATK phase COORD SHOW options.
     - PHASE (VAB B2) – Select NAV and configure NAV phase COORD SHOW options.
     - SHOW (VAB T3) – Deselect.
   - UTIL (VAB T6) – Select.
     - © TIME (VAB R2) – Set Zulu/Local as desired.
     - © SYSTEM TIME> (VAB R3) – Update Local time if necessary.
     - UTIL (VAB T6) – Deselect.
   - Scale (VAB R1 & R2) – Set as desired.
   - CTR (VAB R3) – Set as desired.
   - RTE (VAB B5) – Select.
     - © RTM (VAB B6) – Select desired Route.
     - © DIR (VAB L5) – Set to desired point, if necessary.
     - RTE (VAB B5) – Deselect.
   - MAP (VAB B4) – Select.
     - TYPE (VAB L2) – Set as desired.
     - COLOR BAND (VAB L4) – Set as desired.
     - GRID (VAB T5) – Set as desired.
     - ORIENT (VAB R5) – Set as desired.
     - MAP (VAB B4) – Deselect.
   - INST VAB (L1) – Select if the ADF is intended to be utilized for navigation.
     - UTIL (VAB T6) – Select.
     - © ADF (VAB B6) – Turn on ADF, if necessary.
     - © Configure ADF as desired.
     - UTIL (VAB T6) – Deselect.
     - INST (VAB L1) – Deselect.

4. PLT WPN Fixed Action Button – Press.

- GRAYSCALE (VAB L6) – Select.
- IHADSS BRT and CON knobs – Optimize HDU video (see Video Panel).
- GRAYSCALE (VAB L6) – Deselect.
- SYM knob - As desired (see Video Panel).

CPG WPN Fixed Action Button – Press.

- UTIL (VAB T6) – Press.
- TADS (VAB L4) – Press.
- LASER (VAB L6) – Press.
- Sight Select switch – HMD (see TEDAC Right Handgrip).
- GRAYSCALE (VAB L6) – Select.
- TDU BRT and CON rocker switches – Optimize HDU video (see TEDAC Display Unit).
- GRAYSCALE (VAB L6) – Deselect.
- TDU SYM rocker switch - As desired (see TEDAC Display Unit).

PLT & CPG BORESIGHT (VAB B5) – Select and perform IHADSS boresight procedure. (see IHADSS Boresight)

- BORESIGHT (VAB B5) – Deselect.
- GUN (VAB B2) – Select.
  - BURST LIMIT (VAB L1- L5) – Select.
  - MODE (VAB R2) – Select.
- MSL (VAB B3) – Select.
  - CODE (VAB T4) – Select.
  - © SET (VAB T2) – Select LRFD and set as appropriate.
  - © SET (VAB T2) – Select LST and set as appropriate.
  - © CHAN (VAB T1) – Select missile channels 1-4, ensure a channel matches the LRFD code.
  - CHAN (VAB T1) – Deselect.
  - © PRI (VAB L1) – Select channel that matches the LRFD.
  - © ALT (VAB L2) – Select channel that matches the LST, or as appropriate.
- RKT (VAB B5) – Select.
  - INVENTORY (VAB L1-L5) – Select.
  - QTY (VAB R1) – Select.
  - RKT (VAB B5) – Deselect.
- ACQ (VAB R6) – Set as desired (**CPG** must select SLAVE for cueing within the HMD Flight Symbology).
- MANRNG> (VAB B6) – Set as desired or enter 'A' for Auto-Range.

5. PLT & CPG FCR Fixed Action Button – Press.

- C SCP (VAB T1) – Select as desired.
- UTIL (VAB T6) – Select.
  - © MMA (VAB R6) – Set to NORM to initialize FCR.
  - © PRIORITY – SCHEME (VAB R4) – Select.

6. PLT & CPG A/C Fixed Action Button – Press.

- FLT (VAB T2) – Select.
  - SET VAB (B6) – Select.
  - © HI> (VAB T1) – Set as desired.
  - © LO> (VAB T3) – Set as desired.
  - UNIT (VAB T4) – Set as desired.
  - © ALT> (VAB T5) – Set airfield elevation if known.

    or
  - © PRES> (VAB T6) – Set altimeter if known.
  - UNIT VAB (B2) – Set as desired.
  - SET (VAB B6) – Deselect.
- FUEL (VAB T3) – Select.
  - CHECK (VAB B6) – Select.
  - © MINUTES (VAB R2-R4) – Select as desired.
  - CHECK (VAB B6) – Deselect.
- PERF (VAB T4) – Select.
  - © PERF MODE – MAX (VAB B3) – Select.
  - © PA> (VAB L1) – Set as desired.
  - © FAT> (VAB L2) – Set as desired.
  - © GWT> (VAB L3) – Set as desired.
  - © PERF MODE – PLAN (VAB B4) – Select.
  - © PA> (VAB L1) – Set as desired.
  - © FAT> (VAB L2) – Set as desired.
  - © GWT> (VAB L3) – Set as desired.
  - © PERF MODE – CUR (VAB B2) – Select.
- UTIL (VAB T6) – Select.
  - © ANTI-ICE – SYSTEM (VAB R1) – Set as desired.
  - © ANTI-ICE (VAB R3-R6) – Set as desired (if SYSTEM is set to MANUAL).

7. PLT / CPG COM Fixed Action Button – Press.

- Presets (VAB L1-L5, R1-R5) – Select and tune as desired.
  - © RADIO (VAB T1-T5) – Select.
  - © TUNE (VAB B2) – Select as desired.
  - © TUNE Radio – SC (VAB B6) – Select.
- XPNDR (VAB T3) – Select.
  - © MODE (VAB L1-L6) – Select as appropriate.
  - © MODE 1> (VAB R1) – Set as appropriate.
  - © MODE 2> (VAB R2) – Set as appropriate.
  - © MODE 3> (VAB R3) – Set as appropriate.
  - © MODE 4 (VAB R4) – Set as appropriate.
  - © REPLY (VAB B4) – Select as appropriate.
- UHF (VAB T4) – Select.
  - © GUARD RECEIVER (VAB L6) – Set as desired.

- FM (VAB T5) – Select.
- SET (VAB B5) – Select.
  - © POWER (VAB L5) – Select as appropriate.

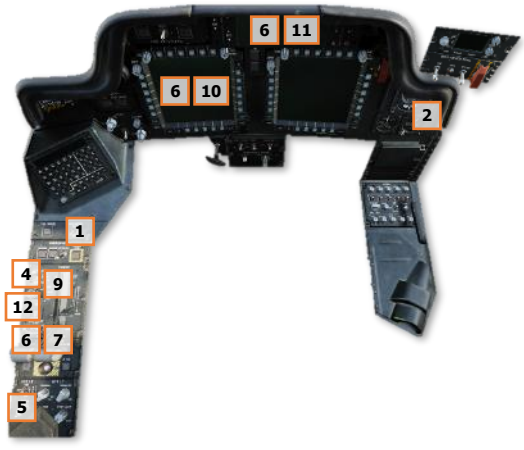
8. PLT CMWS Power/Set knob – ON.

CPG TDU Display knob – DAY or NT, as appropriate.

- Sight Select switch – TADS (see TEDAC Right Handgrip).
- TDU G/S button – Press (see TEDAC Display Unit).
- TDU BRT and CON rocker switches – Optimize TDU video.
- TDU TAD button – Press.
- TDU SYM rocker switch - As desired.
- Sight Select switch – HMD.

Engine Start

Prior to starting the engines, perform the following:



1. PLT & CPG NVS Mode switch – As desired.
2. PLT Standby Attitude Indicator – Uncage.
3. PLT & CPG Area around helicopter – Clear.
4. PLT RTR BRK switch – OFF (or LOCK if performing a Rotor Lock start).
5. PLT EXT LT ANTI-COL – WHT for day, or RED for night.

During normal operations, Engine 1 is started first, followed by Engine 2. The APU must remain in operation until the engine POWER levers are set to FLY and the N_R has stabilized at 101%, otherwise the AC generators will drop offline and the aircraft will lose primary electrical power.

6. PLT First engine – Start as follows:

   NOTE: During the start, if any of the following conditions are observed, abort the start by moving the corresponding POWER lever to OFF:
   - It appears the TGT will exceed 851°C prior to N_G reaching the idle speed of 63%.
   - No increase of TGT, N_P, or ENG OIL PSI within 45 seconds after moving the POWER lever to IDLE.
   - The ENG 1/2 START advisory is removed from the EUFD prior to the N_G reaching 52%.

   - ENG START switch – START; observe "ENG 1 START" or "ENG 2 START" advisory displayed on the EUFD and the START box displayed on the ENG page.
   - POWER lever – IDLE, at first indication of N_G increase and if TGT is less than 80° C.
   - Cockpit indications – Monitor.
     - Engine TGT
     - Engine N_G
     - Engine OIL PSI
     - EUFD Advisory column
7. PLT Second engine – Repeat the steps above after first engine start sequence is complete.
8. PLT RTR BRK switch – OFF.

   NOTE: Prior to advancing the POWER levers to FLY, confirm the ENGINE OIL PSI indications for both engines are less than 70 PSI. If performing operations in cold weather, confirm the NGB TEMP °C indications are above 20° C. (see ENG Systems sub-page for more information.)
9. PLT POWER levers – Advance both POWER levers smoothly to FLY; ensure the TORQUE % indications for both engines increase simultaneously.
10. PLT N_P and N_R – Verify 101%.
11. PLT MSTR WARN, MSTR CAUT, and EUFD – Monitor for any malfunction indications.
12. PLT APU button – Press and release to initiate APU shutdown sequence.

TAXI & BEFORE TAKEOFF

The AH-64 may perform hover taxi (<25 feet and <20 knots) or air taxi (<100 feet and/or >20 knots) operations like any other helicopter, but ground taxi is typically used when feasible. Ground taxi allows the aircraft to be re-positioned away from other aircraft and ground support equipment using a lower power setting, which minimizes the rotor wash effects on the aircraft surroundings. This prevents foreign object damage to other aircraft, blowing dust/snow, and allows ground personnel to continue operations on the flight line with minimal disturbance.

The AH-64 uses a free-rotating tail wheel to facilitate taxi maneuvers on the flight line, which can be selectively locked to the rear position by either crewmember. Steering control is provided by tail rotor thrust, controlled by the anti-torque pedals within the cockpit. As such, it is advisable that the aircrew keep the tail wheel locked until aircraft movement has been initiated and the aircraft is clear of personnel and equipment. This allows the crewmember on the controls to better ascertain the appropriate pedal positions that are required to prevent the tail from adversely swinging to either side after the tail wheel is unlocked.

Before Taxi

Prior to initiating ground taxi, perform the following:

1. PLT / CPG Chocks removed – Verify with ground personnel.
2. PLT / CPG Bleed Air – On (UTIL page).
3. PLT / CPG ANTI-ICE – As required (UTIL page).
4. PLT EXT LT/INTR LT panel – Verify NAV switch is set in accordance with local procedures, ANTI-COL – WHT for day or RED for night, FORM knob set as appropriate.
5. PLT & CPG Searchlight – As required.
6. PLT PARK BRAKE – Release by applying wheel brake pressure; ensure PARK BRAKE handle is inward.

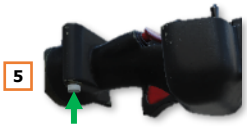
Ground Taxi

NVS mode or the searchlight may be used to assist with ground taxi under low-light conditions, or a combination of both. Ground taxi is typically performed in the following manner:

1. Select Transition symbology mode (Symbology Select switch – Forward).
2. Press and hold the force trim (Force Trim/Hold Mode switch – Forward).
3. With the cyclic in the neutral position, increase the collective to 27-30%.

   NOTE: Additional collective (30-35%) may be necessary to initiate ground taxi movement when the aircraft is at a high gross weight and/or at a location with a high density altitude.
4. Apply forward cyclic to begin taxi movement. Use left/right pedal inputs as necessary to maintain heading and left/right cyclic inputs to maintain a level fuselage attitude. Ensure the aircraft is clear of personnel and equipment before unlocking the tail wheel. The force trim may be held throughout this maneuver as desired, or it may be released and pressed intermittently as necessary.

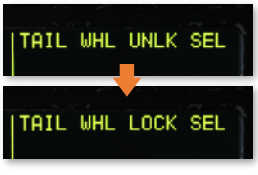
   NOTE: The Horizon Line within the HDU Flight symbology may be used as a reference for a level fuselage attitude. The Skid/Slip Indicator should not be used as a reference as it will not indicate a level fuselage attitude while the aircraft is performing a turn.
5. Prior to initiating a turn when ground taxiing, ensure the tail wheel is unlocked ("UNLOCK" light is illuminated on the TAIL WHEEL button). Either crewmember may unlock the tail wheel, but as a common practice the crewmember on the controls will command tail wheel lock/unlock using the Tail Wheel Lock/Unlock button on the Collective Flight Grip.

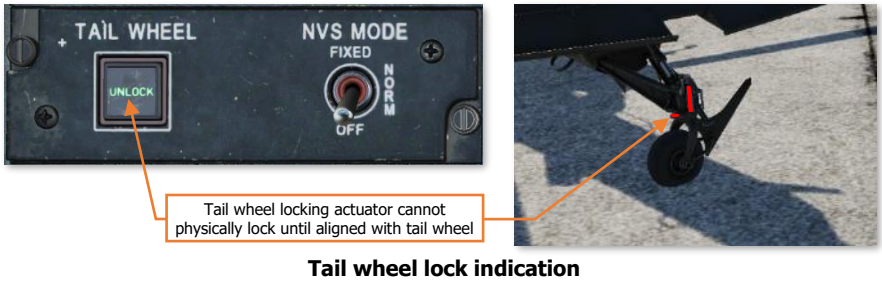


6. Apply pedal in the intended direction of the turn while applying cyclic input in the same direction to maintain a level fuselage attitude. Apply left/right pedal inputs using an alternating sequence of "pressure/counter-pressure" on the pedals to maintain a constant and controlled rate of turn.
7. Prior to stopping the ground taxi or lifting off the ground, ensure the tail wheel is locked ("UNLOCK" light is not illuminated on the TAIL WHEEL button). Once the tail wheel is locked, apply aft cyclic to decelerate the aircraft. When the aircraft has stopped, set the cyclic into the center position prior to lowering the collective. The wheel brakes may also be used to assist with stopping the aircraft.

   NOTE: The "TAIL WHEEL LOCK SEL" and "TAIL WHEEL UNLK SEL" advisories on the EUFD indicate the commanded state of the tail wheel locking actuator as selected by the aircrew, but do not reflect whether the tail wheel is physically locked.

   Only the "UNLOCK" light on the TAIL WHEEL button indicates whether the tail wheel is physically locked ("UNLOCK" light will extinguish when locked).





Tail wheel lock indication

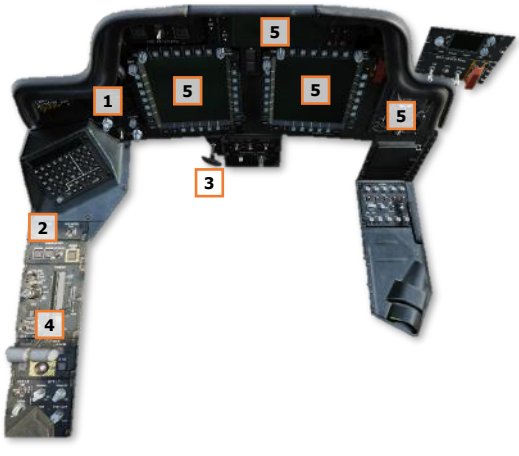
During ground taxi, perform the following:

1. PLT & CPG Wheel brakes – Check in each crew station by applying a slight amount of pressure against the toe brakes.
2. PLT / CPG ENG page – Check; ensure N_P and N_R 101%, all indications green.
3. PLT / CPG FLT page – Check; update altimeter if necessary.
4. PLT Pilot standby instruments – Check; update altimeter if necessary.

Before Takeoff

Perform the following prior to lifting up to a hover or initiating takeoff from the ground:

1. PLT & CPG Weapons systems – Check the following:
   - A/S button – "SAFE" light is illuminated. (see Armament Panel for more information.)
   - GND ORIDE button – Off; "ON" light is not illuminated. (see Armament Panel for more information.)
   - Weapons not actioned – Verify. (see HMD High Action Display for more information.)
2. PLT / CPG TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
3. PLT PARK BRAKE – As desired (Ensure released unless operating on uneven or sloped terrain).
4. PLT & CPG POWER levers – Ensure both POWER levers are set to FLY.
5. PLT / CPG Systems – Check as follows:
   - FUEL page – Verify options set as appropriate.
     - XFER – AUTO.
     - BOOST – OFF.
     - XFEED – NORM.
   - Fuel quantity – Check; verify sufficient fuel is onboard the aircraft for the mission.
   - EUFD – Check; clear of Warnings and Cautions.
   - Engine and flight instruments – Check.
     - N_P/N_R 101%, all indications green.
     - Update altimeter as required on FLT SET page and Pilot's Standby Altimeter.

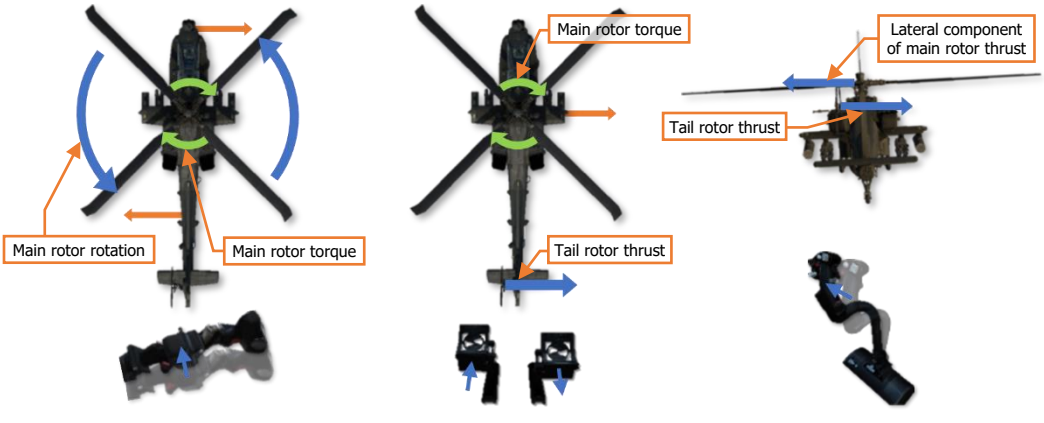


   - ASE – As required.
   - Avionics – As desired (COM/TSD pages).
     - Transponder – NORM; verify correct modes are enabled and codes are set for the mission.
     - Communications – As appropriate; verify on EUFD.
     - Navigation – As appropriate; ensure desired Route or Direct destination is selected.
6. PLT Hover Power Check – Perform. (see Hover Power Check in the next section for more information.)

HOVERING FLIGHT

As a helicopter with a typical operational gross weight between 7.5 to 9.5 tons (7,000 to 8,800 kilograms), a hovering AH-64D can generate enough rotor wash to cause un-secured items to be tossed into the air at best, or cause damage to other nearby aircraft at worst. As such, AH-64D aircrews will typically ground taxi to a safe area before lifting off the ground into a hover or performing a takeoff. If this is not possible, aircrews will immediately reposition their aircraft to a safe area away from equipment or personnel to minimize the time spent hovering in any area within which they may incur injury to personnel or damage to other aircraft.

It is important to understand that when raising the collective, the torque effect from the counter-clockwise rotation of the main rotor will cause the fuselage to spin to the right. This is countered by applying left pedal, which subsequently results in the aircraft drifting to the right from the combined forces of the main rotor torque and the tail rotor thrust. This in turn is countered by applying left cyclic to hover with a slight left bank.



Control inputs to counter forces acting on the aircraft

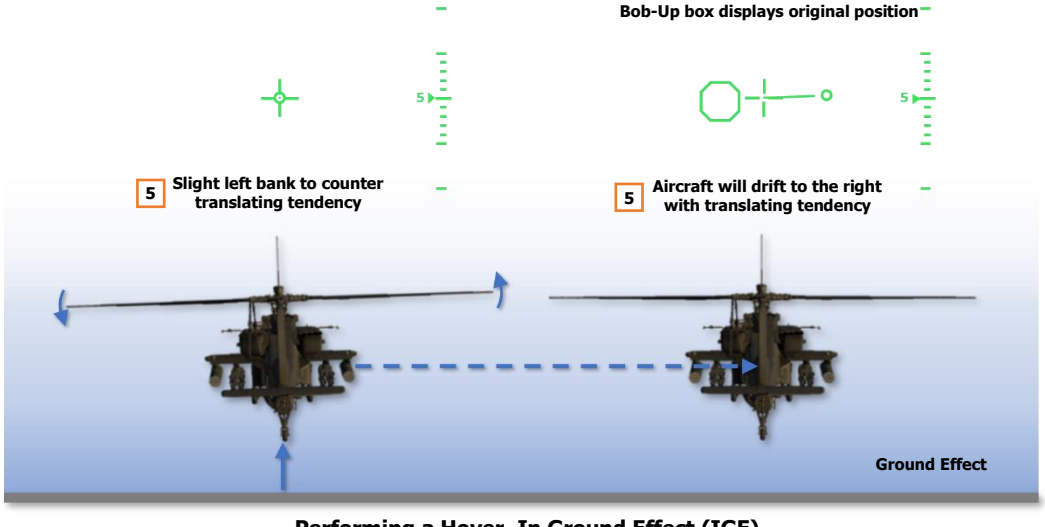
Performing a Hover

NVS mode or the searchlight may be used to assist with hovering under low-light conditions, or a combination of both. Initiating a stationary hover from the ground is typically performed in the following manner:

1. Select Hover symbology mode (Symbology Select switch – Aft). Bob-Up symbology mode may also be utilized if desired.
2. Press and hold the force trim (Force Trim/Hold Mode switch – Forward).
3. With the cyclic in the neutral position, increase the collective while simultaneously applying left pedal input to counter the torque from the main rotor. Left pedal input will cause the aircraft to roll slightly to the right due to the thrust of the tail rotor. A slight left cyclic input should be made to counter the tail rotor thrust and keep the fuselage level.

   NOTE: As the aircraft becomes light on the wheels (approximately 20% below the torque required to hover in ground effect; HOVER Q – REQUIRED IGE), the force trim may be released if desired to allow Heading Hold to engage as the aircraft comes off the "squat" switch (no longer weight-on-wheels).
4. As the aircraft is about to leave the surface, a slight drift in heading may be discerned if the amount of anti-torque pedal input is not correctly balanced against the torque of the main rotor. If the heading begins to drift to the right, tail rotor thrust is insufficient to counter the torque of the main rotor and additional left pedal must be applied. If the heading begins to drift to the left, tail rotor thrust is excessive and left pedal input should be reduced slightly.
5. As the aircraft comes off the surface, apply a slight amount of left cyclic to counter translating tendency. Adjust the cyclic as required to maintain the position of the helicopter over the surface. Adjust the collective as required to maintain altitude over the surface. Adjust the pedals as required to maintain heading.

   NOTE: The combined forces of the main rotor torque and the tail rotor thrust create a sideways translating tendency to the right. As a result, the aircraft will normally hover left side low, depending on the additional effects of any crosswinds.



Performing a Hover, In Ground Effect (IGE)

Hover Power Check

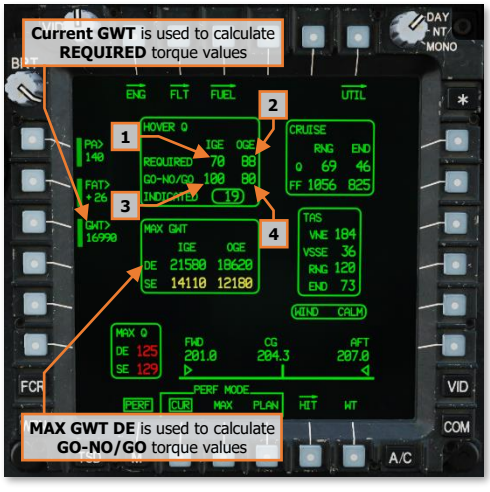
Prior to any mission, or after refueling/rearming operations (if feasible), aircrews perform a hover power check to evaluate their aircraft's measured hover performance compared to the calculated performance on the MPD Performance (PERF) page or their pre-mission performance planning.

A hover power check is performed under the following conditions:

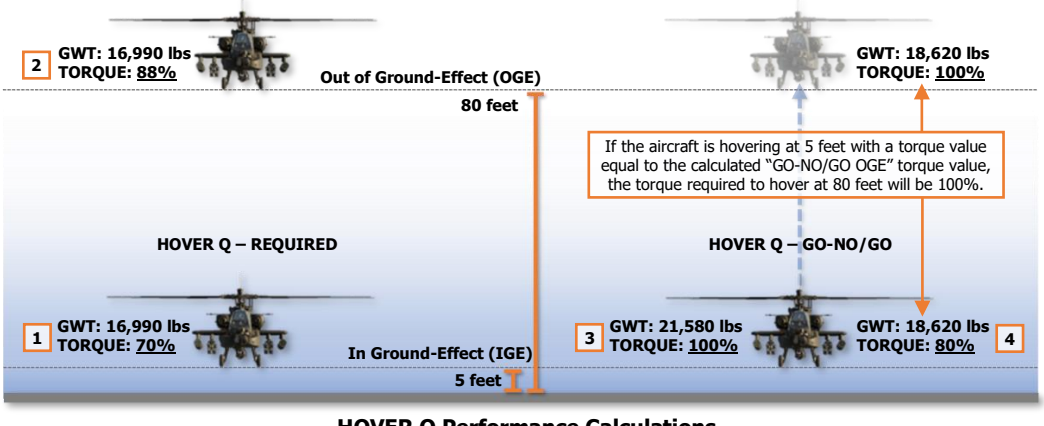
- Aircraft is in a stationary hover in the vicinity of the takeoff area.
- Aircraft heading is aligned with the intended direction of takeoff.
- Aircraft altitude is 5 feet AGL.

The aircrew evaluates the following factors during the hover power check to validate the aircraft performance and whether any aspect of their mission may be impacted:

- Flight control responsiveness and positions required to maintain the hover. Abnormal control positions may indicate an aircraft center-of-gravity (CG) that is out of limits.
- A comparison of HOVER Q values on the PERF page between the REQUIRED IGE and the INDICATED torque values, and whether the data matches the pre-mission performance planning. This is used to validate whether the PERF page is supplying accurate performance calculations for use during the mission.
- HOVER Q values are used to determine whether the assessed aircraft performance will negatively impact any aspect of the mission.



- Sufficient fuel is onboard the aircraft for the mission.



HOVER Q Performance Calculations

TAKEOFF

Several different types of takeoff maneuvers may be performed, depending on the nature of the takeoff area, obstacles or terrain beyond the takeoff area, and the power margins available. When possible, the crew should perform a takeoff that ensures the maximum amount of excess power is available for contingencies while maintaining a safe distance from any potential hazards to the aircraft on climb out, such as vertical hazards or structures. The four types of takeoffs that may be performed in Visual Meteorological Conditions (VMC), and their applications for use, are listed below.

VMC Takeoff. A VMC Takeoff is the most common type of takeoff and can be initiated from the ground or when already established in a stationary hover. This type of takeoff is used when a sufficient power margin (≥10% TQ) is available between the torque required to hover in ground effect (HOVER Q – REQUIRED IGE) and the maximum dual-engine torque available (MAX Q – DE) that does not exceed the dual-engine transmission limit (100% TQ).

VMC Level Acceleration Takeoff. A VMC Level Acceleration Takeoff is considered the safest type of takeoff but requires a sufficient area that is free of obstacles to permit such a maneuver to be performed. It is preferred that a sufficient power margin (≥10% TQ) is available to perform this maneuver; but unlike the VMC Takeoff, it is not necessarily required, depending on the takeoff environment and necessity. The advantage this maneuver provides is remaining outside the "height-velocity avoid" region until a safe single-engine airspeed can be attained, in case of an engine failure.

VMC Minimum Power Takeoff. A VMC Minimum Power Takeoff is performed when there is insufficient power margin (<10% TQ) available between the torque required to hover in ground effect (HOVER Q – REQUIRED IGE) and the maximum dual-engine torque available (MAX Q – DE) that does not exceed the dual-engine transmission limit (100% TQ). In such a scenario when the aircraft is hovering near its maximum dual-engine torque available or its dual-engine transmission limit, this takeoff maneuver is performed. This type of takeoff is used when a combination of environmental conditions and/or weapon and fuel requirements are negatively impacting the aircraft's performance capabilities, but the surface within the takeoff area is unsuitable for a Rolling Takeoff.

Rolling Takeoff. A Rolling Takeoff is performed as the preferred alternative to the VMC Minimum Power Takeoff when conditions permit. In such a scenario when the aircraft is hovering near its maximum dual-engine torque available (MAX Q – DE) or its dual-engine transmission limit (100% TQ), and a suitable takeoff area such as a runway, a road, or other improved surface is available, this takeoff maneuver is performed.

VMC Takeoff

A VMC Takeoff may be performed from the ground or from a stationary hover. When performing the maneuver from the ground, the maneuver is typically performed in the following manner:

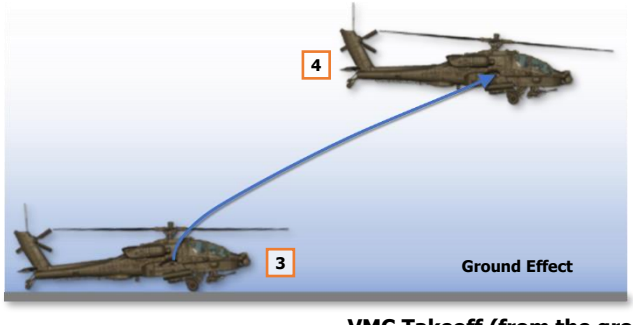
1. Select Transition symbology mode (Symbology Select switch – Forward).
2. Press and hold the force trim (Force Trim/Hold Mode switch – Forward).
3. With the cyclic in the neutral position, increase the collective until the aircraft becomes light on the wheels while applying left pedal to counter the torque and maintain heading. Continue increasing the collective to approximately 10% above the torque required to hover in ground effect (HOVER Q – REQUIRED IGE).

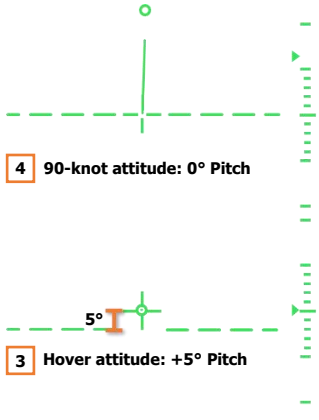
   NOTE: A minimum climb rate of 500 feet per minute (FPM) is typically desired. However, depending on the nature of the takeoff area, additional torque may be necessary to achieve a higher rate of ascent and a steeper climb angle in order to clear obstacles. The Flight Path Vector (FPV) may be used to judge whether the aircraft will clear obstacles within the path of the aircraft. (See IHADSS Flight Symbology for more information.)

4. As the aircraft leaves the ground, apply forward cyclic to obtain a "90-knot" pitch attitude, which corresponds with the Horizon Line bisecting the LOS Reticle within the HDU Flight symbology or the Horizon Line bisecting the Waterline symbol on the MPD FLT page. Use forward/aft cyclic inputs as necessary to maintain this level pitch attitude as the aircraft accelerates through effective translational lift (ETL). The force trim should be held throughout this maneuver if able, but it may be released and pressed intermittently as necessary.

   Use left/right cyclic inputs to maintain the desired ground track and left/right pedal inputs to maintain the takeoff heading until the aircraft has ascended through 50 feet AGL or is clear of all obstacles within the takeoff area.

   Once the aircraft has climbed above 50 feet AGL and is clear of obstacles, adjust the pedals to place the aircraft "in trim" ("Trim ball" centered on the Skid/Slip Indicator).





VMC Takeoff (from the ground)

When performing a VMC Takeoff from a hover, each step is performed in the same manner as departing from the ground, except the 90-knot attitude may be achieved at the initiation of the maneuver rather than as the aircraft leaves the ground.

VMC Level Acceleration Takeoff

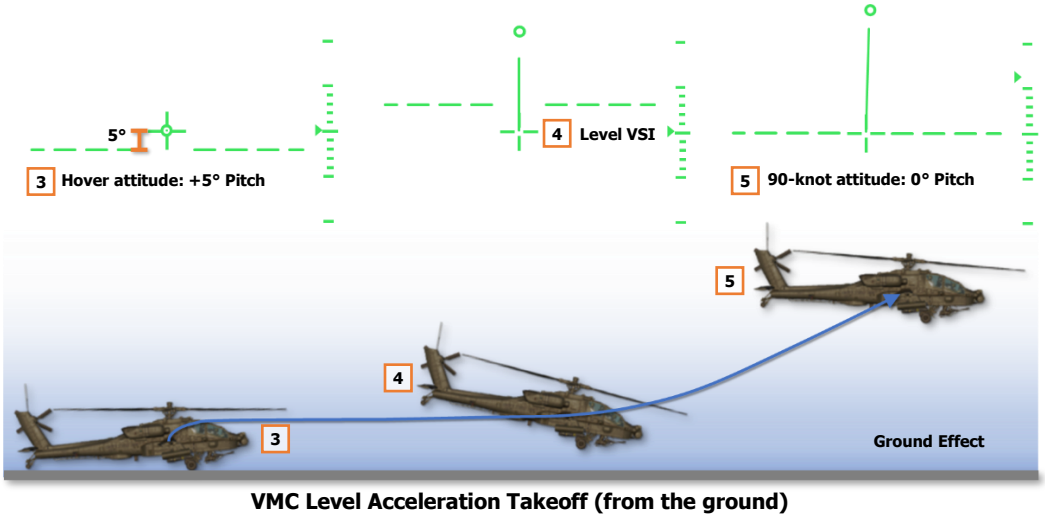
A VMC Level Acceleration Takeoff may be performed from the ground or from a stationary hover. When performing the maneuver from the ground, the maneuver is typically performed in the following manner:

1. Select Transition symbology mode (Symbology Select switch – Forward).
2. Press and hold the force trim (Force Trim/Hold Mode switch – Forward).
3. With the cyclic in the neutral position, increase the collective until the aircraft becomes light on the wheels while applying left pedal to counter the torque and maintain heading. Continue increasing the collective to approximately 10% above the torque required to hover in ground effect (HOVER Q – REQUIRED IGE).

   NOTE: Depending on the length of the takeoff area, additional power may be necessary to accelerate and achieve the desired climb airspeed within a shorter distance in order to clear obstacles.
4. As the aircraft leaves the ground, apply forward cyclic to maintain the aircraft in ground effect with a level VSI. Use forward/aft cyclic inputs as necessary to maintain the VSI at 0 feet per minute (FPM) as the aircraft accelerates through minimum safe single-engine airspeed (VSSE). The force trim should be held throughout this maneuver if able, but it may be released and pressed intermittently as necessary.

   Use left/right cyclic inputs to maintain the desired ground track and left/right pedal inputs to maintain the takeoff heading.
5. As the aircraft accelerates beyond minimum safe single-engine airspeed (VSSE), adjust the cyclic to obtain the required pitch attitude for the desired climb airspeed.

   Once the aircraft has climbed above 50 feet AGL and is clear of obstacles, adjust the pedals to place the aircraft "in trim" ("Trim ball" centered on the Skid/Slip Indicator).



VMC Level Acceleration Takeoff (from the ground)

When performing a VMC Level Acceleration Takeoff from a hover, each step is performed in the same manner as departing from the ground, except the accelerative attitude may be achieved at the initiation of the maneuver rather than as the aircraft leaves the ground.

VMC Minimum Power Takeoff

A VMC Minimum Power Takeoff may be performed from the ground but is typically performed from a stationary hover after verifying the aircraft has sufficient power to hover in ground effect. When performing the maneuver from a hover, the maneuver is typically performed in the following manner:

1. Select Transition symbology mode (Symbology Select switch – Forward).
2. Press and hold the force trim (Force Trim/Hold Mode switch – Forward).
3. From a stationary hover, slowly apply forward cyclic to initiate a level acceleration across the surface while remaining in ground effect. Increase the collective as necessary, not to exceed the maximum dual-engine torque available (MAX Q – DE) or the dual-engine transmission limit (100% TQ), whichever is less.

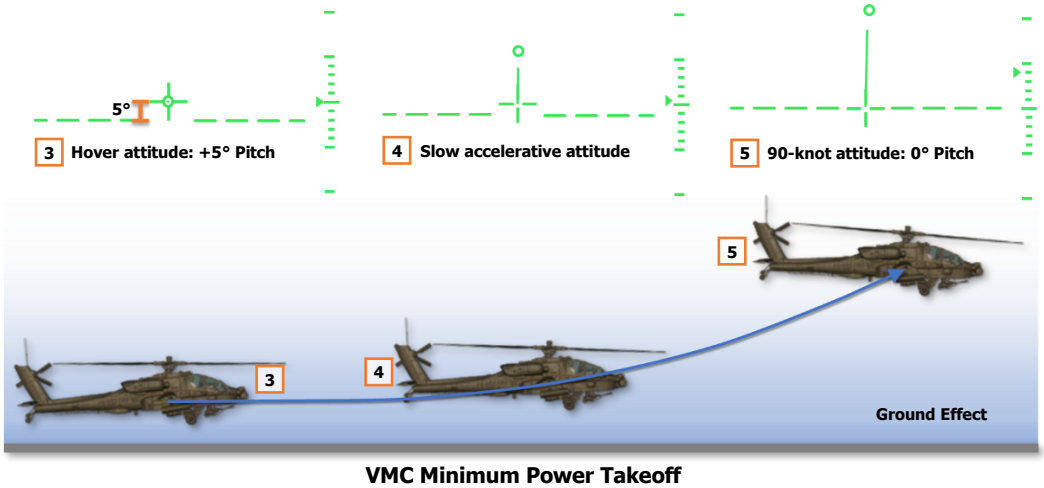
   NOTE: If a hover in ground effect (IGE) at 5 feet AGL can be maintained without exceeding the maximum dual-engine torque available or the dual-engine transmission limit, a VMC Minimum Power Takeoff can be performed. When training this maneuver, IGE hover power is maintained throughout the maneuver. However, during operational missions, any remaining power margin should be utilized without exceeding the maximum dual-engine torque available or the dual-engine transmission limit.

4. As the aircraft accelerates through effective translational lift (ETL) and the rotor system becomes more efficient at producing lift, the aircraft will begin to ascend. Use forward/aft cyclic inputs as necessary to maintain the VSI at 0 feet per minute (FPM) and remain within ground effect. The force trim should be held throughout this maneuver if able, but it may be released and pressed intermittently as necessary.

   Use left/right cyclic inputs to maintain the desired ground track and left/right pedal inputs to maintain the takeoff heading until the aircraft has ascended through 50 feet AGL or is clear of all obstacles within the takeoff area.

5. As the aircraft accelerates beyond minimum safe single-engine airspeed (VSSE), adjust the cyclic to obtain the required pitch attitude for the desired climb airspeed.

   Once the aircraft has climbed above 50 feet AGL and is clear of obstacles, adjust the pedals to place the aircraft "in trim" ("Trim ball" centered on the Skid/Slip Indicator).



VMC Minimum Power Takeoff

Rolling Takeoff

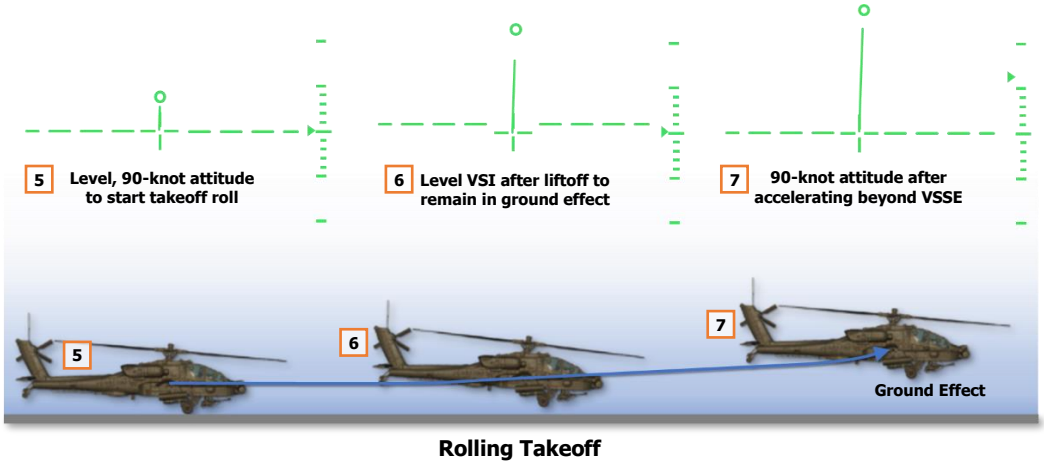
A Rolling Takeoff is performed when the aircraft's power margin is insufficient (<10% below maximum dual-engine torque; MAX Q – DE) to perform a normal takeoff and a suitable takeoff area such as a runway, a road, or other improved surface is available. The maneuver is typically performed in the following manner:

1. Manually set the stabilator angle to 0° (Stabilator Control Switch on the Collective Flight Grip), as indicated on the ENG Systems sub-page.
2. Select Transition symbology mode (Symbology Select switch – Forward).
3. Press and hold the force trim (Force Trim/Hold Mode switch – Forward).
4. With the cyclic in the neutral position, increase the collective to 30-35% TQ.
5. Apply forward cyclic to begin the takeoff roll while progressively increasing collective to approximately 3-5% below the maximum dual-engine torque available (MAX Q – DE). As the tail comes off the surface, use forward/aft cyclic inputs to achieve and maintain a level, 90-knot attitude.

   NOTE: When training this maneuver, increase the collective to 10% below the torque required to hover in ground effect (HOVER Q – REQUIRED IGE) to simulate a limited-power condition.

   Apply left pedal to counter the torque and then left/right pedal inputs as necessary to maintain heading. Use left/right cyclic inputs to maintain the ground track across the takeoff surface. The force trim should be held throughout this maneuver if able, but it may be released and pressed intermittently as necessary.
6. As the aircraft accelerates and the rotor system becomes more efficient at producing lift, the aircraft will become light on the wheels. Use forward/aft cyclic inputs as necessary to maintain the level, 90-knot attitude until the aircraft lifts off the surface. After liftoff, use forward/aft cyclic inputs to remain within ground effect with the VSI at 0 feet per minute (FPM) as the aircraft continues to accelerate.

   Once the aircraft has lifted off the surface, adjust the pedals to place the aircraft "in trim" ("Trim ball" centered on the Skid/Slip Indicator) while using left/right cyclic inputs to maintain the desired ground track within the takeoff area.
7. As the aircraft accelerates beyond minimum safe single-engine airspeed (VSSE), adjust the cyclic to obtain the required pitch attitude for the desired climb airspeed and reset the stabilator to Automatic mode.



Rolling Takeoff

LANDING

Several different types of landing maneuvers may be performed, depending on the nature of the landing area, obstacles near the landing area, and the power margins available. When possible, the crew should perform an approach that ensures the maximum amount of excess power is available for performing a go-around while maintaining a safe distance from any potential hazards to the aircraft, such as vertical hazards or structures.

VMC Approach. A VMC Approach is normally performed when sufficient power margins allow for normal approach angles and deceleration prior to arriving over the intended point of touchdown. Variations in the execution of the VMC Approach are based on the nature of the landing area, obstacles around the landing area, and the whether the aircraft has the power margins to hover out of ground effect (OGE).

Roll-on Landing. A Roll-on Landing may be performed when insufficient power exists to perform a normal VMC Approach. In such a scenario when the aircraft hover performance is calculated to be near its maximum dual-engine torque available (MAX Q – DE) or its dual-engine transmission limit (100% TQ), and a suitable landing area such as a runway, a road, or other improved surface is available, this landing maneuver is performed.

Before Landing

Prior to landing, perform the following:

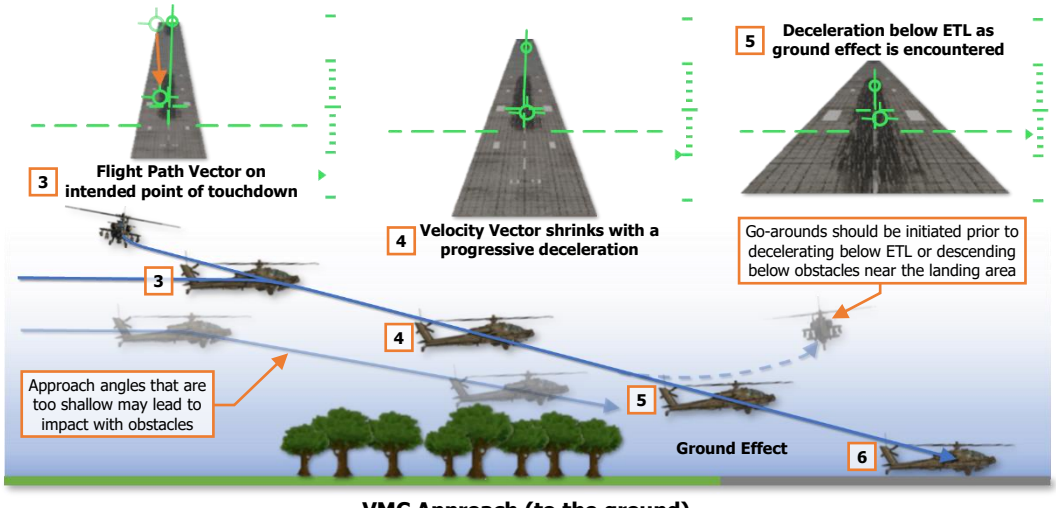
1. PLT & CPG Weapons systems – Check the following:
   - A/S button – "SAFE" light is illuminated. (see Armament Panel for more information.)
   - GND ORIDE button – Off; "ON" light is not illuminated. (see Armament Panel for more information.)
   - Weapons not actioned – Verify. (see HMD High Action Display for more information.)
2. PLT / CPG ASE – As required.
3. PLT / CPG TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
4. PLT PARK BRAKE – Ensure brakes are released, PARK BRAKE handle is inward.

VMC Approach

A VMC Approach may be performed to the ground or to a stationary hover. When performing the maneuver to the ground, the maneuver is typically performed in the following manner:

1. Select Transition symbology mode (Symbology Select switch – Forward) and place the LOS Reticle on the intended point of touchdown. (see IHADSS Flight Symbology for more information.)
2. Press and hold the force trim (Force Trim/Hold Mode switch – Forward).
3. When the desired approach angle is intercepted (whether on final or while still in a base turn toward the landing area), decrease the collective so that the Flight Path Vector (FPV) is aligned with the intended point of touchdown when on the final approach course. Apply aft cyclic to initiate a deceleration at a rate appropriate for the remaining distance to touchdown. Adjust the pedals to maintain the aircraft "in trim". ("Trim ball" centered on the Skid/Slip Indicator).

   NOTE: Steep approach angles should only be utilized if adequate power is available to maintain a slow rate of descent, or if the aircraft performance is such that a hover out of ground effect (OGE) may be performed.
4. Use left/right cyclic inputs to maintain the desired ground track. Use forward/aft cyclic inputs to progressively decelerate so that the Velocity Vector arrives at the center of the LOS Reticle as the aircraft arrives at the intended point of touchdown, effectively reaching zero forward velocity as the aircraft touches down.
5. As the aircraft descends below 50 feet AGL or below the obstacles surrounding the landing area, adjust the pedals to align the aircraft with the landing direction.
6. Once the aircraft touches down, lower the collective to 27-30% torque and adjust the cyclic to eliminate any remaining velocity. Once the aircraft is stationary, neutralize the cyclic and fully lower the collective.



VMC Approach (to the ground)

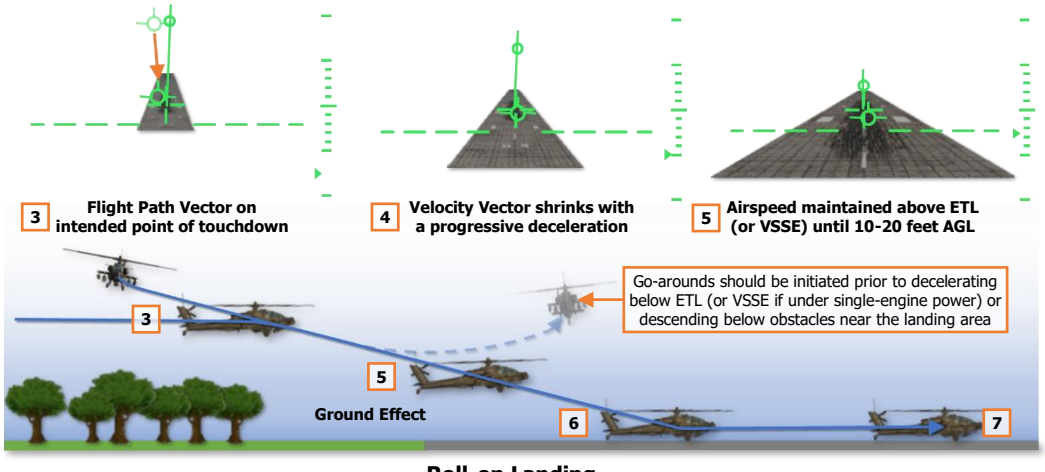
When performing a VMC Approach to a hover, each step is performed in the same manner as an approach to the ground, except the forward velocity and vertical speed are reduced to zero prior to contact with the ground. A VMC Approach may be terminated to a hover in ground effect (IGE) or out of ground effect (OGE), but the aircraft performance must be adequately calculated when terminating to an OGE hover to avoid settling with power.

Roll-on Landing

A Roll-on Landing is performed when the aircraft's power margin is insufficient to perform a normal approach and a suitable landing area such as a runway, a road, or other improved surface is available. The maneuver is typically performed in the following manner:

1. Select Transition symbology mode (Symbology Select switch – Forward) and place the LOS Reticle on the intended point of touchdown. (see IHADSS Flight Symbology for more information.)
2. Press and hold the force trim (Force Trim/Hold Mode switch – Forward).
3. When the desired approach angle is intercepted (whether on final or while still in a base turn toward the landing area), decrease the collective so that the Flight Path Vector (FPV) is aligned with the intended point of touchdown when on the final approach course. Apply aft cyclic to initiate a deceleration at a rate appropriate for the remaining distance to touchdown. Adjust the pedals to maintain the aircraft "in trim". ("Trim ball" centered on the Skid/Slip Indicator).
4. Use left/right cyclic inputs to maintain the desired ground track and left/right pedal inputs to maintain the aircraft "in trim". Adjust the cyclic throughout the approach to progressively decelerate so that the aircraft remains above ETL (24 knots) until 10-20 feet AGL over the landing area.

   NOTE: If performing an approach under single-engine power, do not decelerate below Velocity Safe Single Engine (VSSE) until 10-20 feet AGL over the landing area. (see PERF page for more information.)
5. As the aircraft descends below 50 feet AGL or below the obstacles surrounding the landing area, adjust the pedals to align the aircraft with the landing direction.
6. If possible, adjust the attitude to ensure the aircraft touches down on all three wheels at once to avoid excessive loads on the tail wheel. After touchdown, use left/right cyclic inputs to maintain the ground track across the landing surface and left/right pedal inputs to maintain heading.
7. Lower the collective to a minimum of 30% torque (60% torque if under single-engine power) and apply aft cyclic to aerodynamically decelerate, and/or apply wheel brakes. Once the aircraft is stationary, neutralize the cyclic and fully lower the collective.



Roll-on Landing

Autorotation Landing

An Autorotation Landing must be performed when the aircraft has suffered a dual engine failure. When both engines have failed, the rotor speed (N_R) will decay rapidly and the pilot on the controls must react immediately by adjusting the flight controls as necessary to establish an autorotational descent to landing. The maneuver is typically performed in the following manner:

1. Lower the collective to prevent excessive N_R decay if sufficient altitude and airspeed is available to establish autorotation. (See Autorotation in the Helicopter Fundamentals of Flight chapter for more information.)

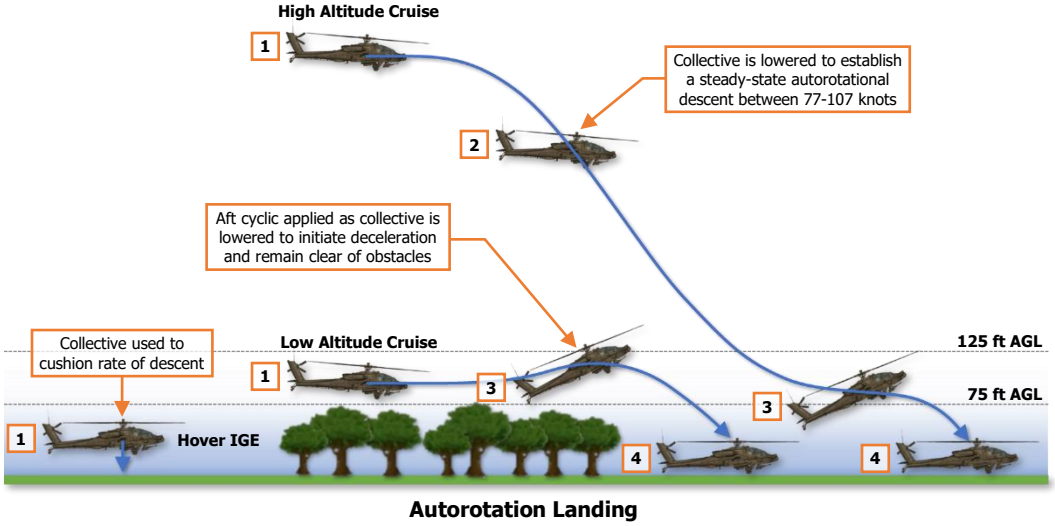
- **Hover IGE.** Adjust collective as necessary to cushion the impact with the ground.
- **Hover OGE.** Lower collective and pitch forward to gain slight forward airspeed before using remaining N_R to cushion the landing. Due to insufficient altitude and airspeed to establish an autorotation, expect a violent landing, depending on the remaining N_R available to cushion rate of descent prior to impact.
- **Cruise speed at low altitude.** Lower collective and apply aft cyclic to simultaneously maintain clearance above obstacles and regain N_R while performing the necessary deceleration (**Step 3**).
- **Cruise speed at high altitude.** Lower collective to establish a steady-state autorotation (**Step 2**) while using forward/aft cyclic inputs to achieve and maintain an airspeed between 77 and 107 knots.

2. During the descent, maintain N_R within normal limits using collective. Use left/right cyclic inputs to maneuver the aircraft to a suitable landing area while using forward/aft cyclic inputs to maintain a suitable autorotation airspeed. Adjust the pedals to maintain the aircraft "in trim". ("Trim ball" centered on the Skid/Slip Indicator).

NOTE: An airspeed of 77 knots will result in the lowest descent rate but a shorter glide distance. An airspeed of 107 knots will result in the maximum glide distance but a higher descent rate.

3. Between 75 and 125 feet AGL, apply aft cyclic to perform a smooth and progressive deceleration flare to reduce airspeed and rate of descent while simultaneously increasing N_R. The rate and magnitude of the deceleration flare will be dictated by the size of the landing area. Use left/right cyclic inputs to maintain the desired ground track. Adjust the pedals to align the aircraft with the landing direction.

4. Apply forward cyclic before the tail wheel contacts the ground while increasing collective to cushion the impact on the main landing gear. Once the aircraft touches down, lower the collective and neutralize the cyclic while maintaining heading and the desired ground track with pedals. Apply wheel brakes as necessary.



Autorotation Landing

AIRCRAFT SHUTDOWN

Just as with departing from its parking location and taxiing to the takeoff area, the AH-64 may perform hover taxi (<25 feet and <20 knots) or air taxi (<100 feet and/or >20 knots) to transition back to the parking area after landing, but ground taxi is typically used when feasible.

Once clear of the active runway or designated arrival/departure area, the transponder is typically set to standby and the exterior lights are set in accordance with local regulations and procedures. As the aircraft is arriving to the designated parking location and in the intended parking heading, it is necessary to straighten the aircraft's direction of travel for a short distance to allow the free-rotating tail wheel to align with the locking actuator. Once the tail wheel has been successfully locked (indicated by the "UNLOCK" light on the TAIL WHEEL button extinguishing), the aircraft can be brought to a stop. (see Ground Taxi for more information.)

The aircraft may be aerodynamically braked using aft cyclic input with 27-30% torque applied, or the wheel brakes may be used in either crewstation. After coming to a halt, the Pilot should set the wheel brakes using the PARK BRAKE handle. (see Parking Brake Handle for more information.)

After Landing Check

After landing, perform the following:

1. PLT / CPG TAIL WHEEL button – Unlock as necessary for ground taxi.
2. PLT EXT LT/INTR LT panel – Set exterior lighting in accordance with local procedures.
3. PLT / CPG Avionics – As desired (COM page).
   - Transponder – STBY.
   - Communications – As appropriate; verify on EUFD.

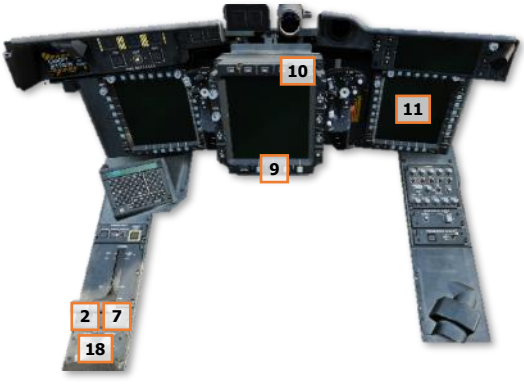
Aircraft Shutdown

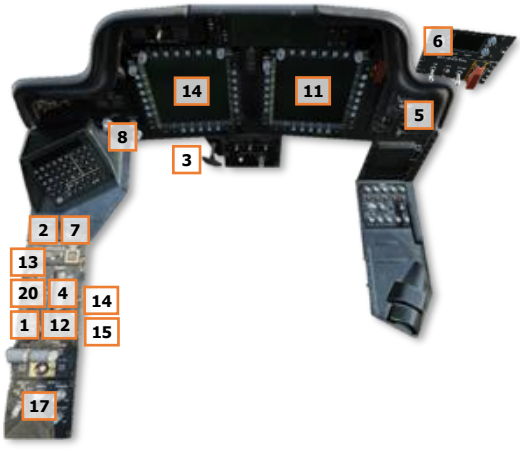
Once stationary in the designated parking location, perform the following:

1. PLT APU button – Press and release to initiate APU start sequence.
2. PLT / CPG TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
3. PLT PARK BRAKE – Brakes set; PARK BRAKE handle is pulled outward.

Prior to retarding the POWER levers to IDLE, verify the "APU ON" advisory message is displayed on the EUFD.

4. PLT POWER levers – Retard both POWER levers to IDLE; press EUFD Stopwatch button to start a timer for a 2-minute engine cooldown. (see Enhanced Up-Front Display (EUFD) for more information.)
5. PLT Standby Attitude Indicator – Cage.
6. PLT CMWS Power/Test knob – OFF. (see Common Missile Warning System for more information.)
7. PLT & CPG NVS Mode switch – OFF.
8. PLT ACM switch – OFF.
9. CPG ACM button – Disable ACM. (see TEDAC Display Unit for more information.)
10. CPG TDU Display knob – OFF.
11. PLT / CPG DMS SHUT DOWN page – MASTER OFF. (see DMS Shutdown page for more information.)
12. PLT POWER levers – OFF after 2 minutes have elapsed on EUFD stopwatch.
13. PLT RTR BRK switch – BRK after N_R has decreased below 50%.
14. PLT Stabilator – Manually set the stabilator angle to 0° (Stabilator Control Switch on the Collective Flight Grip), as indicated on the ENG Systems sub-page.
15. PLT Searchlight – STOW.
16. PLT RTR BRK switch – OFF after main rotor has stopped.
17. PLT EXT LT/INTR LT panel – All interior and exterior lighting to OFF.
18. CPG INTR LT panel – All interior lighting to OFF.
19. PLT APU button – Press and release to initiate APU shutdown sequence.
20. PLT MSTR IGN – OFF.





REFUELING/REARMING

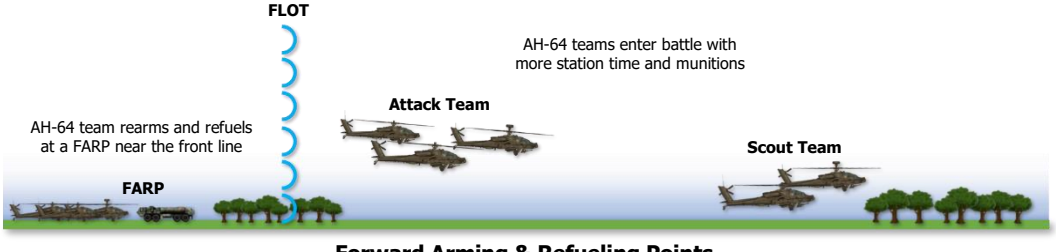
The AH-64 is equally adept at conducting combat operations from large, established airfields or from austere locations in the field, and may be rapidly refueled and rearmed without shutting down the engines, also known as "hot refueling and rearming". However, during hot refueling operations, the right engine is normally reduced to idle power while ground personnel are refueling the helicopter on the right side.

Refueling and rearming may be requested by contacting the Ground Crew through the ICS call radio menu **[RShift+Space]**, or by displaying the Rearming and Refueling window directly **[LAlt+']**.

Repairs may also be requested by contacting the Ground Crew through the ICS call radio menu **[RShift+Space]**, but the engines and APU must be completely shut down and come to a stop before a repair is possible.

Forward Arming and Refueling Points (FARP)

When operating along the Forward Edge of Battle Area (FEBA), the AH-64 can utilize Forward Arming and Refueling Points (FARP) to rapidly refuel and rearm its munitions or receive repairs if necessary. This allows the AH-64 team to reduce the time needed to get back into the fight, respond to enemy movements or changes on the battlefield, or extend the range of the AH-64 team well beyond the Front Line of Own Troops (FLOT).



Forward Arming & Refueling Points

Forward Arming and Refueling Points require specific equipment to be present nearby in order to facilitate rearming, refueling, or repair services for helicopters that have landed at that FARP. The following page describes the requirements for enabling ground support services at FARP locations within DCS.

Ground Support

Ground support in DCS includes Air Traffic Control (ATC) and ground crew personnel.

The availability of ground services depends on the presence of specific units associated with the corresponding services. For example, communication with ATC requires the presence of an intact ATC tower at the airfield, a FARP Command Post or a Truck SKP-11 Mobile ATC vehicle for red coalition FARPs, and a FARP Command Post or an LUV HMMWV Jeep vehicle for blue coalition FARPs.

The following table indicates the required units and conditions for the various ground support services.

SERVICE	REQUIRED UNIT (Blue Coalition)	REQUIRED UNIT (Red Coalition)	CONDITIONS
Airfield ATC	Airfield ATC tower	Airfield ATC tower	ATC tower not destroyed.
Airfield Ground Crew • Rearm • Refuel • Repair • Electrical power • Pneumatic air	None required.	None required.	Airfield must be under coalition control.
FARP ATC	FARP Command Post* LUV HMMWV Jeep	FARP Command Post* Truck SKP-11 Mobile ATC	Unit not destroyed. Unit placed within 150 meters from the center of the FARP.
FARP Ground Crew • Rearm	FARP Ammo Storage* Truck M939 Heavy	FARP Ammo Storage* Truck GAZ-3308 Truck GAZ-66 Truck KAMAZ 43101 Truck Ural-4320 Truck Ural-4320 MCC Truck Ural-4320-31 Arm'd Truck Ural-4320T	Unit not destroyed. Unit placed within 150 meters from the center of the FARP.
FARP Ground Crew • Refuel	FARP Fuel Depot* Refueler M978 HEMTT	FARP Fuel Depot* Refueler ATMZ-5 Refueler ATZ-5 Refueler ATZ-10	Unit not destroyed. Unit placed within 150 meters from the center of the FARP.
FARP Ground Crew • Repair	FARP Tent* Truck M939 Heavy	FARP Tent* LUV UAZ-469 Jeep Truck KAMAZ 43101 Truck Ural-4320-31 Arm'd Truck Ural-4320T Truck ZIL-131 (C2)	Unit not destroyed. Unit placed within 150 meters from the center of the FARP.
FARP Ground Crew • Electrical power	Truck M939 Heavy	GPU APA-5D on Ural-4320 GPU APA-80 on ZIL-131	Unit not destroyed. Unit placed within 150 meters from the center of the FARP.

* Unit is only available as a Static Object within the Mission Editor and may be found within the Structures category. All other units within the table above are required to be an AI-controlled Ground unit.

Attempts to communicate with ATC or ground services of an opposing coalition will be unanswered.

Rapid Refueling/Rearming

Once stationary at the designated refueling/rearming location, perform the following:

1. PLT / CPG TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
2. PLT PARK BRAKE – Brakes set; PARK BRAKE handle is pulled outward.
3. PLT & CPG Weapons systems – Check the following:
   - A/S button – "SAFE" light is illuminated. (see Armament Panel for more information.)
   - GND ORIDE button – Off; "ON" light is not illuminated. (see Armament Panel for more information.)
4. PLT **(If refueling)** POWER lever NO 2 – IDLE.
5. PLT / CPG **(If refueling)** XFER (VAB L4) – OFF (FUEL page).
6. PLT / CPG **(If rearming)** Weapon systems – Power off (WPN Utility sub-page):
   - GUN Power (VAB B2) – Press.
   - MSL Power (VAB B3) – Press.
   - RKT Power (VAB B5) – Press.
7. PLT / CPG Datalink transmissions – Inhibit:
   - DL INHBT (VAB B3) – Select (DL page).
8. PLT EXT LT ANTI-COL switch – OFF.
9. PLT & CPG Refueling/rearming – Perform.

When refueling/rearming is complete, perform the following:

10. PLT / CPG **(If rearming)** Weapon systems – Power on (WPN Utility sub-page):
    - GUN Power (VAB B2) – Press.
    - MSL Power (VAB B3) – Press.
    - RKT Power (VAB B5) – Press.
11. PLT / CPG **(If rearming)** Missile launchers – Verify ARM status (WPN page).
    - LNCHR ARM (VAB R2) – Select, if necessary (WPN Utility sub-page).
12. PLT EXT LT ANTI-COL switch – WHT for day, or RED for night.
13. PLT / CPG Datalink transmissions – Enable:
    - DL INHBT (VAB B3) – Select (DL page).
14. PLT **(If refueling)** POWER lever NO 2 – FLY.
15. PLT / CPG **(If refueling)** XFER (VAB L4) – AUTO (FUEL page).

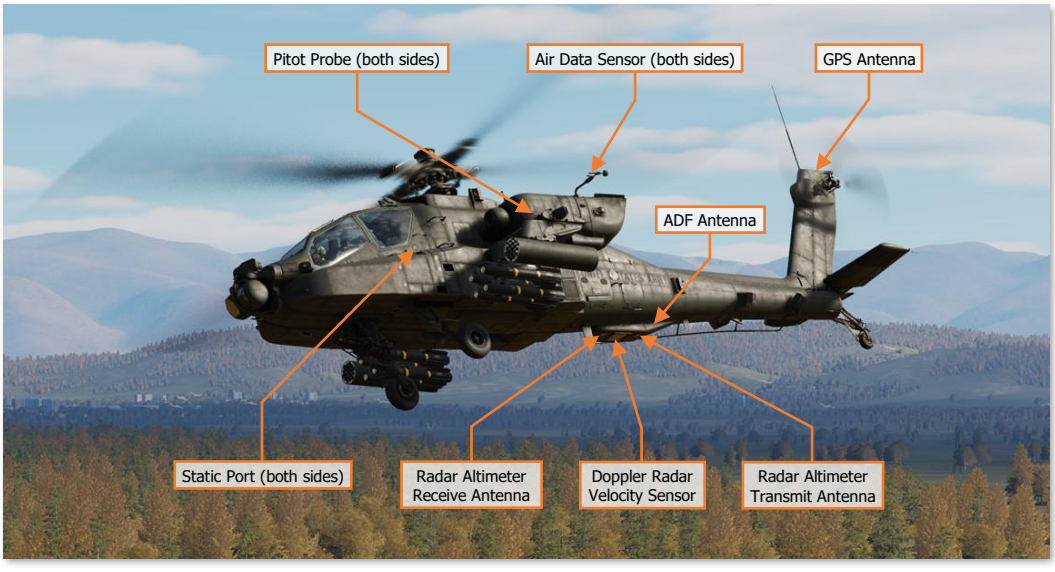
NAVIGATION

US Army photo
by SPC Glenn Anderson

NAVIGATION

The AH-64D primarily navigates by utilizing a pair of Embedded GPS/Inertial Navigation Units (EGI) aided by a Doppler velocity radar and a database of stored points. After the APU is started and generator power is applied to the aircraft, both EGI's will automatically begin their alignment process. Aircrew intervention is normally not required aside from verifying the EGI's alignment status and velocity indications prior to engine start.

Unless updated with a new position via the DTC, the EGI alignment process uses the aircraft's previous position and heading stored in the aircraft memory from when it was last shut down. This stored position, aided by GPS signals, shortens the alignment process considerably, allowing an AH-64D to takeoff within minutes if necessary.



Navigational Sensors

While in flight, the AH-64D receives continuous position updates from GPS satellites to maintain INU position confidence and aid in precision navigation. As an emergency back-up during operations in low-visibility conditions, the AH-64D is equipped with an AN/ARN-149 Automatic Direction Finder.

The AH-64D uses true airspeed calculations derived from the pitot probe mounted on the leading edge of the left wing and the static ports on each side of the airframe. These, along with the air data sensors, aid in more precise ballistic calculations during weapons delivery and are the primary source of air mass data to the Flight Management Computer (FMC).

A set of backup instruments are installed within the Pilot's crewstation that provide indicated airspeed and barometric altitude from the second pitot probe mounted on the leading edge of the right wing and each static port. A standby attitude indicator and a backup magnetic compass is also installed within the Pilot's crewstation.

NOTE: GPS will only be available if the DCS mission date is 28 March 1994 or later. In addition, GPS precision will be degraded unless "USA" is one of the countries assigned to the player's coalition within the DCS mission. However, these limitations may be overridden if *both* of the following conditions are true:

- **Unrestricted SATNAV** is enabled in the player's GAMEPLAY options or <u>is enforced as enabled</u> in the Mission Options for the mission being played.
- **Unrestricted SATNAV** is <u>not enforced as disabled</u> in the Mission Options for the mission being played.

POINTS

The AH-64D's navigational database consists of 149 unique point files that can be uploaded from a removable Data Transfer Cartridge (DTC), with an additional 6 non-loadable point files within the aircraft memory. These point files serve as geographical coordinates of waypoints for navigation and routing, hazards to flight that should be avoided, control measures that are used for battlefield coordination and maneuvers, locations of friendly and enemy forces, and known or suspected locations of hostile air defenses.

Point files within the navigational database are stored in one of three partitions, depending on their type. Points within these partitions may be uploaded from the DTC; and may be added, edited, or deleted from the cockpit.

Waypoints Hazards	General Control Measures Friendly Control Measures Enemy Control Measures	Targets Threats	Terrain
WPTHZ 1-50	CTRLM 51-99	TGT/THRT 1-50	TGT

Point Database Partitions

- **Waypoints/Hazards (WPTHZ) partition.** Points for depicting navigation waypoints and hazards.
- **Control Measures (CTRLM) partition.** Points for depicting friendly and enemy units, airfields, and other graphical control measures for controlling team movements and coordinating with other friendly forces during a mission.
- **Targets/Threats (TGT/THRT) partition.** Points for depicting targets and threats, along with corresponding detection/engagement rings.
- **Targets/Threats (TGT/THRT) extended partition.** Points for storing additional TSD file locations, such as the Pilot and CPG Terrain (TRN) points. The Pilot's TRN point is indexed as T55 and the CPG's TRN point is indexed as T56.

The Target/Threats extended partition only resides within the aircraft memory and cannot be edited by the DTC.

Point Files

Each point file contains five elements of information, which includes the file location within the database, the three-dimensional location of the point, the symbol that is displayed on the TSD at the point's location, and up to three unique alphanumeric characters that may be associated with the point, such as a name or designation.

- **Point Index (W##, H##, C##, T##).** Each point is indexed within the partition it resides, and the index itself is used to reference the point when performing tasks such as reviewing the points information, setting the point as an acquisition source, adding the point to a route, panning the TSD to its location, etc.
    - **Waypoints.** All points of the Waypoint type are indexed within the WPTHZ partition with a leading "W" followed by two digits between 1 and 50 (e.g. "W01"), which are shared with Hazards.
    - **Hazards.** All points of the Hazard type are indexed within the WPTHZ partition with a leading "H" followed by two digits between 1 and 50 (e.g. "H01"), which are shared with Waypoints.
    - **Control Measures.** All points of the Control Measure type are indexed within the CTRLM partition with a leading "C" followed by two digits between 51 and 99 (e.g. "C51").
    - **Targets/Threats.** All points of the Targets/Threats type are indexed within the TGT/THRT partition with a leading "T" followed by two digits between 1 and 50 (e.g. "T01"). Targets/Threats occupy points 100-149 within the database, but are renamed to T01-T50 for presentation to the crew.

  The first 25 points within the WPTHZ and TGT/THRT partitions that are loaded by the DTC are considered "safe sets" and cannot be overridden using the STO functions on the TSD Point sub-page or by the CPG using the STORE/UPDT switch on the TEDAC Left Handgrip. However, Waypoints, Hazards, or Targets/Threats within the "safe sets" may be manually deleted from the cockpit. Once a point is deleted from a "safe set", the point may be overridden at any time in the flight unless the original point is re-loaded from the DTC.

- **Identifier (IDENT).** A point's identifier determines the symbol which is displayed at the point's location on the TSD. 140 different symbols may be chosen, which are identified within the point file using a 1- or 2-digit alphanumeric code.

  Most identifiers are only valid when used with a specific point type. As an example, the Communications Checkpoint identifier of "CC" will only be accepted if the point type was set to Waypoint. However, several identifiers are used by multiple point types and will contextually display different symbols based on which point type was set prior to adding the point. As an example, if the point type was set to Control Measure and "BP" was entered as the identifier, a Battle Position symbol would be displayed; whereas if the point type was set to Target/Threat, a Blowpipe threat symbol would be displayed.

- **Free Text (FREE).** A point's free text may contain up to 3 alphanumeric characters that may be added to the point for additional context as to the nature of the location. If no free text is entered, the free text will simply repeat the point index (e.g. "W01").

- **Coordinates (UTM LAT/LONG).** A point's coordinates is saved in both the MGRS and Latitude/Longitude coordinate systems. When a new point is added, or an existing point's coordinates is edited, the point may be entered in either MGRS 8-digit format or Latitude/Longitude "Degrees, Minutes, Decimals" format (DD°MM.MM' DDD°MM.MM'), but the coordinates will automatically be converted to the opposite format when the coordinates are saved into the point file.

- **Altitude above mean sea level (ALTITUDE).** A point's altitude is saved in feet, based on the altitude above mean sea level (MSL).

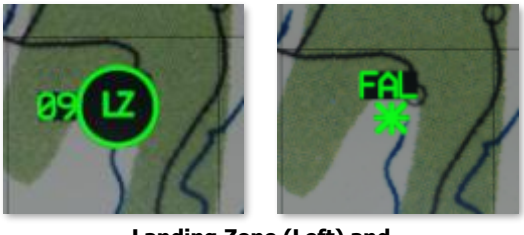
  Digital Terrain Elevation Data (DTED) is typically loaded into the aircraft navigational database. When a new point is added, the altitude will always default to the terrain elevation based on the coordinates already saved within the point file. However, a different altitude may be entered if desired, which will place the point above (or below) the actual terrain elevation. This may be useful when inputting a route in which the points are desired to be displayed at specific altitudes, such as GPS approach waypoints or illumination rockets.

Choosing a Point Identifier

When adding a point during mission planning or while in the aircraft, there are many different types of point symbols that may be selected from the list of 140 abbreviated identifier codes. Choosing the appropriate identifier may be affected by several factors, such as the purpose of the point, the database partition the point will be saved within, whether the point will be stored within a "safe set", or whether the point displays its free text directly on TSD alongside its symbol.

- **Purpose.** Choosing a point symbol based on the purpose of the point itself is useful in providing an immediate context to the crewmembers when viewing the TSD. For example, using a Landing Zone symbol in place of a generic Waypoint symbol allows the crew to immediately recognize what type of location that point represents when viewing the TSD with a quick glance.
- **Partition.** At times, choosing a point symbol may be predicated on whether a specific partition still contains empty point files that are available for use. As an example, entering enemy unit locations as Targets during pre-mission planning may quickly fill the TGT/THRT partition, leaving few empty point files available during the mission to store target locations observed within the TADS. Alternatively, many enemy locations may be stored as enemy control measure symbols.
- **Safe Set.** Only the first 25 points in the WPTHZ and TGT/THRT partitions contain a "safe set" that is protected from accidental overwriting within the cockpit. As such, it may be desired to place certain waypoints within either of these safe set locations to preserve their data during the mission. As an example, it may be desired to load anticipated enemy air defense locations into the first 25 points within the TGT/THRT partition to ensure their locations are not overwritten when the CPG stores targets via the TADS. Another example may be placing any significant hazards (like towers or wires) that are expected to be encountered during low-level night operations may be loaded into the first 25 points within the WPTHZ partition.
- **Free Text.** Most types of control measures will display the 3-character free text alongside their point symbol in lieu of their point index. Under some circumstances, it may be preferable to utilize these types of points if it is desired to leverage the free text itself in describing the nature of the location, even if the icon itself doesn't correlate with the terrain or situation.

  In the example to the right, LZ "Falcon" is marked by a Landing Zone point on the left, and a Ground Light point on the right. A Landing Zone point will not display its free text of "FAL" directly on the TSD, but it can be viewed by entering the TSD Point sub-page and then selecting the point using the cursor to review its information. On the other hand, the Ground Light point displays its free text "FAL" directly on the TSD, but it may not be known by the crew that this point represents an LZ location unless briefed as such.

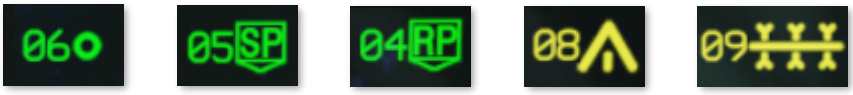


Landing Zone (Left) and Ground Light (Right) point symbols

  In this situation, it is a question of what the location means versus how it is labeled. This question of context should be taken into consideration when planning a mission in which other players may not be aware of the intent behind which points are being used for specific purposes.

Waypoints/Hazards (WPTHZ)

The Waypoints/Hazards partition includes graphics for depicting generic waypoints, communications checkpoints, start and release points of routes, and hazards such as towers or wires. Some of the more commonly used Waypoints/Hazards are shown below.



Waypoint | Start Point | Release Point | Tower <1000' | Wires, Power

Examples of Waypoint/Hazard Symbols

When a WPTHZ point file is set to an identifier that corresponds with a hazard, the point file is presented to the crew as "H##" rather than "W##", even though the point files are within the same partition.

It is important to note that hazards are *always* perpendicular to the flight path of the aircraft on the TSD and *do not* depict the actual direction of the hazard, but its general location only. This is especially important to remember regarding linear hazards such as wires.

Control Measures (CTRLM)

Control measures include graphics for depicting friendly and enemy units, Forward Arming and Refueling Points (FARPs), battle positions, and others. Some of the more commonly used Control Measures are shown below.

Airfield | Battle Position | Checkpoint | Ground Light | Friendly Infantry | Enemy Armor

Examples of Control Measure Symbols

Targets/Threats (TGT/THRT)

Targets/Threats include symbols for depicting the location of targets found during the conduct of a mission or for depicting the location of known or templated air defense systems.

Target Point | 2S6 | SA-8 | SA-15 | ZSU-23-4 | Radar

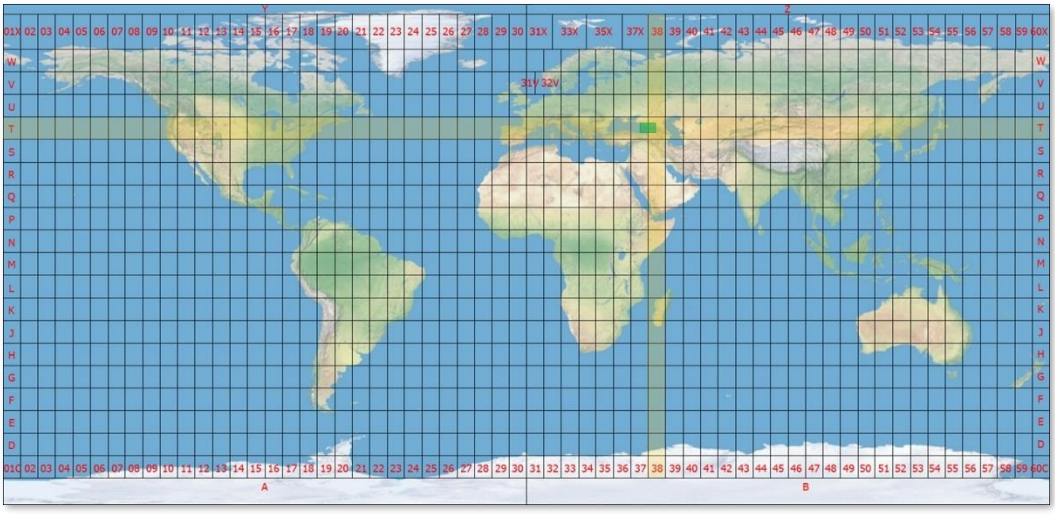
Examples of Target/Threat Symbols

When a point is entered as an air defense threat, rings depicting the detection and/or engagement ranges of the corresponding air defense system may be displayed on the TSD. The display of threat rings may be enabled/disabled on the TSD Threat Show (THRT SHOW) sub-page.

A complete list of point types and their symbols can be found on the TSD Abbreviation (ABR) sub-page or in Appendix C of this manual.

Military Grid Reference System (MGRS)

The Military Grid Reference System is a coordinate system used as an alternative to Latitude/Longitude and is the primary coordinate system used by many military ground forces. MGRS is derived from the Universal Transverse Mercator system which divides a Mercator-projection map of the Earth into 60 zones that are numbered from 01 starting from the 180° meridian and moving eastward. Each UTM zone number is then further sub-divided into 20 zone designators starting from the south pole and moving northward, with the south pole itself split between zone designators A and B and the north pole itself split between zone designators Y and Z. In addition, several non-uniform UTM zones are in northern Europe and the Norwegian and Barents Seas.



Universal Transverse Mercator (UTM) Zones

MGRS further sub-divides the UTM zones into 100×100 kilometer squares identified by a pair of letters, and then each 100 kilometer square is further broken down to 1 meter resolution grid coordinates that are numerically incremented eastward and northward.

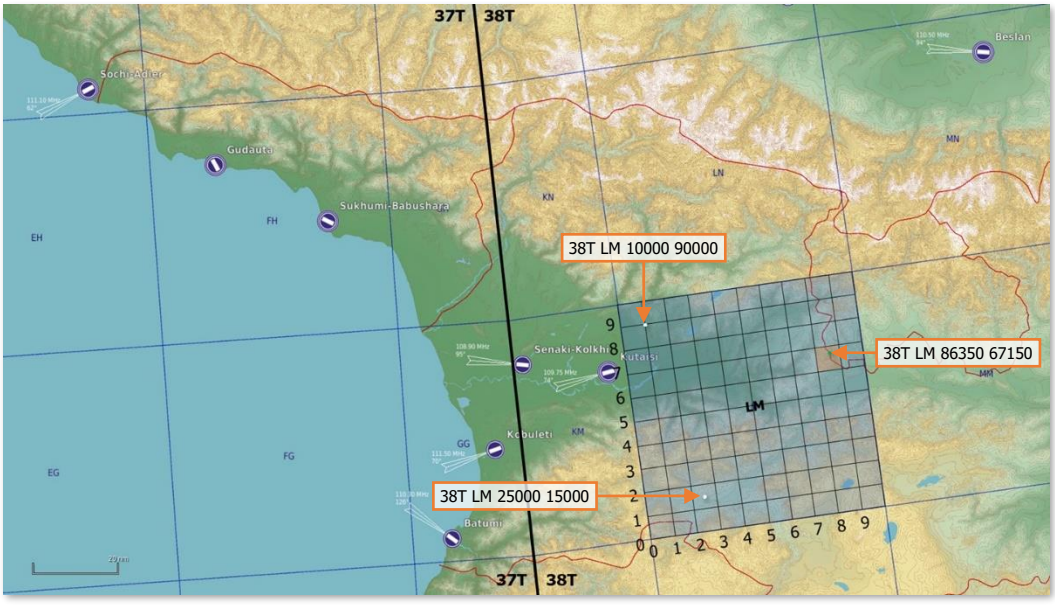
In the image above, a portion of the Caucasus region along the western coast of the Black Sea is highlighted in green. The green highlighted area (expanded on the following page) straddles grid zone designators 37T and 38T. Within that region along the border of South Ossetia is a position on the ground that is identified by the MGRS grid coordinates below.

Grid Zone Designator 38T LM 86350 67150

Square Identifier Easting Northing

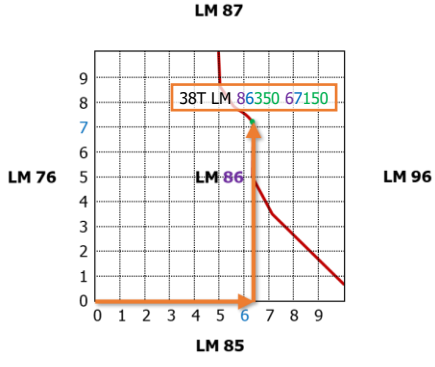
The expanded map below is split between the grid zone designators of 37T and 38T, with the area of interest located within the 100×100 kilometer square identified as LM (Blue Shade), and marked by a green dot. Each 100 km square is further sub-divided into a 100,000×100,000 meter grid.

Note that since the Earth is a sphere and cannot contain a perfect grid of adjacent geometric squares, the 100 km squares that run along the east and west borders of each grid zone designator will not actually be 100 km in width, but will be truncated to account for the curve of the Earth and the difference in east-west circumference between the equator and the polar regions across each numbered UTM zone.



Military Grid Reference System (MGRS)

Within the LM square, the first digit of the easting is attained by proceeding from zero and moving eastward in intervals of 10 kilometers, and then moving northward in the same manner. The grid section containing the green dot, LM86 (Orange Shade), is further expanded in the figure on the right.



As each grid is sub-divided further, the coordinate resolution of the corresponding location becomes more precise.

- 10-kilometer precision – 38T LM 8 6 (2-digit grid)
- 1-kilometer precision – 38T LM 86 67 (4-digit grid)
- 100-meter precision – 38T LM 863 671 (6-digit grid)
- 10-meter precision – 38T LM 8635 6715 (8-digit grid)
- 1-meter precision – 38T LM 86350 67150 (10-digit grid)

When inputting MGRS coordinates into the AH-64D, an 8-digit grid coordinate format must be utilized. During instances in which the 8-digit precision of a location is not known, such as if ground forces were to relay that their position was "38T LM 863 671", the coordinates would be input as 38T LM 8630 6710, with zeros added to the easting and northing as needed to adhere to the required input format.

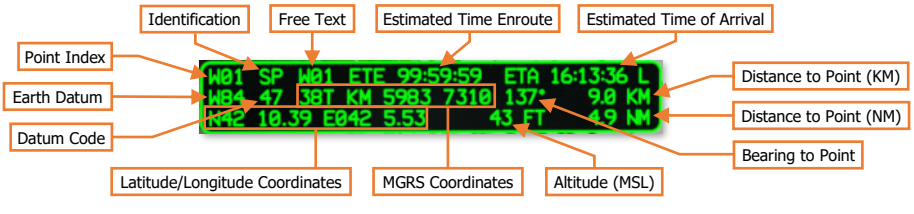
Alternatively, when a 10-digit grid coordinate format is relayed, such as 38T LM 86357 67152, the 5th digit in the easting and northing are simply omitted and the coordinates would be input as 38T LM 8635 6715.

TSD Point (POINT) Sub-page

The POINT sub-page allows either crewmember to add additional point files to the navigational database, edit or delete existing point files from the navigational database, or transmit points to other flight members.

Other Tactical Situation Display functions and sub-pages are desribed in the AH-64D chapter.

1. **Review Point.** Activates the KU for inputting a point file for review. Alternatively, a point may selected for review directly from the TSD by using the MPD cursor.
2. **Add Point format.** Displays the ADD format for creating new point files.
3. **Edit Point format.** Displays the EDIT format for editing existing point files.
4. **Delete Point format.** Displays the DEL format for deleting existing point files.
5. **Store Point format.** Displays the STO format for storing new point files using the CPG's HMD or TADS lines-of-sight, or storing new point files at the current position of the ownship.
6. **Transmit Point format.** Displays the XMIT format for transmitting existing point files to other AH-64Ds via the datalink modem (DL).
7. **ABR sub-page.** Displays the TSD Abbreviation sub-page.
8. **Reviewed Point.** The text of the point that is selected for review will be highlighted in inverse video format.
9. **Review Status Window.** Displays information regarding the reviewed point.

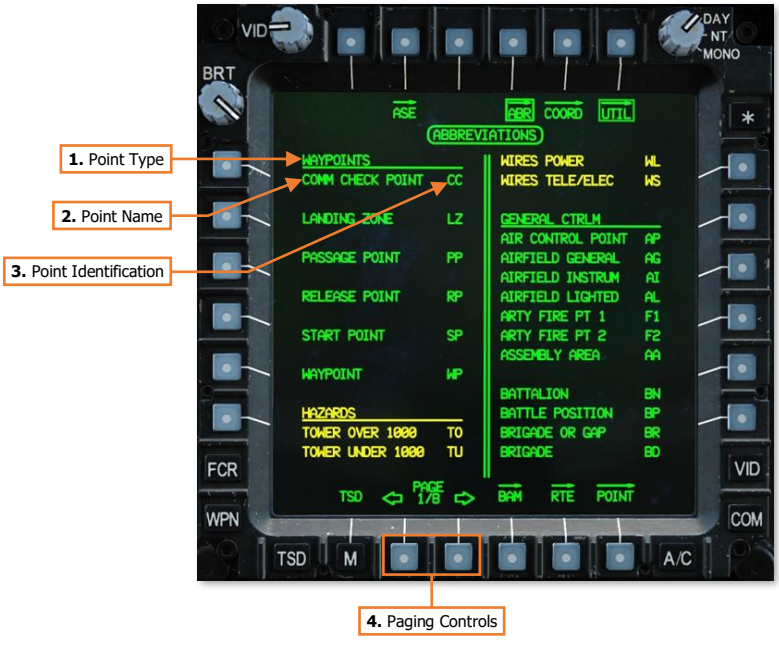


- **Point Index.** The database partition and location within which the point resides.
- **Identification.** The one- or two-character abbreviation of the point, which determines its specific symbol and color.
- **Free Text.** The one-, two-, or three-character text that may be added to the point for additional context as to the nature of the location.
- **Estimated Time Enroute (ETE).** The estimated elapsed time to travel to the point, based on the distance to the point from the ownship's current position and the ownship's current ground speed.
- **Estimated Time of Arrival (ETA).** The estimated time of arrival at the point, based on the current system time and the estimated time enroute (ETE). The ETA time format (Local or Zulu) is based on the system time format selected on the TSD Utility page.
- **Earth Datum.** The geodetic system used to determine the point's location on the Earth.
- **Datum Code.** The one- or two-character abbreviated code of the point's Earth datum.
- **Distance to Point (KM).** The distance from the ownship position to the point's location, in kilometers.
- **Distance to Point (NM).** The distance from the ownship position to the point's location, in nautical miles.
- **Bearing to Point.** The magnetic heading from the ownship position to the point's location.
- **MGRS Coordinates.** The location of the point, in Military Grid Reference System 8-digit grid format.
- **Latitude/Longitude Coordinates.** The location of the point, in Latitude/Longitude Degrees, Minutes, Minute-Decimals format (DD°MM.MM' DDD°MM.MM').
- **Altitude.** The altitude of the point above mean sea level (MSL).

TSD Abbreviation (ABR) Sub-page

The ABR sub-page is used as an in-cockpit reference for either crewmember to review the abbreviated codes (IDENT) that identify the specific point types when interacting with the point database, or adding a new point through the TSD Point sub-page.

The ABR sub-page may also be accessed from the TSD Utility sub-page, as shown below.



1. **Point Type.** Denotes the type of all points listed below. The Point Type headers, followed by Earth Datum headers, are listed in the following sequence on the subsequent ABR sub-pages.

- WAYPOINTS
- HAZARDS
- GENERAL CTRLM
- FRIENDLY CTLRM
- ENEMY CTRLM
- PREPLANNED TGT/THRT
- AIRY AIR
- AUSTRALIAN NATL AUS
- BESSEL 1841 BES
- CLARK 1880 CL0
- CLARK 1866 CL6
- EVEREST SABAH EVB
- EVEREST 1830 EVE
- INTERNATIONAL1924 INT
- MODIFIED AIRY MAI
- EVEREST 1948 MEV
- WORLD GEO SYS 72 W72
- WORLD GEO SYS 84 W84

2. **Point Name.** Denotes the name of the point.

3. **Point Identification.** Denotes the abbreviated identification code of the point. This may be input via the Keyboard Unit (KU) when adding a new point to the TSD.

4. **Paging Controls.** Cycles forward and back through multiple pages of abbreviated identification codes.

Adding a Point

Points may be added to the TSD while the POINT sub-page is displayed in ADD format. A new point may be added by manually entering point file data via the Keyboard Unit (KU) or by "dropping" a new point directly onto the TSD via the MPD cursor.

POINT Add (ADD) format

Pressing the ADD button (VAB L2) displays the POINT sub-page in Add format. Pressing the ADD button a second time returns the POINT sub-page to the original format.

1. **Add Point.** Activates the KU for inputting new point file data. The first data element that may be input is the identifier. (See Adding a Point using the Keyboard Unit for more information.)
2. **Waypoint (WP) Point Type.** Selects the WPTHZ partition for point entry and enables Waypoint-specific identifiers only: CC, LZ, PP, RP, SP, and WP. The selected point type will default to this selection when the POINT page is set to ADD format while the TSD Phase is set to NAV. (See Appendix C for a complete list of Waypoint identifiers.)
3. **Hazard (HZ) Point Type.** Selects the WPTHZ partition for point entry and enables Hazard-specific identifiers only: TO, TU, WL, and WS. (See Appendix C for a complete list of Hazard identifiers.)
4. **Control Measure (CM) Point Type.** Selects the CTRLM partition for point entry and enables Control Measure-specific identifiers only. (See Appendix C for a complete list of Control Measure identifiers.)
5. **Target/Threat Point (TG) Type.** Selects the TGT/THRT partition for point entry and enables Target/Threat-specific identifiers only. The selected point type will default to this selection when the POINT page is set to ADD format while the TSD Phase is set to ATK. (See Appendix C for a complete list of Target/Threat identifiers.)
6. **Next Point File Entry.** Displays the point file index that will be occupied by the next point that is entered.
7. **ABR sub-page.** Displays the TSD Abbreviation sub-page.

Adding a Point using MPD Cursor

A new point may be added to the TSD quickly by selecting the desired point type (VAB L3-L6) and then "dropping" the point onto the TSD at the desired location. However, if the "cursor drop" method is used to add a point, only the point type may be selected and no further point file data may be entered. The default points that are dropped at the cursor location are shown below, based on the selected point type.

Waypoint (WP)

Tower Under 1000′ (TU)

Checkpoint (CP)

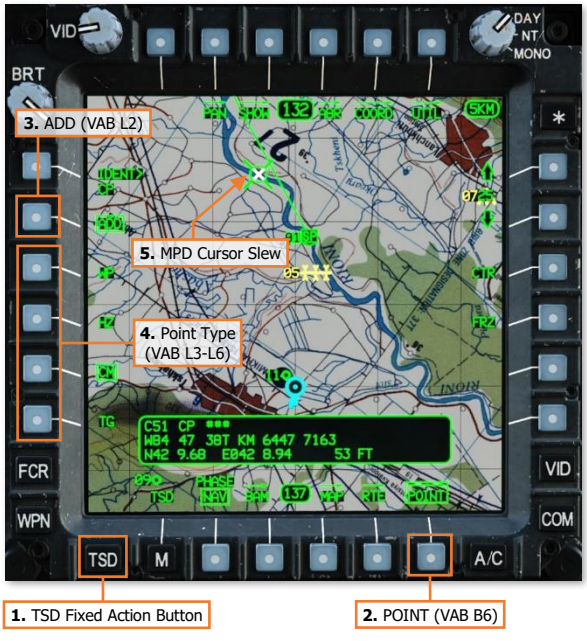
Target point (TG)

When these points are "dropped", the free text will default to the point index within the database (e.g., "W11", "H05", "C51", "T04" etc.). The coordinates will be entered based on the cursor location and the altitude of the point will be entered based on the terrain elevation data for that location on that map.

To quickly add a point using the "cursor drop" method, perform the following:

1. TSD Fixed Action Button – Press.
2. POINT (VAB B6) – Select.
3. ADD (VAB L2) – Select.
4. Point Type (VAB L3-L6) – Select WP, HZ, CM, or TG as desired.
5. MPD Cursor Controller/Enter – Slew to desired location on TSD.

6. MPD Cursor Controller/Enter – Press.



Adding a Point using Keyboard Unit (KU)

A new point may be added by manually entering point file data via the Keyboard Unit (KU). This method allows the crewmember to input each element of the point file sequentially.

To add a point using the KU, perform the following:

1. TSD Fixed Action Button – Press.

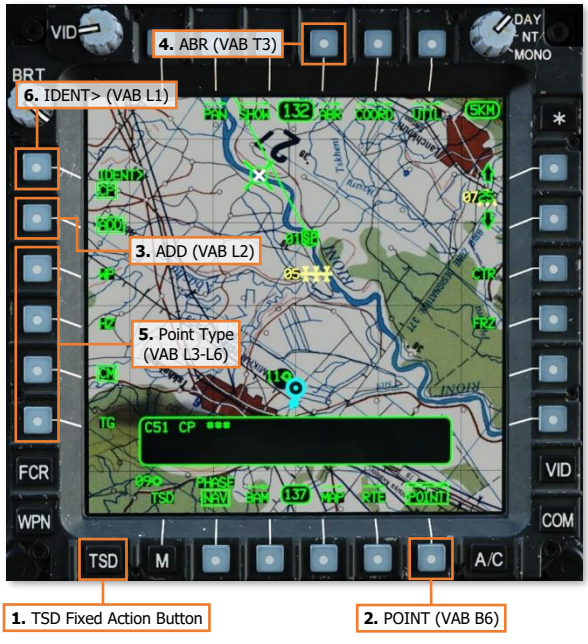
2. POINT (VAB B6) – Select.

3. ADD (VAB L2) – Select.

4. ABR (VAB T4) – Select, as required.

5. Point Type (VAB L3-L6) – Select WP, HZ, CM, or TG as desired.

6. IDENT> (VAB L1) – Select.



Once IDENT> (VAB L1) is pressed, the KU scratchpad display will activate with "IDENT:" as the display prompt. The elements of the new point file may then be entered, with the ENTER button on the KU commanding the KU to accept the current entry and progress to the next display prompt in the sequence.

If an entry is invalid and cannot be accepted by the KU, the scratchpad display will flash. Any button on the KU may then be pressed to acknowledge the invalid entry condition, after which a different data entry may be input.

IDENT:

7. Input identifier data, and press ENTER on the KU.

FREE:

8. Input free text data, and press ENTER on the KU.

UTM LAT/LONG:

The KU scratchpad will initialize to the UTM LAT/LONG: prompt by displaying the current MGRS coordinates of the ownship. The cursor is automatically placed at the first digit of the "easting" numerals (shown at right).

9. Input location data using any of the following methods:

- Input MGRS coordinates in an 8-digit format as a continuous string without spaces and press ENTER on the KU (e.g., 38T KM 5644 8074 would be input as "38TKM56448074").

If a different grid zone designator and/or square identifier is to be entered, the KU arrow keys should be used to place the cursor over the first character to be overwritten, and then the remainder of the coordinate data may be typed over.

- Press CLR and input Latitude/Longitude coordinates in Degrees-Minutes-Decimals format as a continuous string without spaces, decimals, or special characters and press ENTER on the KU (e.g., N42°14.45′ E°042°02.88′ would be input as "N421445E0420288")

- Press CLR and input the name of an existing point file to copy its coordinates into the new point file and press ENTER on the KU (e.g., "W11", "H05", "C51", "T04", etc).

- Use the MPD Cursor Controller/Enter to slew the MPD cursor to the desired location on TSD and then press Cursor-Enter.

ALTITUDE:

The KU scratchpad will initialize to the ALTITUDE: prompt by displaying the digital terrain elevation data at the coordinates that was just entered within the new point file. The cursor is automatically placed at the first digit.

10. Input altitude data using either of the following methods:

- Accept the default terrain elevation by pressing ENTER on the KU.
- Input a different altitude value in feet above mean sea level (MSL) by typing over the existing data and press ENTER on the KU.

After the altitude data has been accepted, the new point file will be saved within the navigational database and automatically selected for review on the POINT sub-page.

Editing a Point

Points may be edited while the POINT sub-page is displayed in EDIT format. Existing point files may receive changes to their free text, coordinates, or altitude data elements; however, the point file identifier may not be changed.

POINT Edit (EDIT) format

Pressing the EDIT button (VAB L3) displays the POINT sub-page in Edit format. Pressing the EDIT button a second time returns the POINT sub-page to the original format.

1. **Edit Point.** Activates the KU for editing point file data of the point selected for review. The first data element that may be edited is the free text. (See Editing a Point using the Keyboard Unit for more information.)
2. **Reviewed Point.** The text of the point that is selected for review will be highlighted in inverse video format.
3. **Review Status Window.** Displays information regarding the reviewed point.

Editing a Point using Keyboard Unit (KU)

An existing point can only be edited by manually entering point file data via the Keyboard Unit (KU). This method requires the crewmember to review each element of the point file sequentially and, if necessary, input new data using the KU when the respective prompt is displayed on the KU scratchpad.

To edit a point using the KU, perform the following:

1. TSD Fixed Action Button – Press.

2. POINT (VAB B6) – Select.

3. POINT> (VAB L1) – Select and input the point index of the point to be edited into the KU (e.g., "W11", "H05", "C51", "T04", etc).

or

3. MPD Cursor Controller/Enter – Select the point to be edited on TSD.

4. EDIT (VAB L3) – Select.

5. FREE> (VAB L1) – Select.

Once FREE> (VAB L1) is pressed, the KU scratchpad display will activate with "FREE:" as the display prompt. The elements of the point file may then be edited, with the ENTER button on the KU commanding the KU to accept the current entry and progress to the next display prompt in the sequence.

If an entry is invalid and cannot be accepted by the KU, the scratchpad display will flash. Any button on the KU may then be pressed to acknowledge the invalid entry condition, after which a different data entry may be input.

FREE:

6. If the existing free text is desired, simply press ENTER to accept the existing data.

If different free text data is desired, the new free text may be input by typing over the existing data and then press ENTER on the KU.

UTM LAT/LONG:

The KU scratchpad will initialize to the UTM LAT/LONG: prompt with the cursor automatically placed at the first digit of the "easting" numerals (shown at right).

7. If the existing location is desired, simply press ENTER to accept the existing data.

If different location data is desired, the new location data may be input using any of the following methods:

- Input MGRS coordinates in an 8-digit format as a continuous string without spaces and press ENTER on the KU (e.g., 38T KM 5644 8074 would be input as "38TKM56448074").

If a different grid zone designator and/or square identifier is to be entered, the KU arrow keys should be used to place the cursor over the first character to be overwritten, and then the remainder of the coordinate data may be typed over.

- Press CLR and input Latitude/Longitude coordinates in Degrees-Minutes-Decimals format as a continuous string without spaces, decimals, or special characters and press ENTER on the KU (e.g., N42°14.45' E°042°02.88' would be input as "N421445E0420288")

- Press CLR and input the name of an existing point file to copy its coordinates into the new point file and press ENTER on the KU (e.g., "W11", "H05", "C51", "T04", etc).

- Use the MPD Cursor Controller/Enter to slew the MPD cursor to the desired location on TSD and then press Cursor-Enter.

ALTITUDE:

The KU scratchpad will initialize to the ALTITUDE: prompt with the cursor automatically placed at the first digit.

8. If the existing altitude is desired, simply press ENTER to accept the existing data.

If different altitude data is desired, input a different altitude value in feet above mean sea level (MSL) by typing over the existing data and press ENTER on the KU.

After the altitude data has been accepted, the changes to the point file will be reflected within the navigational database and may be reviewed within the Review Status Window on the POINT sub-page.

In the image shown to the right, the free text was modified from the default data of "W01" to "SPT", with the existing location and altitude data accepted without changes.

Deleting a Point

Points may be deleted while the POINT sub-page is displayed in DEL format. A confirmation must be received by the crewmember to delete the point from the navigational database.

POINT Delete (DEL) format

Pressing the DEL button (VAB L4) displays the POINT sub-page in Delete format and replaces the DEL button with a two-button Grouped button confirmation option. Pressing the NO button (VAB L4) will abort the deletion process and return the POINT sub-page to the original format.

1. **Review Point.** Activates the KU for inputting a point file for review. Alternatively, a point may selected for review directly from the TSD by using the MPD cursor. (See Deleting a Point for more information.)
2. **Confirm Point Deletion.** Deletes the point that is selected for review.
3. **Abort Point Deletion.** Aborts the deletion process and returns the POINT sub-page to the original format.
4. **Reviewed Point.** The text of the point that is selected for review will be highlighted in inverse video format.
5. **Review Status Window.** Displays information regarding the reviewed point.

Deleting a Point

To delete an existing point, perform the following:

1. TSD Fixed Action Button – Press.
2. POINT (VAB B6) – Select.
3. POINT> (VAB L1) – Select and input the point index of the point to be deleted into the KU (e.g., "W11", "H05", "C51", "T04", etc).

   or

3. MPD Cursor Controller/Enter – Select the point to be deleted on TSD.

4. DEL (VAB L4) – Select.
5. YES (VAB L3) – Select to confirm deletion.

   or

5. NO (VAB L4) – Select to abort deletion.

Storing a Point

Waypoints or Target points may be selectively stored to the TSD while the POINT sub-page is displayed in STO format. A new point may be stored using either a "flyover" store or a "CPG Sight" store.

When the POINT sub-page is displayed in STO format, the Review Status window will display the information that will be entered into the next point file if the NOW button (VAB L1) is pressed or, in the case of the CPG, if the STORE/UPDT button on the TEDAC Left Handgrip is momentarily set to the STORE position. This includes the next empty point file index of the selected type, and the aircraft's current position and altitude.

POINT Store (STO) format

Pressing the STO button (VAB L5) displays the POINT sub-page in Store format. Pressing the STO button a second time returns the POINT sub-page to the original format.

1. **Store Now.** Stores a new point at the current coordinates of the ownship. (See Storing a Point using Fly-over for more information.)
2. **Point Type.** Toggles the point type of the next point to be stored.
   - **WP.** The next point to be stored will be entered as a Waypoint (WP). The point type will default to this selection when the POINT page is set to STO format while the TSD Phase is set to NAV.
   - **TG.** The next point to be stored will be entered as a Target (TG) point. The point type will default to this selection when the POINT page is set to STO format while the TSD Phase is set to ATK.
3. **Next Point File Entry.** Displays the point file index that will be occupied by the next point that is stored.
4. **Review Status Window.** Displays the coordinates that will be entered into the next point file if the NOW button (VAB L1) is pressed. When a point is stored using NOW (VAB L1), the point's free text is automatically entered as "FLY". When a point is stored using the CPG HMD or TADS, the point's free text is automatically entered as "HMD" or "TAD" respectively.

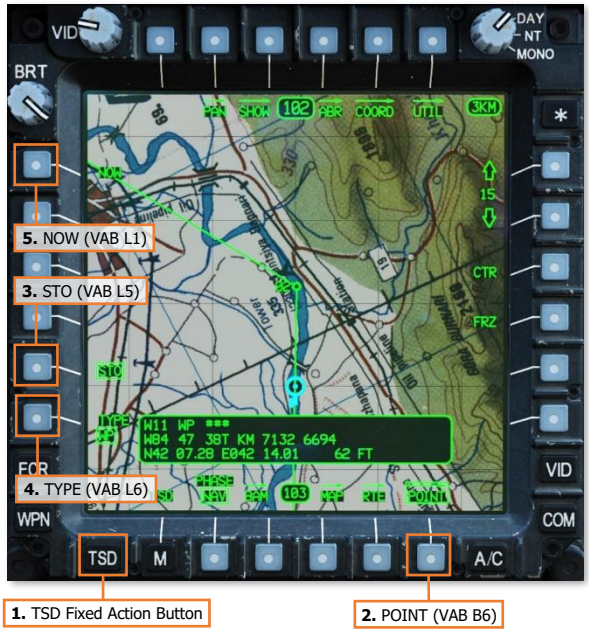
Storing a Point using Fly-over

A new point may be stored to the TSD using the current aircraft position in a "fly-over" method, and may be performed by either crewmember.

To store a point at the current aircraft position, perform the following:

1. TSD Fixed Action Button – Press.
2. POINT (VAB B6) – Select.
3. STO (VAB L5) – Select.
4. TYPE (VAB L6) – Select WP or TG as desired.
5. NOW (VAB L1) - Select.

After storing the point, the TSD will return to the main format of the POINT sub-page, and display the fly-over point's information in the Review Status window.

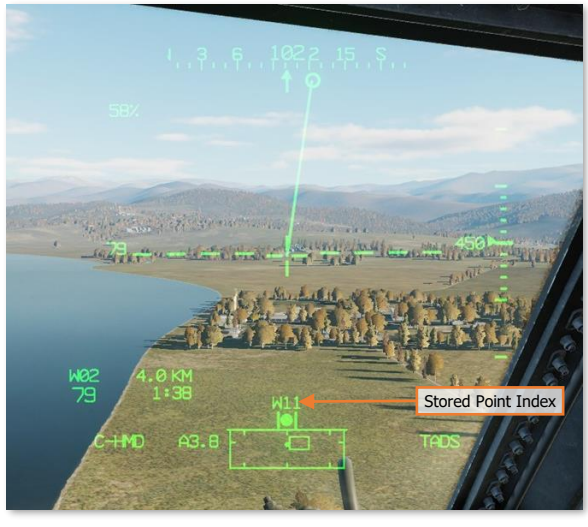


Storing a Point using CPG Sight (HMD)

A new point may be stored to the TSD using the CPG HMD line-of-sight. Although a manual range may be used if necessary, an automatic range will typically provide greater precision when operating over relatively flat terrain.

To store a point at the CPG's HMD line-of-sight using an Automatic range, perform the following:

1. Sight Select switch – HMD.
2. WPN Fixed Action Button – Press.
3. MANRNG (VAB B6) – Select, enter "A" on the KU, and press ENTER.
4. TSD Fixed Action Button – Press.
5. POINT (VAB B6) – Select.
6. STO (VAB L5) – Select.
7. TYPE (VAB L6) – Select WP or TG as desired.
8. Position the HMD LOS Reticle over the desired location.
9. STORE/UPDT switch – STORE.



Storing a point using the HMD line-of-sight

Storing a Point using CPG Sight (TADS)

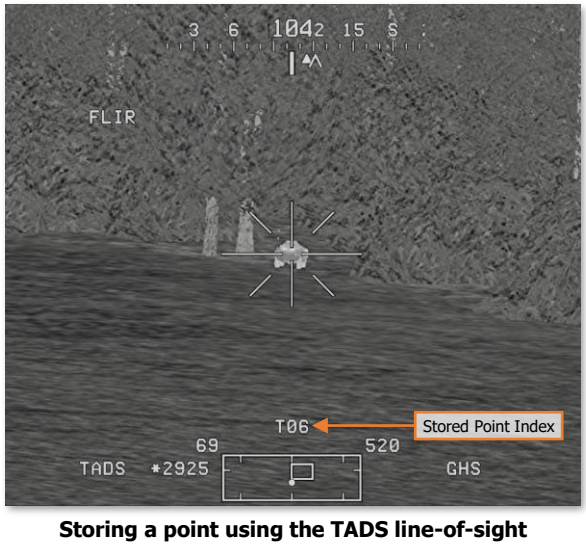
A new point may be stored to the TSD using the TADS line-of-sight. Although an automatic or manual range may be used if necessary, a laser range will provide the best precision when storing a point using the TADS.

NOTE: The CPG may store a Target (TG) point at the TADS line-of-sight and current range source any time the TADS is the selected sight and the STORE/UPDT switch on the TEDAC Left Handgrip is momentarily set to the STORE position. The TSD is not required to be displayed and set to the STO sub-page to perform this action.

Although this method allows targets to be stored more quickly by excluding steps 3 through 6 below, the option to store a Waypoint (WP) in lieu of a Target (TG) point will not be available if the POINT sub-page STO format is not utilized.

To store a point at the CPG TADS line-of-sight using a laser range, perform the following:

1. NVS Mode switch – OFF, if applicable.
2. Sight Select switch – TADS.
3. Sight Manual Tracker – Position the TADS LOS Reticle over the desired location.
4. TSD Fixed Action Button – Press.
5. POINT (VAB B6) – Select.
6. STO (VAB L5) – Select.
7. TYPE (VAB L6) – Select WP or TG as desired.
8. ARM/SAFE button – ARM.
9. LRFD trigger – 1st detent for ranging.
10. STORE/UPDT switch – STORE.



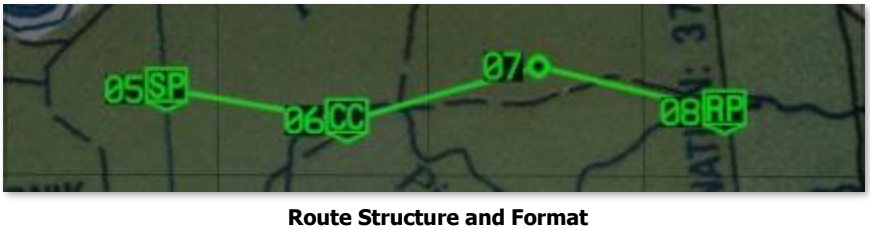
Storing a point using the TADS line-of-sight

ROUTES

The AH-64D navigational database can store 10 unique routes, each consisting of up to 100 point entries. Route sequences may consist of any combination of Waypoints/Hazards and Control Measures, but may not include any points from the Targets/Threats partition. However, "direct" routes may be plotted from the aircraft's current position to any point file within the database at any time, to include Targets/Threats.

Routes typically consist of a Start Point (SP) and end with a Release Point (RP). When planning a mission, it is useful to have multiple ingress and egress routes to and from the objective area. A route should not be considered a flight plan, but rather an avenue to reach the objective area, reposition to different sectors of the battlefield, or a method to control multiple flights of aircraft. As such, most route points are not required to be directly overflown.

In the example below, a route is shown on the TSD that includes a Start Point, a Communications Checkpoint, a standard Waypoint, a Release Point, and a solid green line linking each point within the route. As each point within the route is reached, the next point in the route sequence is automatically selected for navigation.



Route Structure and Format

If any point is manually selected on the TSD for navigation, a direct route will be created leading to that point. If the point that is selected for creation of a direct route is within the current route sequence, the direct route will be removed upon arrival at that point, the route sequence will return to full intensity, and the route will sequence through the remainder of the subsequent route points.

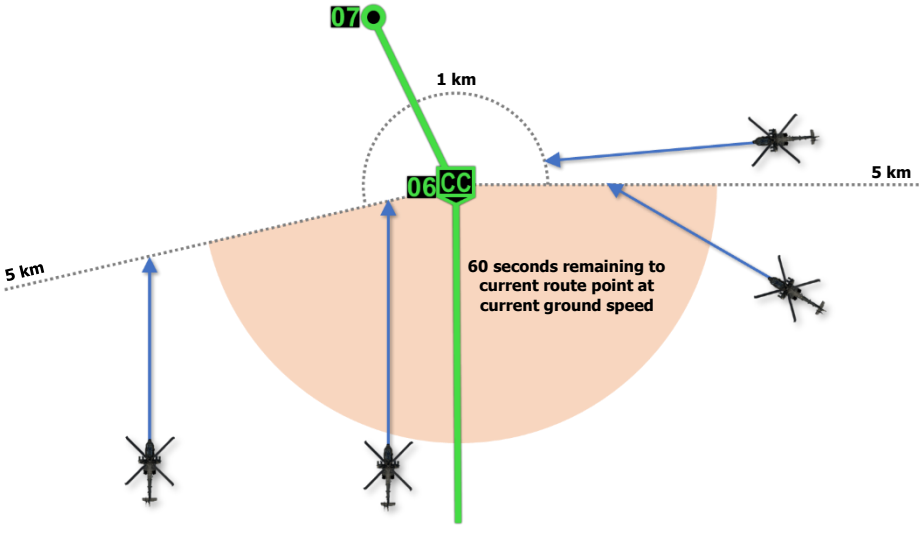
Route Sequencing

When navigating along a route, the next route point in the route sequence will be selected automatically when the current route point is passed. The threshold at which the route point is sequenced is based on the geometry between the current route point and the next route point, the position of the helicopter in relation to the current route point, and the proximity of the helicopter to the current route point.

The primary threshold for sequencing the route point extends 5 kilometers to either side of the route itself, the angle of which depends on the turn direction to the next route point.

- Along the outboard side of the turn, the threshold extends at a 90° angle from the route line as it approaches the current route point. When crossing this threshold within 5 kilometers of the current route point, while flying a course toward the next route point, the route point is sequenced.
- Along the inboard side of the turn, the threshold extends at an angle bisection between the route line leading to the current route point and the route line leading to the next route point. When crossing this threshold within 5 kilometers of the current route point, while flying a course toward the next route point, the route point is sequenced.

The secondary threshold for sequencing the route point encircles the current route point at a radius of 1 kilometer, on the opposite side of the primary threshold.



Route Sequencing Threshold

If the helicopter is proceeding along the current route in the same direction as the route itself, and the ETE to the current route point is 60 seconds or less at the current ground speed (Orange Shade), the EUFD will display the "WPT APPROACHING" advisory if a non-frozen TSD is not displayed in either crewstation.

If the helicopter is proceeding along the current route in the same direction as the route itself, the route point will be sequenced when passing within 5 kilometers of the current route point as shown in the figure above. If the helicopter is rejoining the route from the opposite direction of the route itself, the route point will be sequenced when within 1 kilometer of the current route point as shown in the figure above. In either case, the EUFD will display the "WAYPOINT PASSED" advisory for 60 seconds after the route point is sequenced if a non-frozen TSD is not displayed in either crewstation.

Displaying a non-frozen TSD in either crewstation will acknowledge the "WPT APPROACHING" or "WAYPOINT PASSED" advisories, resulting in removal from the EUFD.

TSD Route (RTE) Sub-page

The RTE sub-page is used to review information regarding the current route and its points, plot a direct route to a different point in the route or any point outside of the current route sequence, or edit the current route by adding or deleting points from the route sequence. Routes themselves may be selected or deleted entirely from the TSD Route Menu sub-page.

NOTE: If a point is deleted from a route sequence, it is not removed from the navigational database. Point files may only be deleted from the database using the TSD Point sub-page.

By default, the current route is only displayed on the TSD page when set to NAV phase, or any time the RTE sub-page is displayed. However, the current route may be enabled for display on the TSD in the ATK phase if desired. (See TSD Show sub-page for more information.)

1. **Aircraft Heading.** Displays a digital readout of the aircraft's current magnetic heading in 1° increments.
2. **Route Line.** Displays the current route as a solid green line.

   When a direct route is created to any point file, the direct route will be displayed as a full intensity green line and the route line will be displayed as a partial intensity green line
3. **Add Point format.** Displays the ADD format for adding points to the current route.
4. **Delete Point format.** Displays the DEL format for removing points from the current route.
5. **Direct Route format.** Displays the DIR format for creating a direct route to an existing point file.
6. **Command Heading.** Indicates the magnetic heading to the point selected for navigation.
7. **Reviewed Point.** The text of the point that is selected for review will be highlighted in inverse video format.
8. **Route Scroll.** Scrolls the Route Points window forward through route sequence when VAB R1 is pressed, or backward through the route sequence when VAB R6 is pressed.

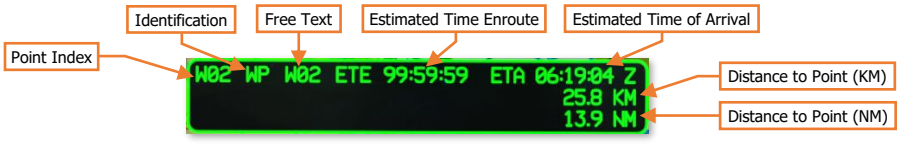
9. **Route Points Window.** Displays the point files within the current route sequence and permits selection of the points for review, navigation, editing of the current route. The points window may be scrolled forward or backwards through the route sequence using the Route Scroll buttons (VAB R1/R6).

Each point file within the Route Points window is displayed as a 4-character sequence, with the first two characters representing the point file's identifier code, and the last two characters representing the point file's numerical index within its database partition. In the example to the left, the point file is W04 within the WPTHZ partition, which is identified as a Release Point.

When a point file within the Route Points window is selected for review, the point's label within the Route Points window is outlined within a box.

When a point file within the Route Points window is selected as the navigation destination, the point's label within the Route Points window is underlined.

10. **Review Status Window.** Displays information regarding the reviewed route point.



- **Point Index.** The database partition and location within which the point resides.
- **Identification.** The one- or two-character abbreviation of the point, which determines its specific symbol and color.
- **Free Text.** The one-, two-, or three-character text that may be added to the point for additional context as to the nature of the location.
- **Estimated Time Enroute (ETE).** The estimated elapsed time to travel to the next point within the route sequence, and each subsequent route leg, until arrival at the reviewed point within the route sequence, based on the current ground speed.

  When a direct route is created to any point file, the ETE will be calculated based on the straight-line distance from the ownship position to the reviewed point and the current ground speed.
- **Estimated Time of Arrival (ETA).** The estimated time of arrival at the reviewed point, based on the current system time and the estimated time enroute (ETE). The ETA time format (Local or Zulu) is based on the system time format selected on the TSD Utility sub-page.

  When a direct route is created to any point file, the ETA will be calculated based on the straight-line distance from the ownship position to the reviewed point and the current ground speed.
- **Distance to Point (KM).** The combined distance, in kilometers, from the ownship position to the next point within the route sequence, and each subsequent route leg, until arrival at the reviewed point.

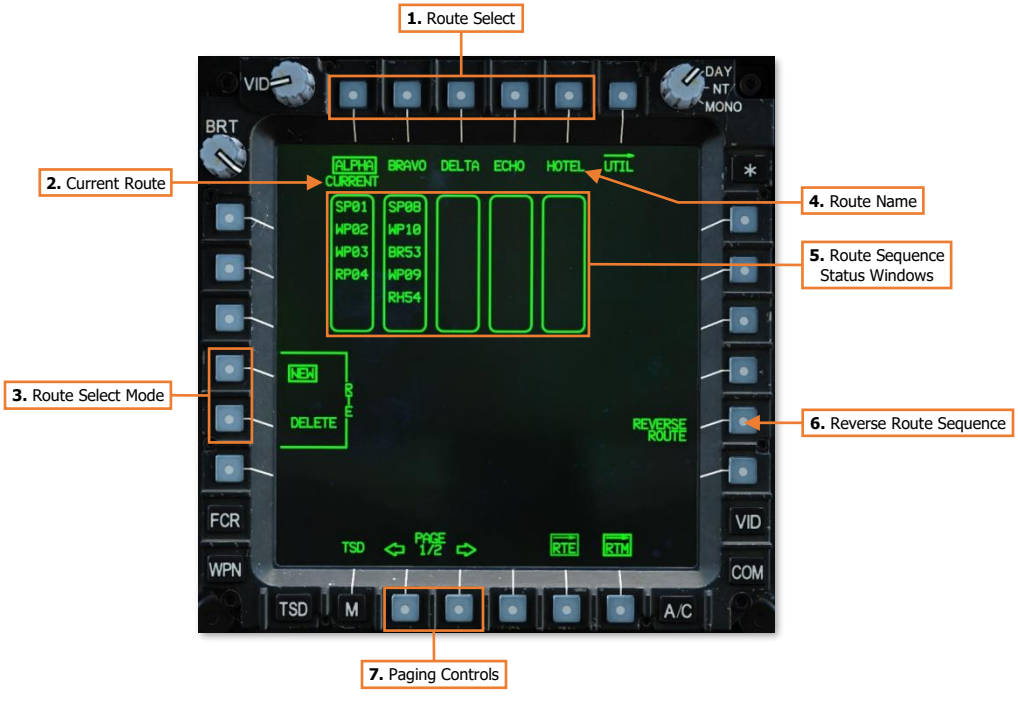
  When a direct route is created to any point file, the distance will be calculated as a straight-line distance from the ownship position to the reviewed point.
- **Distance to Point (NM).** The combined distance, in nautical miles, from the ownship position to the next point within the route sequence, and each subsequent route leg, until arrival at the reviewed point.

  When a direct route is created to any point file, the distance will be calculated as a straight-line distance from the ownship position to the reviewed point.

11. **RTM sub-page.** Displays the TSD Route Menu sub-page.

TSD Route Menu (RTM) Sub-page

The RTM sub-page is used to select a different route sequence for navigation, reverse the current route sequence, or delete all point files from any of the stored route sequences.

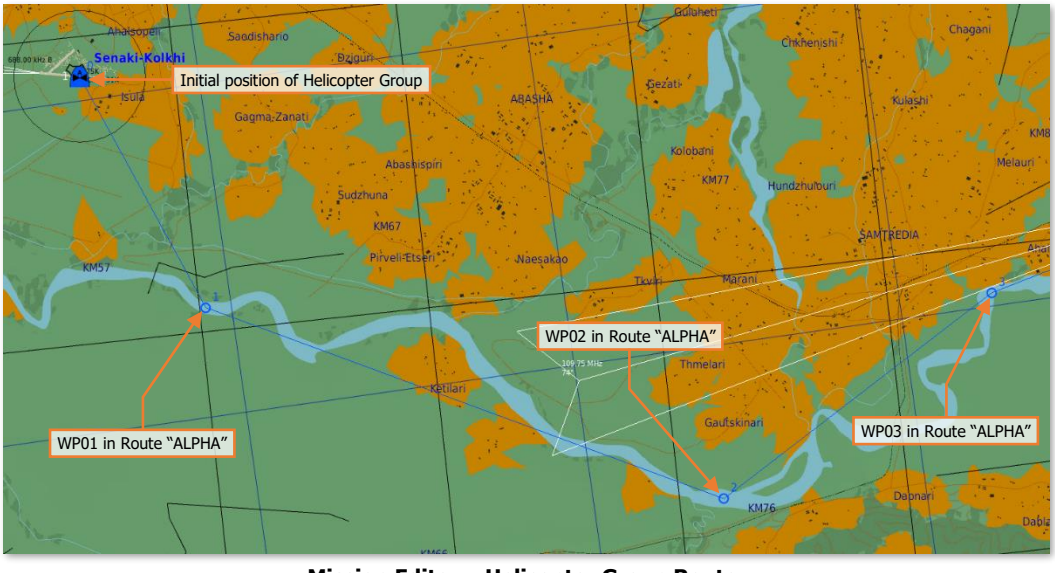


1. **Route Select.** Selects a route sequence for navigation or for deletion, depending on the Route Select Mode that has been selected at (VAB L4/L5).
2. **Current Route.** Indicates the route sequence that is being used for navigation.
3. **Route Select Mode.** Determines the function of the Route Select buttons (VAB T1-T5).
   - **NEW.** The Command Heading, Navigation Fly-To Cue, and Waypoint Status windows will switch navigation to the first point within the selected route sequence, and any direct route lines will be removed from the TSD.
   - **DELETE.** All point files are removed from the route sequence that is subsequently selected. The route name will remain and cannot be changed from within the cockpit.
4. **Route Name.** Displays the 5-character name of the corresponding route sequence.
5. **Route Sequence Status windows.** Displays the first six point files within the route sequence, in order of navigation.
6. **Reverse Route Sequence.** Inverts the route sequence so that the route may be flown in the reverse direction. Each point file will automatically sequence to the next in reverse order as the route is flown. The Route Sequence Status windows will update accordingly to reflect the sequence.
7. **Paging Controls.** Cycles forward and back between the first and second pages of route sequences.

Creating a Route using the Mission Editor

When using the Mission Editor, waypoints placed on the map from the Helicopter Group's Route tab will auto-populate into the DCS: AH-64D as the default TSD route sequence, Route "ALPHA". Each waypoint following the initial Helicopter Group position (waypoint 0) will be displayed as a Waypoint (WP) on the TSD, as part of Route "ALPHA", and numbered in accordance with their sequence within the Mission Editor.

NOTE: It is currently only possible to generate one route in the Mission Editor. The remaining nine routes on the Route Menu (RTM) sub-page will be empty of any points. However, points may be added to the remaining routes from the cockpit, if desired, after the mission starts.



Mission Editor – Helicopter Group Route

Point files within the AH-64D's navigational database are input and displayed in three dimensions, therefore it may be advisable to set the altitude of all waypoints within the Mission Editor to the minimum value, which corresponds with ground level; especially if intended to mark a specific location or landmark. However, under certain circumstances it may be useful to place them at altitudes above ground, depending on how they are intended to be utilized during the mission. This may be useful to mark locations over the battlefield for illumination rockets or to build 3-dimensional instrument approaches during low-visibility conditions.

Creating a Route using the Route (RTE) sub-page

When creating a new route, an empty route should be selected on the TSD Route Menu sub-page. After an empty route has been selected, it may be necessary pan the TSD to the first point to be added to the route, and any subsequent points, if not currently located within the viewable TSD footprint. Alternatively, if the point file indexes of the points are known, they may be manually input using the Keyboard Unit (KU).

NOTE: Routes may only be created or modified using existing points within the navigational database, which cannot be added from the TSD Route sub-page. (See TSD Point sub-page for more information).

To add points to a new route, perform the following:

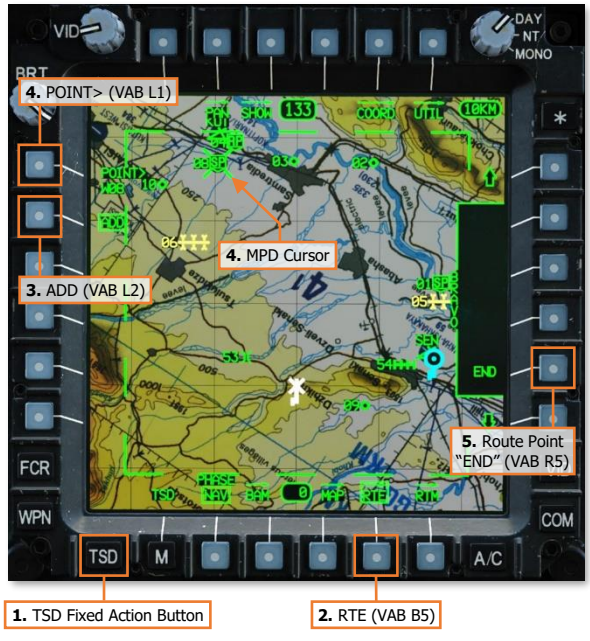
1. TSD Fixed Action Button – Press.
2. RTE (VAB B5) – Select.
3. ADD (VAB L2) – Select.
4. POINT> (VAB L1) – Select and input the point index of the point to be added into the KU (e.g., "W11", "H05", "C51", etc).

   or

4. MPD Cursor Controller/Enter – Select the point to be added on TSD.

5. Route Point (VAB R5) – Select the button adjacent to the route "END" identifier to place the point at the start of the route.

   The route "END" identifier will move to the following position within the route sequence.



6. POINT> (VAB L1) – Select and input the point index of the next point to be added into the KU (e.g., "W11", "H05", "C51", etc).

or

6. MPD Cursor Controller/Enter – Select the next point to be added on TSD.

7. The Route Scroll buttons (VAB R1/R6) may be used as necessary to advance up (or down) within the route sequence.

8. Route Point (VAB R2-R5) – Select the button adjacent to the route "END" identifier to place the next point at the end of the route.

The route "END" identifier will move to the following position within the route sequence. Repeat steps 6 and 7 as necessary until all points are added to the route sequence as intended.

As each point is added, the route line will be re-drawn as appropriate.

NOTE: If it is desired to insert any points into an existing route, or to remove points from the route, see Editing a Route on the following pages.

Creating a Direct Route using the Route (RTE) sub-page

Any point within the navigational database may be used to create a direct route, to include Target/Threat points. When a direct route is created, a solid green line will be plotted from the ownship's present position to the point, and the route sequence will be displayed in partial intensity.

NOTE: If the point that is selected for creation of a direct route is within the current route sequence, upon arrival at the point the direct route will be removed, the route sequence will return to full intensity, and the route will sequence through the remainder of the subsequent route points.

To create a direct route to a point, perform the following:

1. TSD Fixed Action Button – Press.

2. RTE (VAB B5) – Select.

3. DIR (VAB L5) – Select.

4. POINT> (VAB L1) – Select and input the point index for creating a direct route into the KU (e.g., "W11", "H05", "C51", etc).

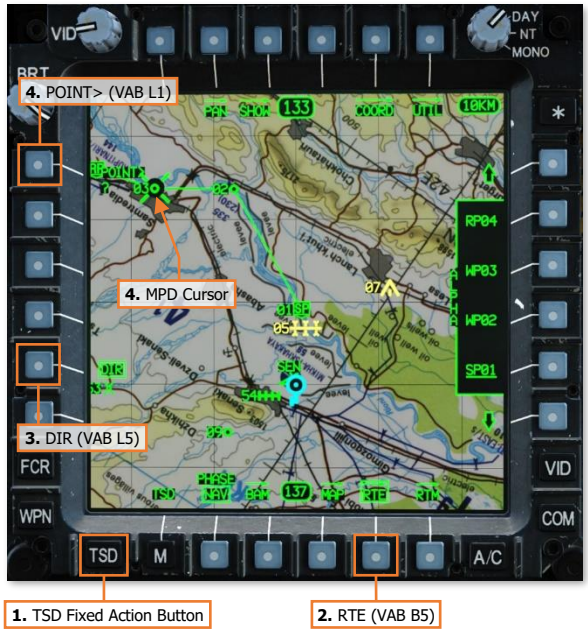
or

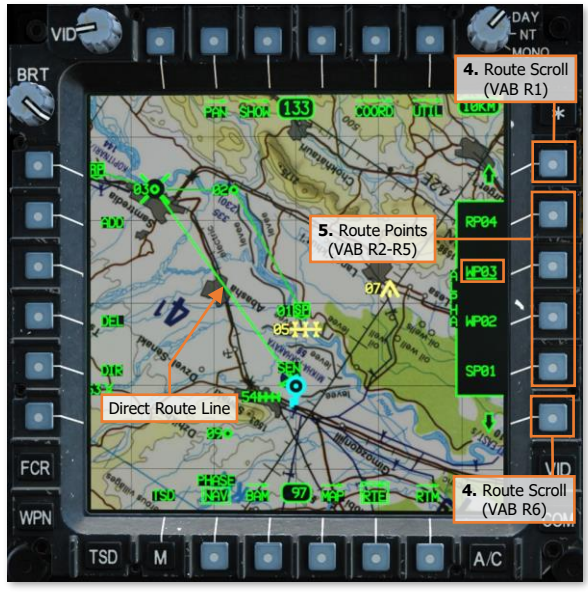
4. MPD Cursor Controller/Enter – Select the point desired for creating a direct route.

or, if the point is part of the current route

4. Route Scroll (VAB R1/R6) – Select, as necessary.

5. Route Points (VAB R2-R5) – Select the button that corresponds with the point desired for creating a direct route.

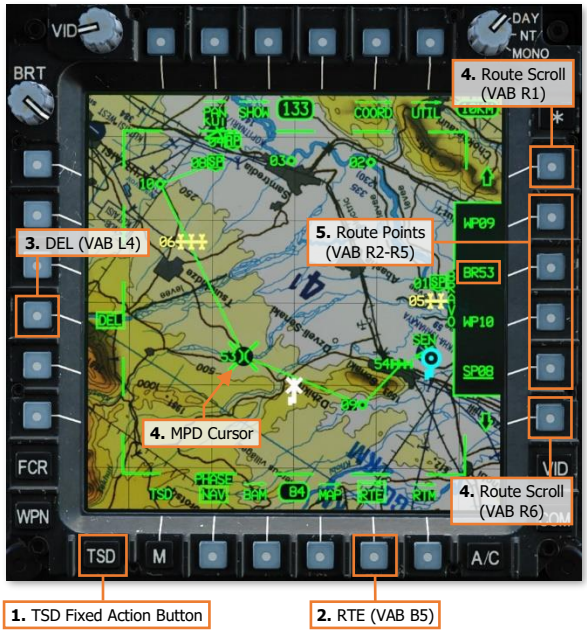




Editing a Route using the Route (RTE) sub-page

To remove a point from the current route, perform the following:

1. TSD Fixed Action Button – Press.
2. RTE (VAB B5) – Select.
3. DEL (VAB L4) – Select.
4. MPD Cursor Controller/Enter – Select the point to be removed on TSD.



or

4. Route Scroll (VAB R1/R6) – Select, as necessary.
5. Route Points (VAB R2-R5) – Select the button that corresponds with the point to be removed.

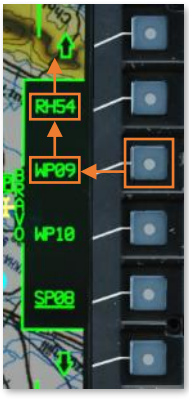
To insert a point into the current route, perform the following:

1. TSD Fixed Action Button – Press.
2. RTE (VAB B5) – Select.
3. ADD (VAB L2) – Select.
4. POINT> (VAB L1) – Select and input the point index of the point to be inserted into the KU (e.g., "W11", "H05", "C51", etc).

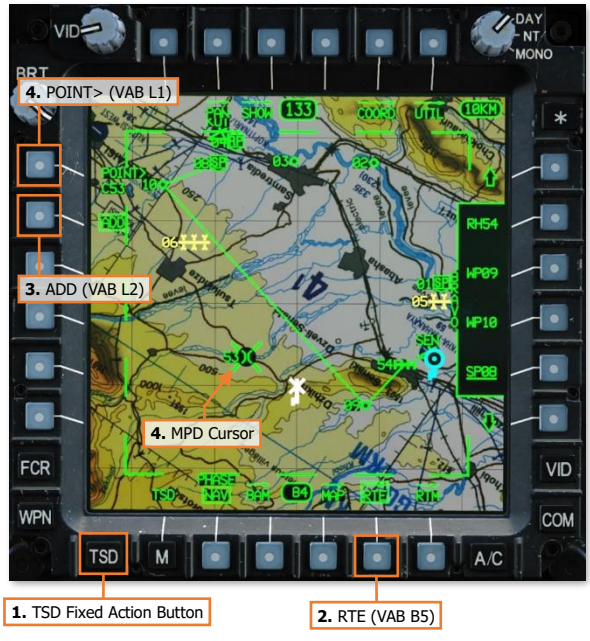
   or

4. MPD Cursor Controller/Enter – Select the point to be inserted on TSD.

5. Route Points (VAB R2-R5) – Select the button that corresponds with the desired location within the route to which the point will be inserted.



NOTE: When a point is inserted into a position within the route sequence that is not the END, the point that is located at that position within the route sequence will move to the subsequent position above it. All other points that follow will move to subsequent positions accordingly.

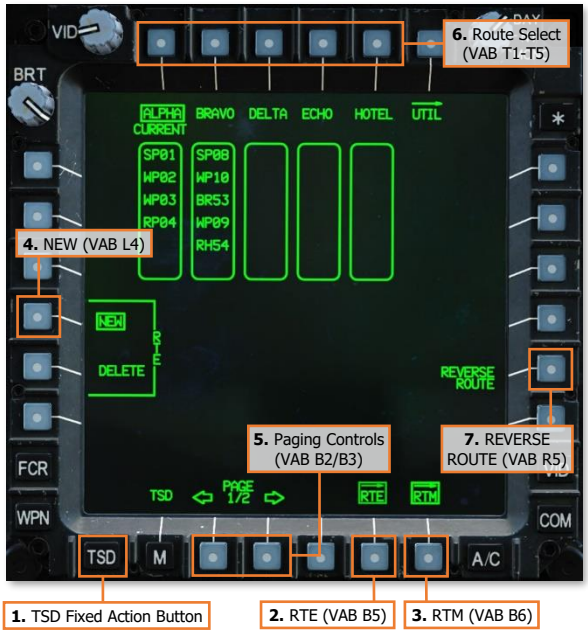


Selecting a Route using the Route Menu (RTM) sub-page

The route marked as CURRENT on the RTM sub-page is the route sequence currently being utilized for the purpose of navigation.

To select a new route for navigation, perform the following:

1. TSD Fixed Action Button – Press.
2. RTE (VAB B5) – Select.
3. RTM (VAB B6) – Select.
4. NEW (VAB L4) – Verify boxed.
5. Paging Controls (VAB B2/B3) – Select as necessary to view the available route sequences.
6. Route Select (VAB T1-T5) – Select the desired route sequence.
7. REVERSE ROUTE (VAB R5) – Select as necessary, depending on the direction the route is intended to be flown.



Deleting a Route using the Route Menu (RTM) sub-page

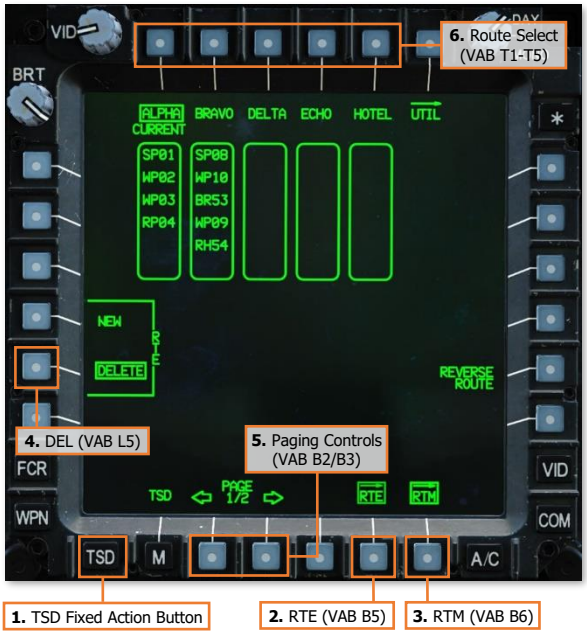
All point files within a route sequence may be deleted on the RTM sub-page, however the name of the route sequence itself will remain.

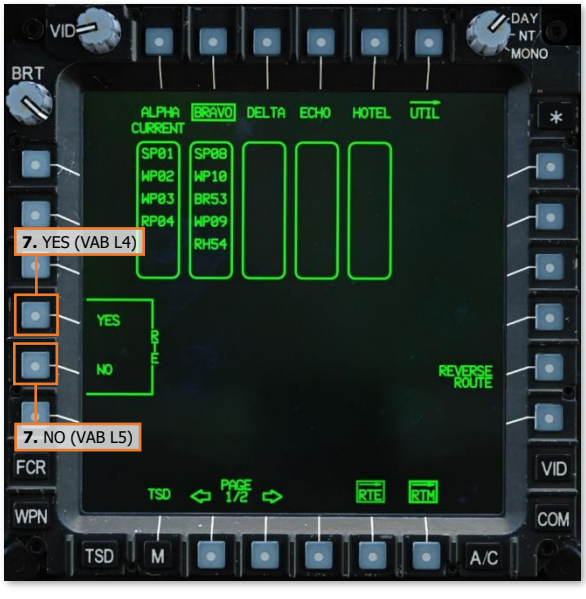
To select a route for deletion, perform the following:

1. TSD Fixed Action Button – Press.
2. RTE (VAB B5) – Select.
3. RTM (VAB B6) – Select.
4. DEL (VAB L5) – Select
5. Paging Controls (VAB B2/B3) – Select as necessary to view the available route sequences.
6. Route Select (VAB T1-T5) – Select the route sequence that is intended for deletion.
7. YES (VAB L4) – Select to confirm deletion.

   or

7. NO (VAB L5) – Select to abort deletion.





RADIO NAVIGATION IN LOW-VISIBILITY CONDITIONS

Although the AH-64D was not designed to perform flight within Instrument Meteorological Conditions (IMC), it can perform limited navigation under such conditions with on-board equipment. This equipment primarily includes the AN/ARN-149 Automatic Direction Finder (ADF) receiver, the Instruments (INST) sub-page of the TSD, along with the associated navigation symbology on the Flight (FLT) page and in the IHADSS Flight symbology.

The AN/ARN-149 ADF is a radio navigation receiver with a directional antenna for determining a coarse azimuth to an AM radio signal within the frequency range of 100.0 to 2199.5 kHz. Audio from AM radio signals received within this frequency range may also be monitored by the crew using the ADF audio channel of the ICS.

The ADF receiver is controlled through the TSD Instruments (INST) sub-page on the TSD. The INST sub-page format enables the crew to determine relative bearings from known Non-Directional Beacon (NDB) stations; and integrates the radio navigation equipment with the existing functionality of the TSD moving map, routes, points database, waypoint status, winds, and endurance data.

(See the TSD Instruments sub-page for more information.)

Setting the Color Band Shading to "A/C" on the TSD Map sub-page may aid in maintaining clearance above terrain and obstacles when operating in low-visibility conditions.

NOTE: The Common Missile Warning System (CMWS) utilizes the ADF audio channel of the ICS to provide missile threat warnings to the crew. To monitor the ADF receiver audio, the CMWS/NAV switch must be set to the NAV position on the CMWS Control Panel, which is located in the Pilot crewstation.

TSD Instruments (INST) Sub-page

The INST sub-page of the Tactical Situation Display is a sub-page optimized for radio navigation and includes controls for the AN/ARN-149 Automatic Direction Finder (ADF).

Any time the INST sub-page is displayed, the Horizontal Situation Indicator (HSI) will be displayed around the Ownship, regardless of whether the crewmember has enabled the HSI for display on the TSD SHOW sub-page.

NOTE: If the ARN-149 ADF receiver is not powered on the INST Utility sub-page, the following items will not be displayed on the INST sub-page.

- ADF Frequency (VAB L3)
- Last ADF Frequency (VAB L5)
- ADF Status Window
- ADF Bearing Pointer
- ADF Tone (VAB R4)
- ADF Identification (VAB R5)
- ADF Test (VAB R6)

All remaining functions of the Tactical Situation Display (TSD) page that are not described below are described in the Multi-Purpose Display (MPD) section of the AH-64D chapter.

1. **Stopwatch Controls.** Controls the stopwatch timer within the crewstation.
   - **START/STOP.** Starts or pauses the stopwatch timer. When the stopwatch timer is running, the START label will be replaced with the STOP label. When the stopwatch timer has been paused or reset, the STOP label will be replaced with the START label.
   - **RESET.** Stops and resets the stopwatch timer to 0:00:00.
2. **Stopwatch Timer.** Displays the elapsed time in H:MM:SS format, from 0:00:00 to a maximum of 9:59:59.

   NOTE: The stopwatch timer in each crewstation is independent of the other. Starting, stopping, or resetting the stopwatch timer in one crewstation will have no effect on the stopwatch timer in the other crewstation.
3. **UTIL sub-page.** Displays the INST Utility sub-page.

4. **ADF Status Window.** Displays the tuned ADF Preset ID, ADF frequency, and morse code equivalent of the Preset ID for identifying the NDB station via the ADF audio channel. If the ADF is manually tuned to a frequency in lieu of an ADF Preset, only the ADF frequency will be displayed.

   When the ADF is tuned to an emergency frequency (500 or 2182 kHz), the ADF status window will display EMER and the morse code equivalent of "S-O-S".

5. **ADF Bearing Pointer.** Indicates the bearing toward the AM radio signal as measured by the ADF receiver.

6. **Selected Heading Indicator.** Indicates the Selected Heading value input via the KU.

7. **Selected Heading.** Activates the KU for inputting a magnetic heading. After entry, the Selected Heading Indicator will be displayed at this heading around the HSI. Valid frequency headings are 001° to 360° in 1-degree increments.

8. **ADF Frequency.** Activates the KU for inputting a frequency. After entry, the ADF receiver will be tuned to this frequency. Valid frequency range is 100.0-2199.5 kHz in 0.1 kHz increments.

9. **Last ADF Frequency.** Tunes the ADF to the previous radio frequency. Subsequent presses of this button will toggle between the current and previous frequencies.

10. **ADF Tone.** Not implemented.

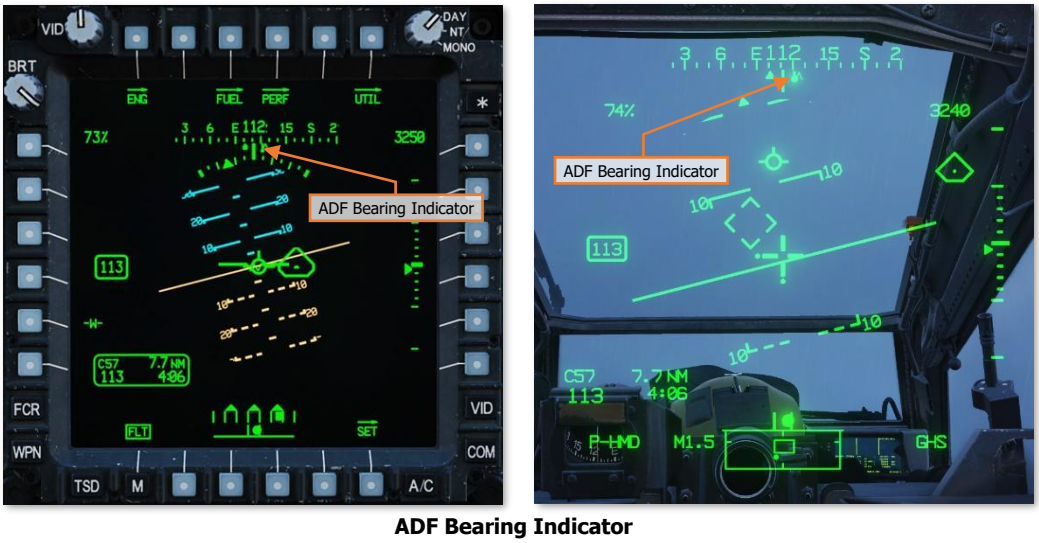
11. **ADF Identification.** Not implemented.

12. **ADF Test.** Performs a test of the ADF receiver. When pressed, the ADF Bearing Pointer will momentarily shift 90° clockwise before returning to the original bearing. A faulty system circuit could cause the ADF Bearing Pointer to shift to a value other than 90° clockwise.

    NOTE: The rate at which the ADF Bearing Indicator returns to the original bearing direction indicates the relative strength of the AM signal being received. The faster the return, the stronger the signal.

13. **Reverse Heading Indicator.** Indicates the reverse heading from the Selected Heading input via the KU.

Any time the ARN-149 ADF is set to ADF mode on the INST Utility sub-page and is receiving a signal over the corresponding frequency, the ADF Bearing Indicator (resembling an inverted "lollipop") will be displayed along the Heading Tape on the FLT page and in the IHADSS Flight symbology.

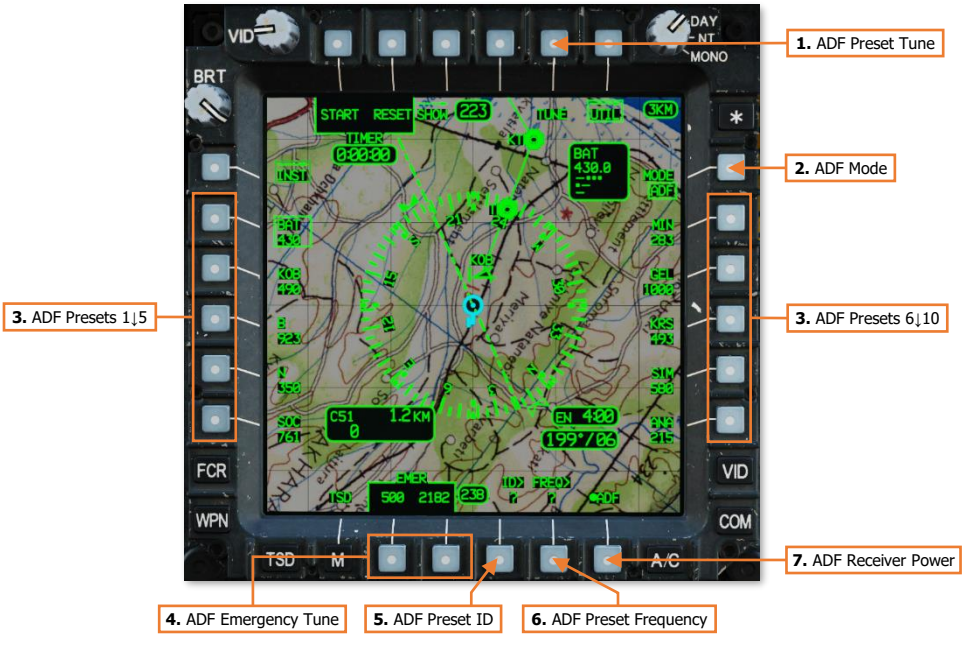


ADF Bearing Indicator

TSD Instruments, Utility (UTIL) Sub-page

The INST Utility sub-page includes controls for powering the AN/ARN-149 ADF receiver, tuning the ADF to a preset NDB station, or editing any of the ten preset NDB stations.

NOTE: If the ARN-149 ADF receiver is not powered at VAB B6, the remaining items on the INST Utility sub-page will not be displayed.



1. **ADF Preset Tune.** Tunes the ADF receiver to the selected ADF Preset.
2. **ADF Mode.** Toggles the ADF receiver between Automatic Direction Finder (ADF) and Antenna (ANT) modes.
   - **ADF.** Displays the ADF Bearing Pointer for indicating the measured bearing to the received AM radio signal and supplies received radio audio to the ADF audio channel.
   - **ANT.** Supplies received radio audio to the ADF audio channel but does not display the ADF Bearing Pointer.
3. **ADF Presets.** Selects the corresponding ADF Preset for tuning or editing.
4. **ADF Emergency Tune.** Tunes the ADF receiver to an international distress frequency.
   - **500.** Tunes the ADF receiver to 500.0 kHz.
   - **2182.** Tunes the ADF receiver to 2182.0 kHz.
5. **ADF Preset ID.** Activates the KU for inputting a new 3-character identifier for the selected ADF Preset.
6. **ADF Preset Frequency.** Activates the KU for inputting a new frequency for the selected ADF Preset. Valid frequency range is 100.0-2199.5 kHz in 0.1 kHz increments.
7. **ADF Receiver Power.** Enables/disables the AN/ARN-149 ADF receiver.

Tuning the ADF to an NDB Frequency

The ADF receiver may be tuned to a manual frequency on the INST sub-page or to a preset frequency on the INST UTIL sub-page. After powering the ADF receiver (VAB B6) on the INST UTIL sub-page, additional options are presented to the crew on both sub-pages which include ADF presets and emergency frequencies for tuning.

To tune the ADF to a manual or preset frequency, perform the following:

1. TSD Fixed Action Button – Press.
2. INST (VAB L1) – Select.
3. FREQ> (VAB L3) – Select and input the manual frequency using the KU.

   or

3. UTIL (VAB T6) – Select.
4. Preset (VAB L2-L6, R2-R6) – Select as desired.
5. TUNE (VAB T5) – Select.

Editing an ADF Preset

An existing ADF preset may be edited by entering a different 3-character identifier or radio frequency via the Keyboard Unit (KU). The ADF status window will automatically display the morse code that should be expected to be heard over the NDB station based on the 3-character identifier of the tuned preset.

To edit an ADF preset using the KU, perform the following:

1. TSD Fixed Action Button – Press.
2. INST (VAB L1) – Select.
3. UTIL (VAB T6) – Select.
4. Preset (VAB L2-L6, R2-R6) – Select as desired.
5. ID> (VAB B4) – Select and input the desired 3-character identifier.
6. FREQ> (VAB B5) – Select and input the desired frequency.

RADIO COMMUNICATIONS

US Army photo
by SPC Glenn Anderson

RADIO COMMUNICATIONS

The AH-64D's communications systems are fully integrated into the avionics, allowing either crewmember to interact with and use any radio onboard the aircraft through the EUFD and MPD controls.

Radio Communications Equipment

The ARC-186(V) VHF radio provides two-way line-of-sight communications over VHF-AM frequencies and is normally used for communicating with Air Traffic Control (ATC). The radio is not capable of secure communications. Its antenna is located on the top of the cambered fin.

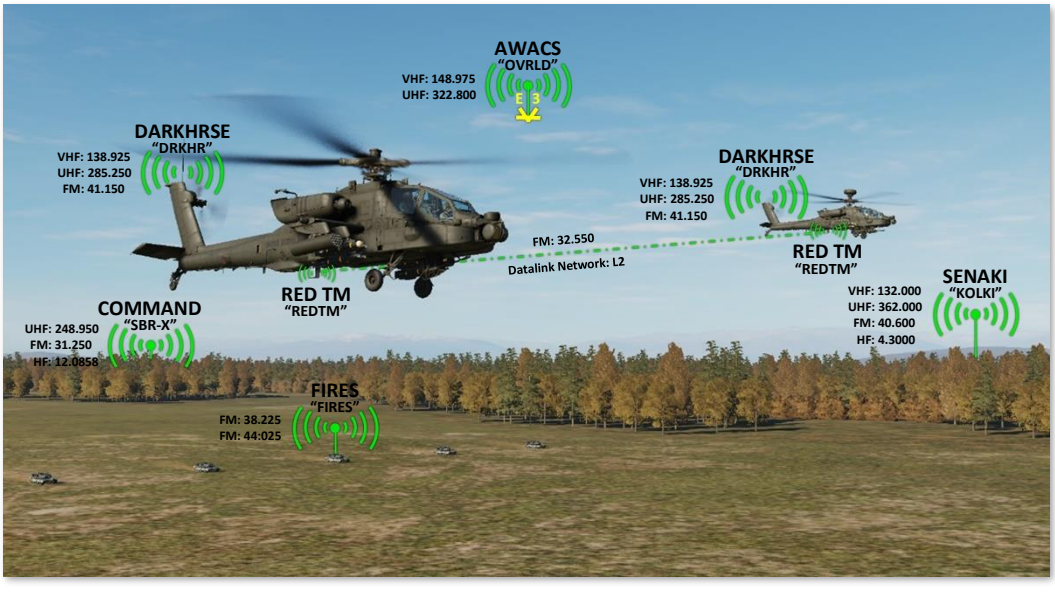
The ARC-164(V) UHF radio provides two-way line-of-sight communications over UHF-AM frequencies and is normally used for communicating with ATC, other aircraft, or ground forces. The radio contains an additional receiver tuned to the GUARD frequency of 243.0 MHz, the ability to communicate on HAVE QUICK frequency-hopping nets, and can be connected to a KY-58 module for secure communications. Its antenna is located on the underside of the tail boom, aft of the navigational sponson containing the Doppler velocity and radar altimeter antennas.

Two ARC-201D SINCGARS (Single Channel Ground and Airborne Radio System) radio sets provide two-way line-of-sight communications over VHF-FM frequencies and are normally used for communicating with ground forces and other AH-64 team members. Both radios have embedded secure communications capability and can communicate on frequency-hopping nets. The FM1 radio shares the tail-mounted whip antenna with the VHF radio, and the FM2 antenna is located on the underside of the tail boom, forward of the navigational sponson. The FM1 radio is paired with an Improved FM (IFM) amplifier which can vary the output power of the radio.

The ARC-220 HF radio provides two-way, non-line-of-sight (NLOS) and over-the-horizon (OTH) communications over shortwave frequencies. The radio has an embedded modem for sending and receiving data transmissions, can operate using frequency-hopping nets, and can be connected to a KY-100 module for secure communications capability. The ARC-220 is also capable of communications using Automatic Link Establishment (ALE) multi-channel nets to decrease crew workload and increase communications reliability. The HF radio utilizes a near-vertical incidence skywave (NVIS) type antenna which runs along the right side of the tail boom and is paired with a dedicated amplifier which can vary the output power of the radio.

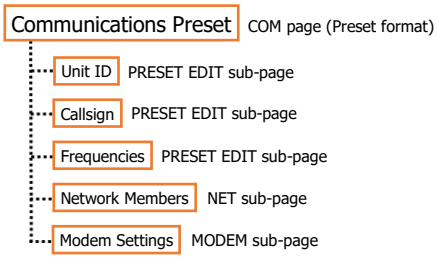
Communications Architecture

The operation of the AH-64D's communications system is designed for use in combat, in which the expected nature of the mission involves the employment of teams, platoons, or entire companies of AH-64Ds against conventional ground forces. The architecture of the communications system integrates voice and data networks into a single interface and is optimized for pre-planned operations; but remains sufficiently flexible to respond to a rapidly evolving battlefield or last-minute changes in the mission.



The architecture of the AH-64D communications interface primarily revolves around the use of "presets". Up to 10 presets may be accessed on the COM page at any given time. Unlike singular preset frequencies that may be selected from a physical radio control panel, each preset within the AH-64D includes:

- Details regarding the unit, echelon, or organization the preset pertains to.
- A list of frequencies that may be utilized for voice and data transmission, to include the primary frequency and radio that are intended to be used during the mission.



Communications Preset Architecture

- A list of flight members that may send/receive data through the datalink network associated with that preset.
- Modem settings used when sending/receiving data over the datalink network associated with that preset.

When one of the ten presets are selected on the main COM page, the COM page is displayed in Preset format, which presents information pertinent to that preset, such as the unit ID, callsign, and frequencies, and allows that preset to be tuned (which will also configure the datalink according to the network and modem settings).

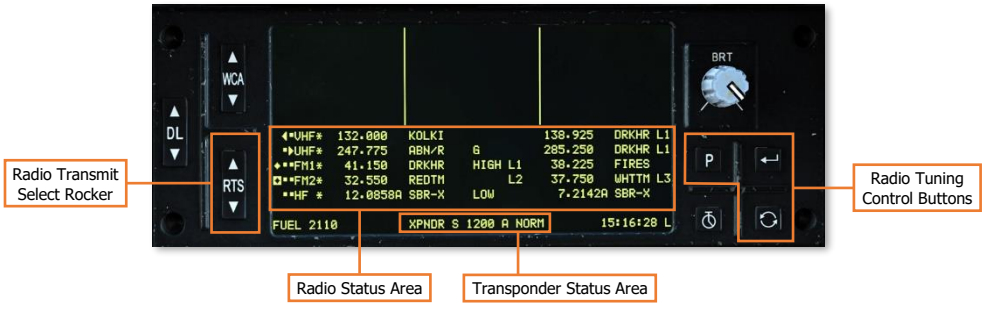
If desired, the crewmember may edit details or frequencies of the preset itself by accessing the PRESET EDIT sub-page. Additionally, the network members of the preset may be edited on the NET sub-page, and the modem settings on the MODEM sub-page. (See the Datalink chapter for more information regarding datalink network and modem settings.)

Communications Controls

The aircrew interacts with and controls the communications equipment using a combination of the Multi-Purpose Displays (MPD), the Enhanced Upfront Display (EUFD), and the Communications Panel located within each cockpit. (See the COM page for more information regarding MPD controls.)

EUFD Controls

The Enhanced Up-Front Display (EUFD) provides the aircrew with a consolidated location for viewing the current configuration and datalink settings of each radio, and the transponder.



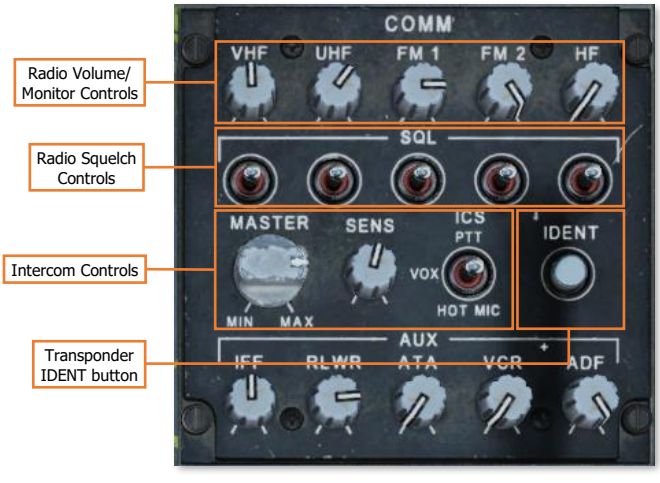
If generator power is lost, crewmembers may still use any radio using the EUFD while operating on battery power, to include tuning preset frequencies.

(See Enhanced Up-Front Display (EUFD) for more information.)

Communications Panel Controls

The Communications panel controls the volume of the intercom and radios. The panel can also be used to toggle the squelch of an individual radio or change the ICS mode of operation.

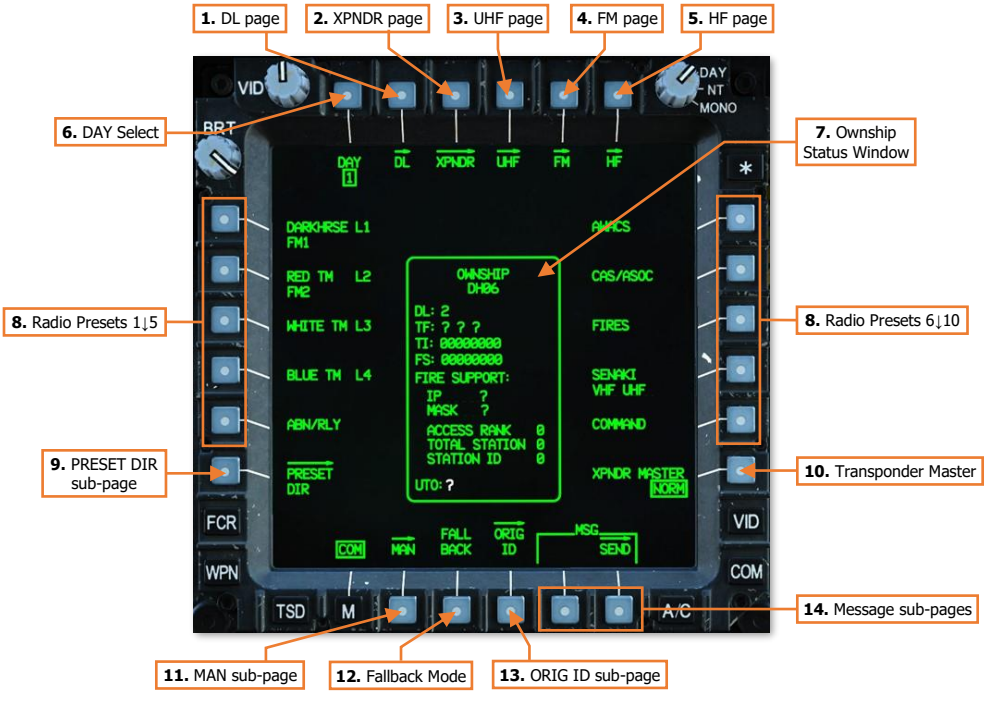
(See Communications Panel for more information.)



Communications (COM) Page

The Communications page presents an overview of the aircraft's communications system. The COM page displays 10 presets that may be assigned to a radio for voice/data communications, the aircraft's current datalink configuration, and the transponder state. The COM page also includes access to additional MPD pages for configuring specific radio equipment, manually tuning a radio frequency for voice-only communications, and sending/receiving text messages and mission files over the datalink.

See the Datalink chapter for more information regarding the Datalink (DL) page, Originator ID (ORIG ID) sub-page, and Message (MSG) sub-pages.



1. **DL page.** Displays the Datalink (DL) page. (N/I)
2. **XPNDR page.** Displays the Transponder (XPNDR) page. (N/I)
3. **UHF page.** Displays the UHF radio page. (N/I)
4. **FM page.** Displays the FM radio page. (N/I)
5. **HF page.** Displays the HF radio page. (N/I)
6. **DAY Select.** Not implemented.
7. **Ownship Status Window.** Displays the aircraft's current network configuration for datalink operations.
8. **Radio Presets.** Displays the Preset format with additional options for editing or tuning the selected preset. Each preset entry is labeled using the preset's Unit ID and the selected modem protocol, if any.

   If any radios have been tuned to the preset, the corresponding radio(s) will be identified in the second line of text directly below the preset entry. If more than three radios have been tuned to the same preset, the VHF, UHF, FM1, FM2, and HF radios will be truncated as V, U, 1, 2, and H, respectively.

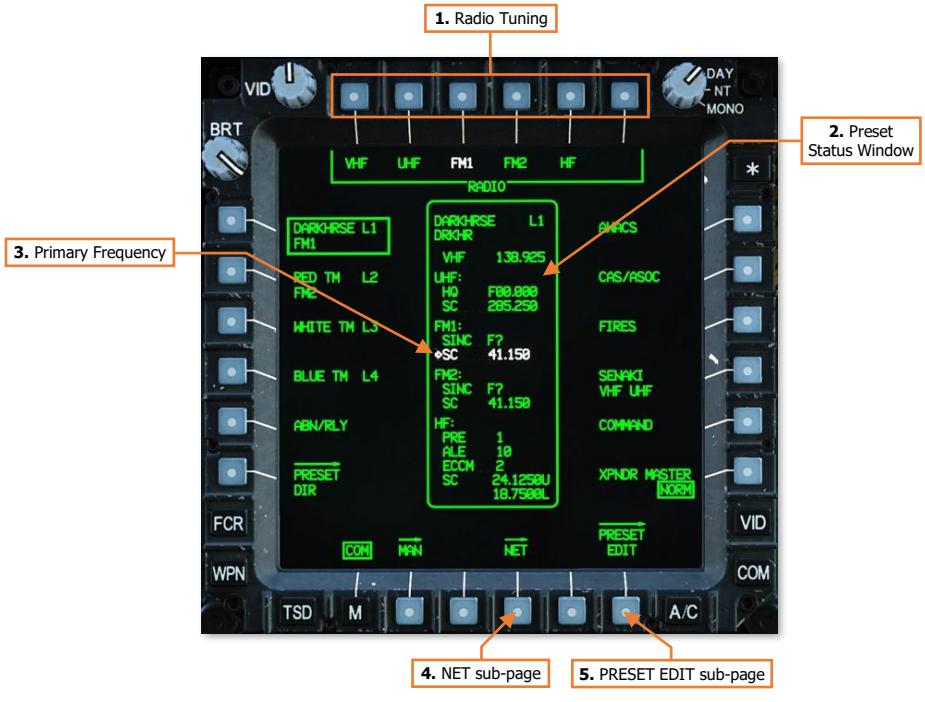
9. **PRESET DIR sub-page.** Not implemented.
10. **Transponder Master.** Sets the transponder to Normal (NORM) operation or Standby (STBY).
11. **Fallback Mode.** Not implemented.
12. **MAN sub-page.** Displays the Manual (MAN) sub-page.
13. **ORIG ID sub-page.** Displays the Originator ID (ORIG ID) sub-page.
14. **Message sub-pages.** Displays the corresponding sub-pages for sending or receiving messages via the datalink.

Tuning a Radio to a Preset

When a preset is selected, the COM page displays information about the preset, options along the top of the page for tuning the preset to a radio net, and options along the bottom of the page for editing the preset itself.

COM Preset Format

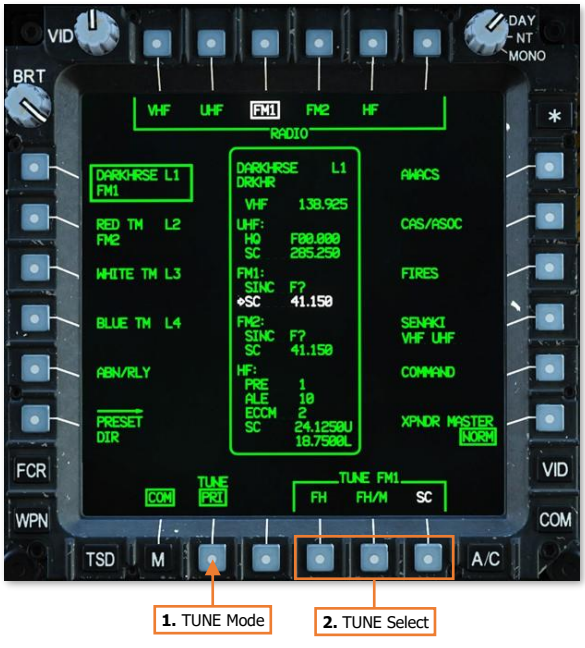
Selecting a preset displays the COM page in Preset format with a box around the preset selection. Selecting the same preset a second time de-selects the preset and returns the COM page to its original format.



1. **RADIO Tuning.** Displays preset tuning options for any of the aircraft's radios.
   - **RADIO – VHF.** Displays VHF tuning options.
   - **RADIO – UHF.** Displays UHF tuning options.
   - **RADIO – FM1.** Displays FM1 tuning options.
   - **RADIO – FM2.** Displays FM2 tuning options.
   - **RADIO – HF.** Displays HF tuning options.
2. **Preset Status Window.** Displays the preset's unit ID, callsign, frequency list, primary frequency, and modem protocol, if any.
3. **Primary Frequency.** The preset's primary frequency and corresponding radio is highlighted in white.
4. **NET sub-page.** Displays the Network (NET) sub-page. (See the Datalink chapter for more information.)
5. **PRESET EDIT sub-page.** Displays the Preset Edit (PRESET EDIT) sub-page.

COM Preset Format – Tuning Options

Selecting a radio when the COM page is in Preset format will display additional options for how the preset is assigned to the corresponding radio. Selecting the same radio a second time de-selects the radio, removes the additional options, and restores the MAN, NET, and PRESET EDIT sub-page options.



1. **TUNE Mode.** Selects the radio tuning mode that will be used when a preset is assigned to the selected radio.
   - **PRI.** The selected preset will be assigned to the primary slot of the selected radio.

     When a preset is assigned to a radio in the primary slot, the corresponding radio will be tuned to the preset. The preset or manual frequency that is already in the primary slot will be transferred to the standby slot, and the preset or manual frequency that is already in the standby slot will be removed.
   - **STBY.** The selected preset will be assigned to the standby slot of the selected radio.

     When a preset is assigned to a radio in the standby slot, the preset or manual frequency that is already in the standby slot will be replaced by the selected preset.
2. **TUNE Select.** Displays tuning options for the selected preset and selected radio.
   - **TUNE – FH.** Not implemented.
   - **TUNE – FH/M.** Not implemented.
   - **TUNE – SC.** Assigns the single-channel (i.e., single frequency) radio net displayed within the Preset Status window to the selected radio, in accordance with the selected Tune mode.

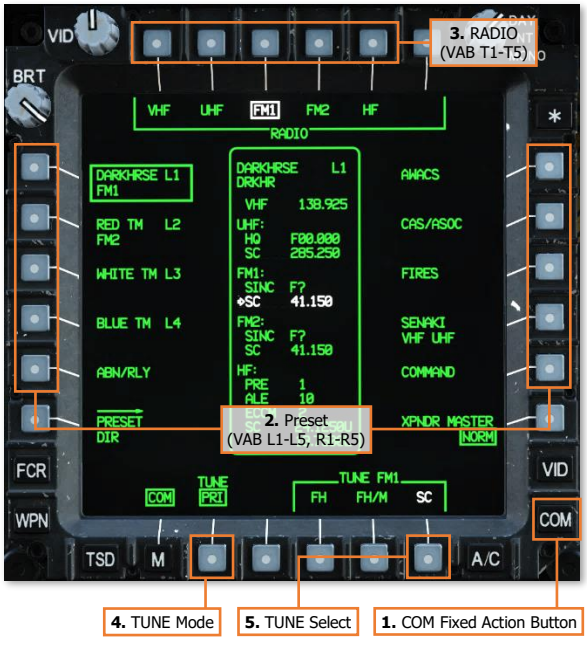
Tuning a Radio to a Preset using an MPD

When a preset is selected from the COM page, tuning options will be sequentially presented for the crewmember to choose which radio to assign the preset, whether the preset is assigned to the primary or standby slots on the EUFD, and which type of radio net is assigned to the radio.

To assign a preset frequency/network to a radio using an MPD, perform the following:

1. COM Fixed Action Button – Press.
2. Preset (VAB L1-L5, R1-R5) – Select as desired.
3. RADIO (VAB T1-T5) – Select as desired.
4. TUNE Mode (VAB B2) – Set as PRI or STBY as desired.
5. TUNE Select (VAB B6) – Select SC.

After the radio is tuned as selected, the TUNE Select options will collapse and a different radio may be selected (VAB T1-T5) to tune from the same preset.



Tuning a Radio to a Preset using the EUFD

Pressing the EUFD Preset button displays the Preset list for the selected radio along the right side of the EUFD. While this menu is displayed, the WCA rocker is used to scroll up and down within the preset list. Once a preset has been selected with the arrow, pressing the Enter button will assign the selected preset to the primary slot of the corresponding radio, which will then be tuned to the preset frequency.

To assign a preset frequency/network to a radio using the EUFD, perform the following:

1. EUFD Preset button – Press to display the preset list
2. RTS rocker switch – Select radio to tune.
3. WCA rocker switch – Select preset frequency from preset list.
4. EUFD Enter button – Press.

The EUFD Preset function can be useful to tune a radio without changing an MPD to the COM page. The Preset function on EUFD is limited to tuning single-channel frequencies only and cannot be used to tune frequency-hopping nets.

Editing a Preset

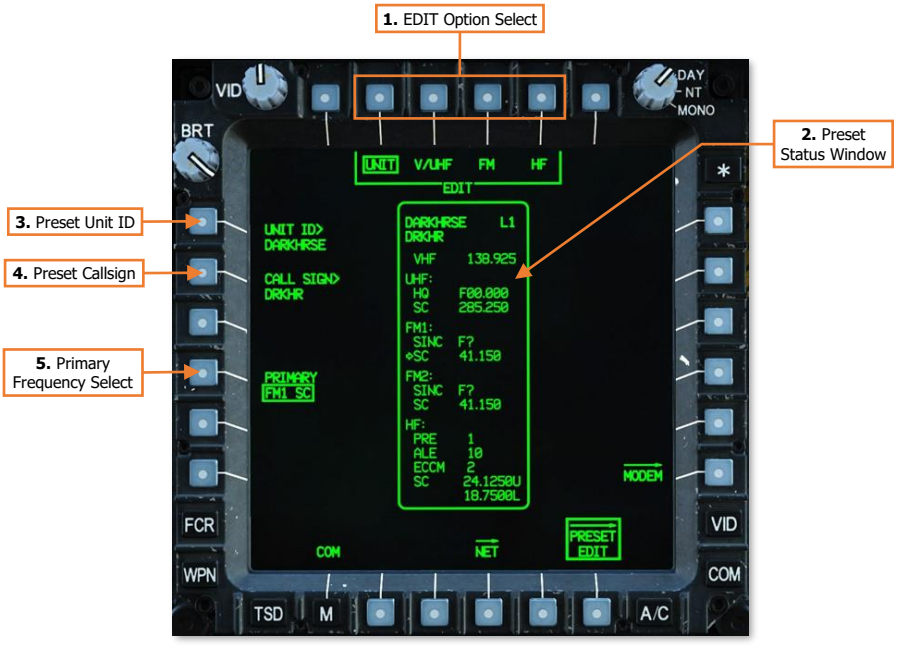
Any preset may be edited from within the cockpit by either crewmember. The preset may be modified in how it is presented on the MPDs and EUFD, which frequencies are tuned when the preset is assigned to a radio, or the composition of the network and modem settings when the preset is utilized for datalink functions.

COM Preset Edit (PRESET EDIT) Sub-Page

The PRESET EDIT sub-page allows the aircrew to modify any data associated with the selected preset. The datalink network and modem settings associated with the preset may be modified from the NET and MODEM sub-pages respectively. (See the Datalink chapter for more information.)

UNIT Edit Options

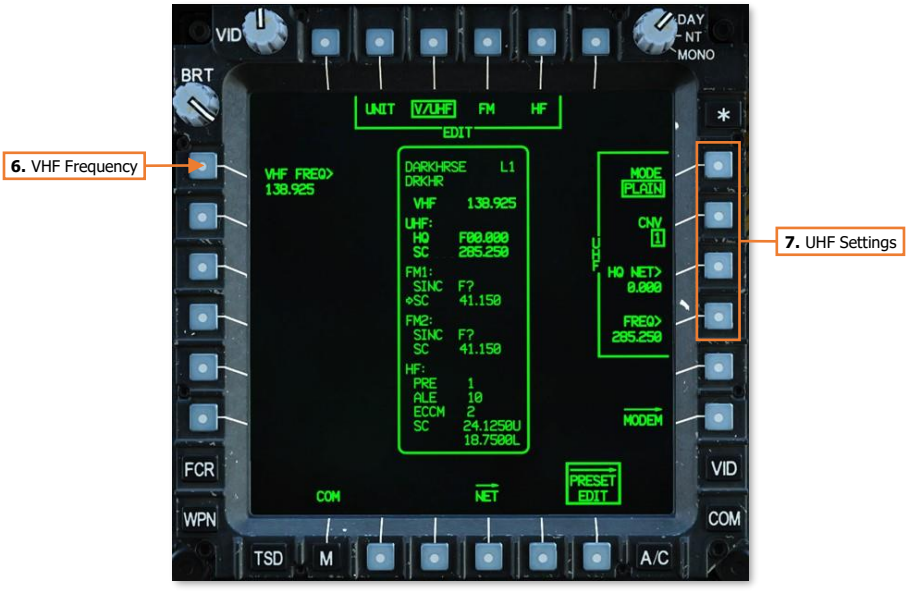
The UNIT options allow the crewmember to edit how the preset itself is presented on the MPDs and EUFD.



1. **EDIT Option Select.** Displays options for editing other data fields within the displayed preset.
2. **Preset Status Window.** Displays the preset's unit ID, callsign, frequency list, primary frequency, and modem protocol, if any. Data fields that may be changed using the current Edit options are shown in full-intensity. Data fields that may be changed from another Edit option are shown in partial-intensity.
3. **Preset Unit ID.** Activates the KU for inputting a Unit ID for the preset. The Unit ID determines how the preset is displayed on the COM page and EUFD Preset list. Up to 8 alphanumeric characters may be entered.
4. **Preset Callsign.** Activates the KU for inputting a Callsign for the preset. The Callsign determines how the preset is displayed on the EUFD when assigned to a radio. Up to 5 alphanumeric characters may be entered.
5. **Primary Frequency Select.** Displays options for designating a primary frequency and radio for the preset. When assigned as Primary, the corresponding entries on the COM Preset format are displayed in white to highlight the intended radio and net with which the preset is intended to be utilized. The primary designation does not affect the function of any radio equipment or how the preset is assigned to a specific radio.

V/UHF Edit Options

The V/UHF edit options allow the crewmember to edit the VHF and UHF radio configurations when the preset is assigned to the ARC-186(V) or ARC-164(V) radios, respectively.



6. **VHF Frequency.** Activates the KU for inputting a VHF-AM frequency for the preset. Valid frequency entries are between 108.000 and 151.975 MHz in 0.025 MHz increments. Frequencies between 108.000 and 115.975 MHz are limited to receive-only

7. **UHF Settings.** Displays settings for configuring UHF radio nets for the preset.
   - **MODE.** Toggles the UHF radio between unsecure (PLAIN) and secure (CIPHER) communications. (N/I)
   - **CNV.** Displays options for secure radio communications. (N/I)
   - **HQ NET>.** Activates the KU for inputting a Have Quick net for the preset. (N/I)
   - **FREQ>.** Activates the KU for inputting a single-channel UHF-AM frequency for the preset. Valid frequency entries are between 225.000 and 399.975 MHz in 0.025 MHz increments.

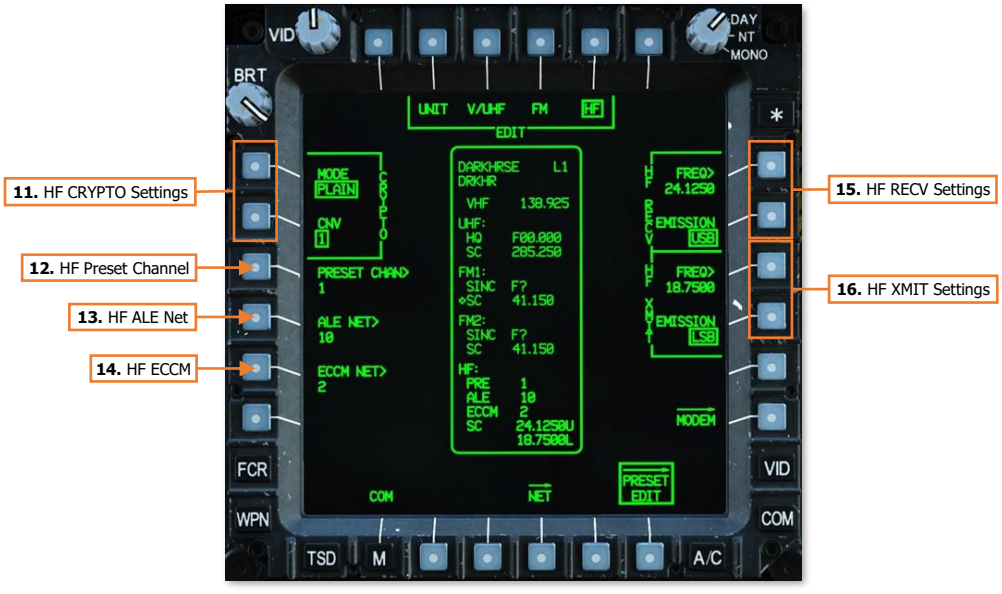
FM Edit Options

The FM edit options allow the crewmember to edit the FM1 or FM2 radio configurations when the preset is assigned to either of the ARC-201D radios.

8. **FM1 Settings.** Displays settings for configuring FM1 radio nets for the preset.
   - **MODE.** Toggles the FM1 radio between unsecure (PLAIN) and secure (CIPHER) communications. (N/I)
   - **CNV.** Displays options for secure radio communications. (N/I)
   - **HOPSET.** Displays options for frequency-hopping radio communications. (N/I)
   - **FREQ>.** Activates the KU for inputting a single-channel VHF-FM frequency for the preset. Valid frequency entries are between 30.000 and 87.975 MHz in 0.025 MHz increments.
9. **FM2 Settings.** Displays settings for configuring FM2 radio nets for the preset.
   - **MODE.** Toggles the FM2 radio between unsecure (PLAIN) and secure (CIPHER) communications. (N/I)
   - **CNV.** Displays options for secure radio communications. (N/I)
   - **HOPSET.** Displays options for frequency-hopping radio communications. (N/I)
   - **FREQ>.** Activates the KU for inputting a single-channel VHF-FM frequency for the preset. Valid frequency entries are between 30.000 and 87.975 MHz in 0.025 MHz increments.
10. **FM Data Swap.** Swaps the FM radio options between the FM1 and FM2 configurations.

HF Edit Options

The HF edit options allow the crewmember to edit the HF radio configuration when the preset is assigned to the ARC-220 radio.



11. **HF CRYPTO Settings.** Displays settings for configuring the HF radio for secure radio communications.
    - **MODE.** Toggles the HF radio between unsecure (PLAIN) and secure (CIPHER) communications. (N/I)
    - **CNV.** Displays options for secure radio communications. (N/I)
12. **HF Preset Channel.** Activates the KU for inputting a preset HF channel for the preset. (N/I)
13. **HF ALE Net.** Activates the KU for inputting an HF ALE net for the preset. (N/I)
14. **HF ECCM Net.** Activates the KU for inputting an ECCM net for the preset. (N/I)
15. **HF RECV Settings.** Displays settings for configuring single-channel HF radio reception for the preset.
    - **HF Receive Frequency.** Activates the KU for inputting a single-channel HF frequency for the preset. Valid frequency entries are between 2.0000 and 29.9999 MHz, in 0.0001 MHz increments.
    - **HF Receive Emission Mode.** Not implemented.
16. **HF XMIT Settings.** Displays settings for configuring single-channel HF radio transmissions for the preset.
    - **HF Transmit Frequency.** Activates the KU for inputting a single-channel HF frequency for the preset. Valid frequency entries are between 2.0000 and 29.9999 MHz, in 0.0001 MHz increments.
    - **HF Transmit Emission Mode.** Not implemented.

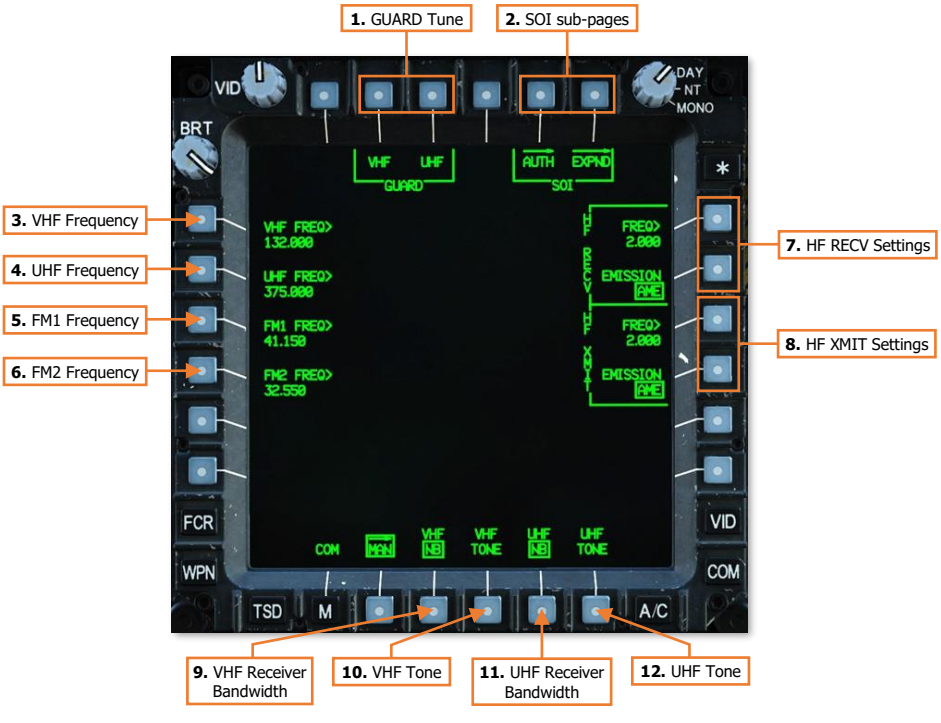
Manually Tuning a Radio

If necessary, the radios may be manually tuned to a frequency that is not included within a programmed preset. However, manually tuning a radio will also remove any datalink capability through that radio. When a radio is manually tuned, the Callsign list on the EUFD will display "MAN" to the right of the corresponding frequency.

When a manual frequency is entered, it is always assigned in the primary slot of the corresponding radio, which will be immediately tuned to the frequency. The preset that is already in the primary slot will be transferred to the standby slot. This allows any unplanned radio communications over the manual frequency to occur immediately, which may be time critical due to a change in mission or rapid changes on the battlefield; but also allows the aircrew to just as easily return to the previous preset (and datalink network) prior to the radio being manually tuned.

COM Manual (MAN) Sub-Page

The MAN sub-page allows either crewmember to tune a radio frequency that is not included within a programmed preset or to rapidly tune the VHF or UHF radios to international GUARD frequencies.



1. **GUARD Tune**. Immediately tunes the VHF or UHF radios to a GUARD frequency.
   - **VHF.** Sets the current VHF frequency to the standby frequency slot and tunes the primary VHF frequency to 121.500 MHz.
   - **UHF.** Sets the current UHF frequency to the standby frequency slot and tunes the primary UHF frequency to 243.000 MHz.
2. **SOI sub-pages.** Not implemented.

3. **VHF Frequency.** Activates the KU for inputting a VHF-AM frequency. If the entry is valid, the current VHF frequency will be set to the standby frequency slot and the frequency entered on the KU will be tuned to the primary VHF frequency slot.

   Valid frequency entries are between 108.000 and 151.975 MHz in 0.025 MHz increments. Frequencies between 108.000 and 115.975 MHz are limited to receive-only.

4. **UHF Frequency.** Activates the KU for inputting a UHF-AM frequency. If the entry is valid, the current UHF frequency will be set to the standby frequency slot and the frequency entered on the KU will be tuned to the primary UHF frequency slot.

   Valid frequency entries are between 225.000 and 399.975 MHz in 0.025 MHz increments.

5. **FM1 Frequency.** Activates the KU for inputting a VHF-FM frequency. If the entry is valid, the current FM1 frequency will be set to the standby frequency slot and the frequency entered on the KU will be tuned to the primary FM1 frequency slot.

   Valid frequency entries are between 30.000 and 87.975 MHz in 0.025 MHz increments.

6. **FM2 Frequency.** Activates the KU for inputting a VHF-FM frequency. If the entry is valid, the current FM2 frequency will be set to the standby frequency slot and the frequency entered on the KU will be tuned to the primary FM2 frequency slot.

   Valid frequency entries are between 30.000 and 87.975 MHz in 0.025 MHz increments.

7. **HF RECV Settings.** Manually sets the HF receive frequency and emission mode.

   - **HF Receive Frequency.** Activates the KU for inputting an HF frequency. If the entry is valid, the current HF frequency will be set to the standby frequency slot and the frequency entered on the KU will be tuned to the primary HF frequency slot.

     Valid frequency entries are between 2.0000 and 29.9999 MHz, in 0.0001 MHz increments.

   - **HF Receive Emission Mode.** Not implemented.

8. **HF XMIT Settings.** Manually sets the HF transmit frequency and emission mode.

   - **HF Transmit Frequency.** Activates the KU for inputting an HF transmission frequency. If the entry is valid, the current HF transmit frequency will be set to the standby frequency slot and the frequency entered on the KU will be tuned to the primary HF frequency slot.

     Valid frequency entries are between 2.0000 and 29.9999 MHz, in 0.0001 MHz increments.

   - **HF Transmit Emission Mode.** Not implemented.

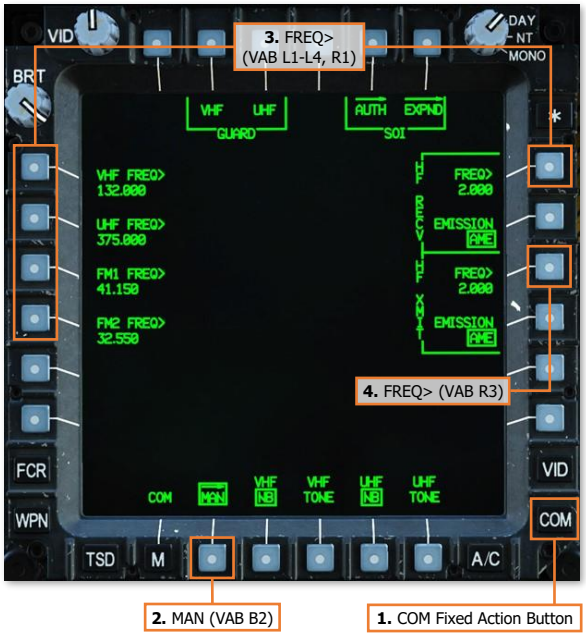
9. **VHF Receiver Bandwidth.** Not implemented.

10. **VHF Tone.** When pressed, the VHF audio channel will emit a solid tone for maintenance testing.

11. **UHF Receiver Bandwidth.** Not implemented.

12. **UHF Tone.** When pressed, the UHF audio channel will emit a solid tone for maintenance testing.

Manually Tuning a Radio Frequency



To manually tune a VHF frequency, perform the following:

1. COM Fixed Action Button – Press.
2. MAN (VAB B2) – Select.
3. VHF> (VAB L1) – Select and input the frequency.

To manually tune a UHF frequency, perform the following:

1. COM Fixed Action Button – Press.
2. MAN (VAB B2) – Select.
3. UHF> (VAB L2) – Select and input the frequency.

To manually tune an FM frequency, perform the following:

1. COM Fixed Action Button – Press.
2. MAN (VAB B2) – Select.
3. FM1> (VAB L3) – Select and input the frequency.

   or

3. FM2> (VAB L4) – Select and input the frequency.

To manually tune an HF frequency, perform the following:

1. COM Fixed Action Button – Press.
2. MAN (VAB B2) – Select.
3. HF RECV – FREQ> (VAB R1) – Select and input the receive frequency.
4. HF XMIT – FREQ> (VAB R3) – Select and input the transmit frequency.

RADIO HAND & FOOT CONTROLS

Either crewmember may transmit over any radio, using either the PTT/RTS switch on the cyclic grip or the left floor-mounted foot switch.

Cyclic & Collective Controls

The Pilot and Copilot/Gunner Cyclic Grips include identical controls for radio selection and transmission.

Pressing the switch to the left transmits over the crewmember's selected radio. Pressing the switch to the right transmits over the ICS between the two crewstations (and ground crews). Depressing the PTT/RTS switch inward advances the EUFD Radio Transmit Select Indicator for the crewstation to the next radio in sequence.

Foot Controls

The Pilot and Copilot/Gunner crewstations include floor-mounted foot switches for radio and ICS transmission.

Pressing the left floor switch transmits over the crewmember's selected radio. Pressing the right floor switch transmits over the ICS between the two crewstations (and ground crews).

TACTICAL EMPLOYMENT

US Army photo
by CPT Peter Smedberg

ATTACK HELICOPTERS IN COMBAT

The most basic description of an attack helicopter is a rotary-winged aircraft that is specifically equipped with weapons and munitions to destroy targets on the battlefield. For attack helicopters that are designed to engage medium and heavy armor units, a common euphemism to describe such helicopters is a "flying tank". While this may convey the relative lethality these attack helicopters possess when compared to a main battle tank, it often lends itself to a misconception that attack helicopters are bulletproof or can withstand enormous amounts of punishment while continuing to engage enemy forces.

Although most attack helicopters are armored or reinforced against various calibers of weapons fire, such protection is only in the most critical areas of the airframe. Extra armor equates to additional weight, which hinders performance of the aircraft itself, as well as reducing the amount of fuel or weapons the helicopter can carry to the fight. Because of this limitation, armored protection is prioritized for the most critical components (to include the aircrew), with system redundancy and crashworthiness making up the remainder of the aircraft resistance to hostile fire.

Such redundancy and crashworthiness are implemented to ensure crew survival and recovery of the airframe to friendly locations for repairs. While "fighting to the death" as shown in the movies may seem worthwhile to achieve immediate mission results, in reality it hinders the long-term strategic objectives of a military conflict. An attack helicopter, by its nature as an airborne weapons system, can achieve something that similarly armed ground vehicles cannot: mobility and speed across any terrain or obstacle. This speed and the ability to traverse any terrain by simply flying above it means an attack helicopter can more easily attack targets behind enemy lines, engage targets that are beyond the reach of friendly artillery, perform reconnaissance and screening operations in areas that ground vehicles cannot, and more rapidly respond to changes on the battlefield in real-time.

YAH-64A (US Army)

Attack helicopters can be employed independently of ground forces to shape the battlefield ahead of friendly ground offensives. Alternatively, they may be employed in conjunction with ground forces to mass fires against the enemy at decisive points in a battle; or used as close-in security to protect friendly ground forces from hostile attack. Depending on which country or branch of service an attack helicopter originates, such units are employed as either Close Air Support (CAS) aircraft or as "maneuver units" (much in the same manner infantry or armor units are employed in conventional maneuver warfare).

AH-64D flying over Fort Irwin, CA (US Army photo by SGT Charles Probst)

In the CAS role, one key difference between attack helicopters and most fixed-wing attack aircraft is the economy of firepower. Fixed-wing attack aircraft may be able to physically carry a much greater payload of munitions as far as pure tonnage is concerned, but purpose-built attack helicopters are often equipped with a greater number of smaller munitions that are accurate and highly effective against various types of ground vehicles.

Pre-production AH-64A (US Army)

In addition, most attack helicopters are also equipped with machine guns or medium-caliber automatic cannons coupled with highly accurate fire control systems that can engage or suppress ground forces at close ranges, as well as unguided rocket systems for large area suppression. Most modern attack helicopters are quite capable of employing all of these weapon systems against multiple targets within a short time span, without the time needed by fixed-wing attack aircraft to reorient between attack runs against successive targets. This persistence of fire allows attack helicopters to maintain pressure on enemy forces in a manner that cannot be matched by fixed-wing aircraft.

Mobility, Standoff, and Planning

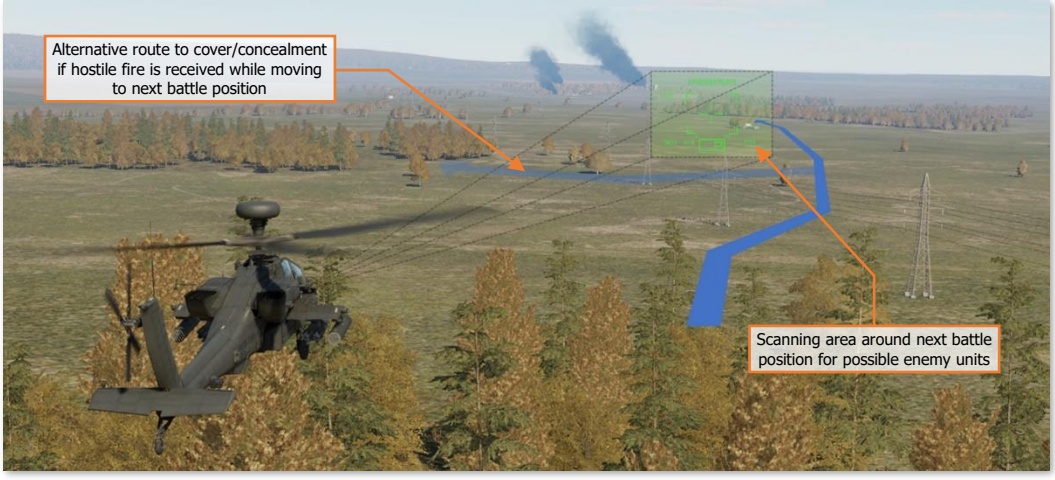
The primary advantage of a helicopter on the battlefield when compared to their ground vehicle counterparts is their ability to cover distances across any terrain within a short amount of time. This battlefield mobility allows helicopters to rapidly move troops and equipment to the rear of enemy echelons, rapidly resupply or reinforce dispersed units, evacuate wounded soldiers to receive medical treatment, respond to enemy attacks on flanks of friendly units, respond to calls for fire support along the front line, or exploit targets of opportunity beyond the front line.

As discussed above, helicopters are still quite vulnerable to enemy weapons fire. When hovering or flying at low-speed, helicopters are vulnerable to engagement by ATGM's or even a tank's main gun. The primary method for attack helicopters to mitigate such threat weapons is *standoff*. Whenever possible, an attack helicopter aircrew should always choose a battle position that places the enemy within the maximum effective range of their weapons, while remaining outside the maximum effective range of the enemy's. When standoff cannot be maintained due to changes on the battlefield, the aircrew can utilize the attack helicopter's *mobility* to rapidly re-position the attack helicopter to regain and maintain that standoff for as long as possible. This maximizes the attack helicopter's lethality against the enemy, while minimizing the enemy's ability to engage it.

A key part in maintaining standoff from enemy forces, especially in situations where enemy positions are not well known, is *planning*. Even before climbing into the cockpit, air routes, terrain, suspected/known enemy positions, enemy weapon systems, and even the weather, should all be evaluated to understand how each factor will affect the aircrew's ability to maintain standoff or remain masked behind terrain from the enemy. However, even with a thorough plan, discretion should be taken when moving within hostile territory. Blindly bounding from one position to the next without performing reconnaissance of the route to that next position, and any potential fields of observation or fire, is a good way to be surprised by a missile or stream of tracers directed at your aircraft.

Enemy units may be lurking around the next tree line

It is very possible that an attack helicopter aircrew can get themselves pinned down by hostile ground forces. If the aircrew rushes from one terrain feature to the next without verifying the security of their next position or the route to get there, the aircrew may be unable to go forward, they may be unable to go back, and if they climb above the terrain, they may be engaged by air defenses. In this instance, the aircrew may need to risk the success of their mission by expending significant quantities of munitions to fight their way out.



Recon next battle position with alternative sources of cover

Weapons discipline is another practice that is important. Despite its firepower, an attack helicopter only has a limited amount of munitions onboard to achieve the mission. These weapons should be used in a manner that achieves the maximum effect on the battlefield whenever possible. Destroying every enemy that is detected while enroute to the objective may feel satisfying, but running out of munitions prior to achieving the mission objective(s) will remove that satisfaction quickly. Attack helicopters, by nature of their mobility and standoff, have the advantage of being more selective about what engagements they choose to commit to, from where they may engage their targets, and what targets they bypass and report to higher echelons.

Even when the primary objective is spotted, tactical patience should be exercised to fully develop the situation and determine what else may be in the area. Prior to pulling the trigger, scanning the area for other enemy positions nearby is important to ensure survival of the attack helicopter team. If the team has enough weapons to spare, it may be wise to sanitize the immediate area of any threats (such as air defense units) prior to engaging the primary targets.

Masking/Un-Masking and Terrain Flight

During armed conflicts in theaters which contain large numbers of air defenses, low-level tactics are the best advantage that attack helicopters can employ. Although fixed-wing aircraft can use high speeds to minimize the time spent inside the engagement zone of an air defense unit, helicopters must use terrain and other forms of cover to limit their exposure to attain a reasonable level of survivability. The level of exposure and time spent outside of cover and concealment should be primarily dependent on threat reaction time, but also may be predicated on the time needed to perform sensor scans of an area or employ a weapon against a target. These two factors – time needed by the enemy to detect/engage you versus time needed by you to detect/engage the enemy – should constantly be weighed against the other throughout the mission as the tactical situation evolves.

When used in a conflict against armor supported by air defenses, attack helicopters such as the AH-64 are often maneuvered akin to an infantryman or a sniper, rather than a conventional aircraft. When attack helicopters utilize terrain and other forms of cover and concealment to remain hidden from enemy observation, this is known as "masking". When moving between battle positions near enemy units, attack helicopters bound from one battle position to the next to minimize exposure to enemy fire (much in the same manner an infantryman bounds from cover to cover) in an effort to remain undetected for as long as possible until they are ready to attack.

To perform sensor scans of the battlefield or engage enemy targets with their weapon systems, attack helicopters must "un-mask" from behind cover. Depending on the nature of the cover/concealment, attack helicopters may un-mask vertically or laterally to expose their sensors or weapon systems. When an attack is initiated, the enemy should be engaged within the shortest amount of time possible before re-masking and relocating to a different battle position. Weapons fire reveals the attack helicopter's presence to the enemy, just as a sniper reveals his position by firing on the enemy.

Un-masking from behind cover

The most advantageous factor attack helicopters can use for their protection is terrain. Mother Earth will always provide the best protection from enemy observation and weapons fire, just assuredly as it protects the infantryman. However, low-altitude flight can be quite demanding on an aircrew, especially at night or in low-visibility conditions. As such, the speed that helicopters can attain when operating at low altitudes is dependent on the nature of the terrain, the tactical situation, the time of day, enemy air defenses, and how much power margin is available to the aircrew.

Conversely, in a threat environment where air defenses are low and the most prevalent threat to helicopters is small arms fire such as rifles or machine guns, it may be advantageous to maintain a higher altitude outside the engagement ranges of such weapons. This will improve the range at which aircrews can detect the enemy, as well as placing less demand on an aircrew when compared to flying at low altitude, allowing them to focus on engaging the enemy.

AH-64 TACTICAL EMPLOYMENT

Pre-mission planning is the most important part of any successful combat mission. Just as in the case with other military aircraft, factors such as terrain and threat locations should be considered when planning mission routes, altitudes, and weapon loads. Routes and altitudes should be selected to maximize survivability and reduce the probability of detection by threat weapon systems.

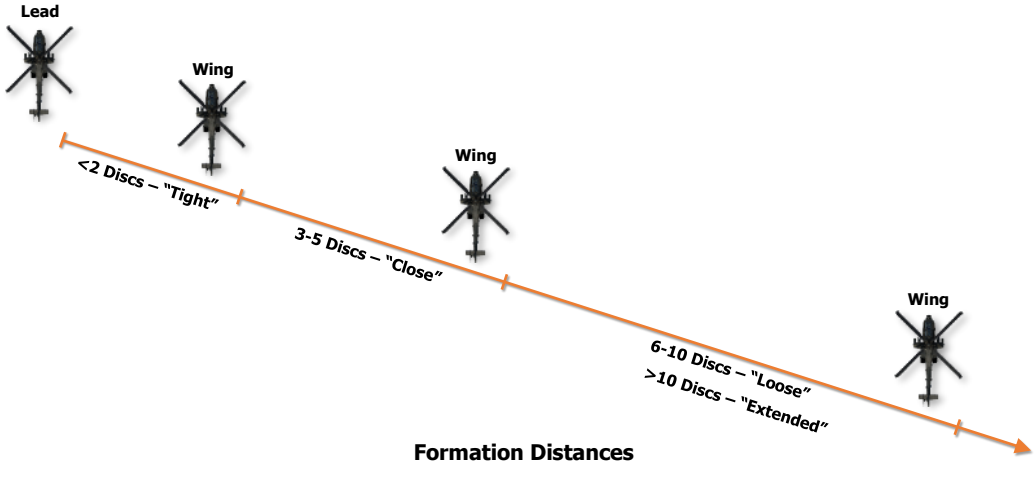
Routes, pre-planned targets, enemy threats, and other graphical control measures can be displayed on the AH-64D's Tactical Situation Display (TSD) along with information from the aircraft's sensors to enhance situational awareness and provide an overview of the surroundings. The TSD can further enhance situational awareness of potential threat blind spots by using Color Bands (enabled from the TSD Map sub-page and TSD Threat Show sub-page) and selecting an appropriate map type and scale. Configuring the SHOW options on the TSD is important in ensuring critical information is present on the TSD for crews to reference during each phase of the mission.

Upon departure from the airfield, assembly area, or FARP, or when approaching the Forward Edge of Battle Area (FEBA), aircrews should conduct pre-combat checks and ensure the aircraft is ready to respond to enemy contact. Accordingly, the AH-64D team should adjust their formation and flight patterns to those which are best suited for the tactical situation, terrain, and airspeeds they intend to fly.

Team Maneuvering

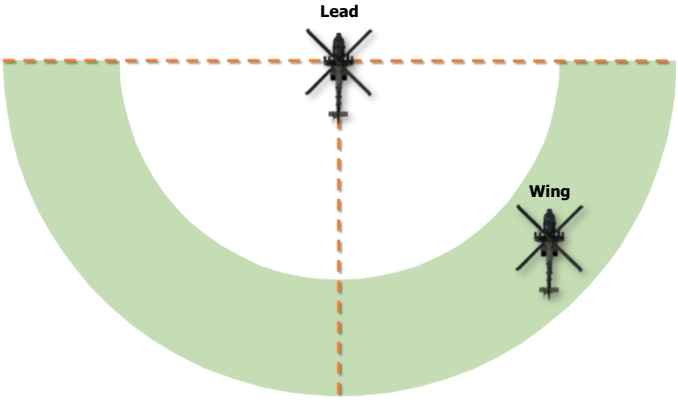
The basic building block of any U.S. Army attack helicopter unit is an Air Weapons Team (AWT or simply "team") of two AH-64's under the control of an Air Mission Commander (AMC), which is typically the most experienced Pilot-in-Command (PC) within the flight. The AMC is responsible for ensuring the success of the team's mission and is the overall weapons release authority for the team.

Maneuverability is the primary consideration for the AWT. The lead aircraft ("Lead") should strive to maneuver in a predictable manner for the wingman ("Wing" or "Trail"); and the wingman should strive to position their aircraft in such a way to never inhibit the lead aircraft's ability to maneuver while always being ready to provide suppressive fire in support of Lead, if needed. Distance between aircraft can vary based on terrain, proximity to the ground, illumination/visibility, and expected or known enemy threats; but distances may range from 3 to 5 rotor discs to a kilometer or more. Distances are typically greater when over open terrain, whereas distances between aircraft will be less when operating in restrictive terrain.



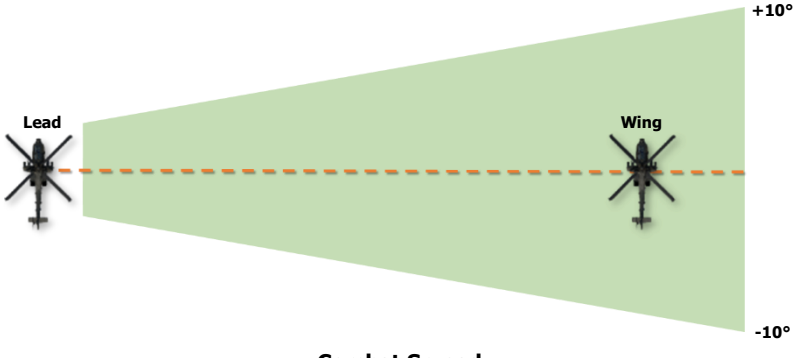
Formation Distances

Combat Cruise is the standard formation for AWT employment. It is preferable at very low altitudes and provides the most flexibility of the flight while reducing predictability. *Combat Cruise* provides an area to the rear of the lead aircraft, along their aft hemisphere, for wingmen to maneuver. The trail aircraft positions their aircraft in such a way to provide fire support for the lead aircraft if unexpected enemy units are encountered. *Combat Cruise Left/Right* "pins" the wingmen to one side of the lead aircraft during situations in which maneuvers to the opposite side are not feasible, possibly due to terrain.



Combat Cruise

Combat Spread maximizes forward firepower with overlapping sensor fields-of-view and weapons fields-of-fire, at the expense of ease of maneuverability and team flexibility. The trail aircraft sets their position abeam of the lead aircraft at the 3 o'clock or 9 o'clock positions. *Combat Spread* requires a high degree of scanning and coordination between the Pilot's in each aircraft, particularly at night due to the field-of-view limitations of Night Vision Systems (NVS). Distance between aircraft should be based on maneuver room, visibility, terrain, and expected enemy contact.



Combat Spread

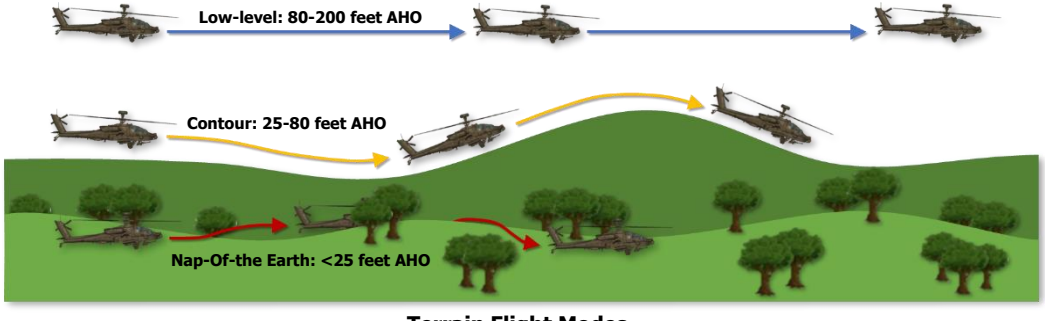
Terrain Flight Modes

The purpose of terrain flight and the associated modes of terrain flight is to deny or delay enemy forces the ability to detect, track, and engage the aircraft. Terrain flight requires constant visual scanning to see and avoid obstacles, particularly at night. The most important rule when conducting terrain flight is to never "out-fly" the capabilities of the sensor being used for flight, nor the capabilities of the aircrew to respond to low-level hazards. If weather and ambient lighting conditions restrict or reduce visibility, the aircrew should decrease their airspeed. Continuous operations in a single terrain flight mode is typically unlikely, as terrain and vegetation will vary throughout the Area of Operations (AO). Crews can expect to transition into and out of each mode as a natural part of performing terrain flight operations. The modes of terrain flight are defined below:

- **Low-level.** Low-level flight is conducted at a constant altitude and airspeed, typically between 80 to 200 feet above the highest obstacle (AHO). Under these conditions, it will most likely be advantageous to use a "Traveling" movement technique (constant altitude and airspeed) to rapidly transit from one place to another, however this method provides the least amount of security for unexpected enemy encounters.

- **Contour.** Contour flight is conducted at low altitude conforming to the contours of the earth, typically between 25 to 80 feet AHO. It is characterized by varying airspeeds and altitude, which will be dictated by the terrain itself and obstacles. Under these conditions, it will most likely be advantageous to use a "Traveling Overwatch" movement technique (varying altitudes and airspeeds) and utilize Combat Cruise as the formation pattern in which the trail aircraft is positioned to respond to enemy contact.

- **Nap-Of-the-Earth (NOE).** NOE flight is conducted at low airspeeds and altitudes as close to the earth's surface as vegetation and obstacles permit, usually between the surface and 25 feet AHO. Under these conditions, it will most likely be advantageous to use a "Bounding Overwatch" movement technique, where one aircraft maintains position and provides cover while the other aircraft moves to the next position. Care should be taken to avoid bounding beyond the range of the weapon systems of the aircraft providing cover.

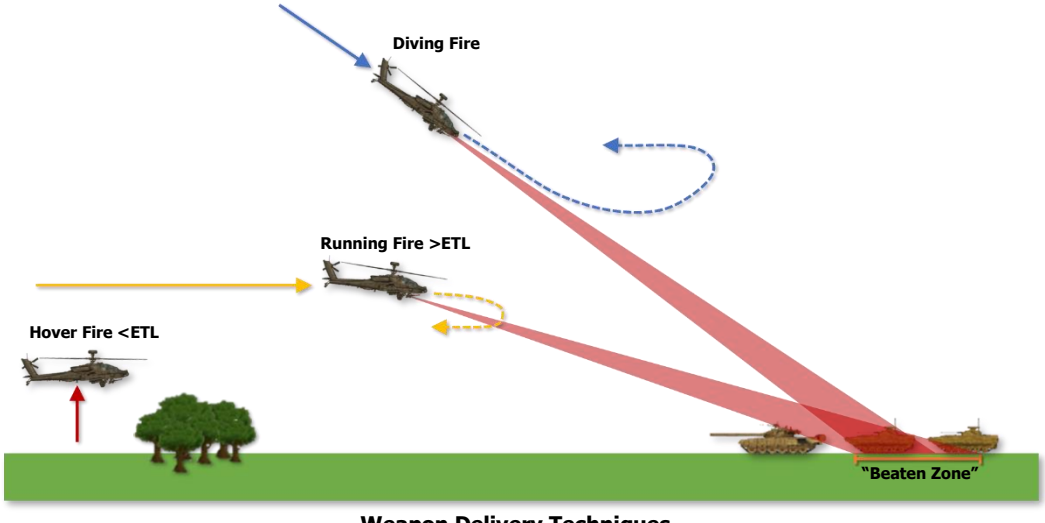


Terrain Flight Modes

Weapon Delivery Techniques

The three techniques for weapons delivery from an attack helicopter are defined below:

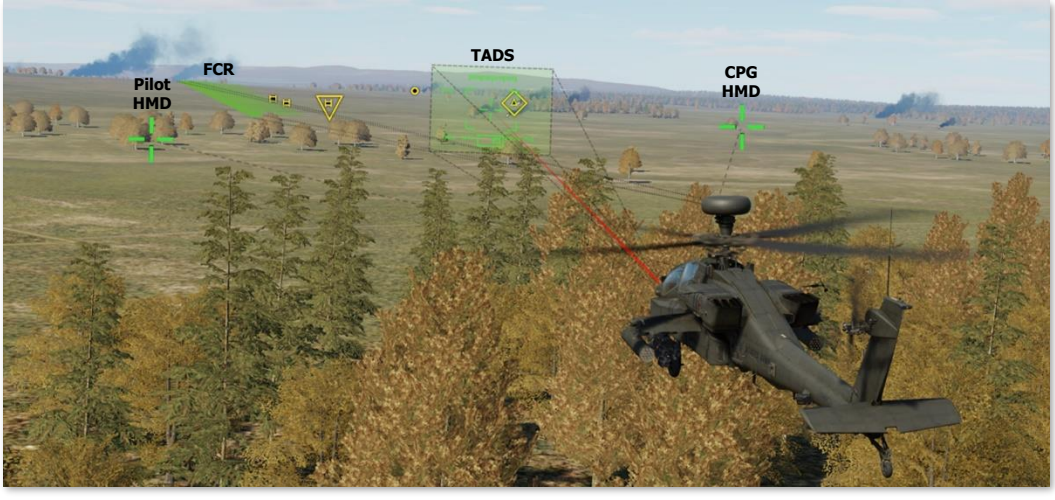
- **Hover Fire.** Hover fire is typically conducted at speeds less than effective translational lift (ETL, roughly 16-24 knots airspeed) and may be conducted from a stationary hover or a hover with movement; such as laterally un-masking.
- **Running Fire.** Running fire is typically conducted at speeds greater than ETL. Forward airspeed adds stability to the helicopter and increases the accuracy of unguided weapon systems, particularly rockets.
- **Diving Fire.** Diving fire is an engagement conducted in a diving profile, typically between -10° to -30° pitch attitudes. Airspeed and altitude will be determined by the expected threat level from enemy defenses and desired weapons effects, with a steeper dive providing a smaller "beaten zone" and improved accuracy. However, a steep dive will also require more altitude for recovery. Diving fire may be performed following a climb from low altitudes (a "bump" from behind cover), or from level flight at high altitudes.



Weapon Delivery Techniques

SIGHTS AND SENSORS

The AH-64D uses a wide range of sensors to detect, acquire, and engage targets on the battlefield. These sensors range from the basic "Mark 1 eyeball" to an advanced fire control radar, and each sensor is integrated into the aircraft's Data Management System to enhance situational awareness and facilitate rapid engagement of enemy forces during day or night.



AH-64D Sights and Sensors

Although the AH-64D is equipped with a multitude of sensors for various purposes (such as the radar altimeter or Doppler radar velocity sensor that aid in flight operations and navigation), sensors such as the optical cameras in the nose turret or the mast-mounted fire control radar perform targeting against enemy locations and equipment. These sensors are grouped within specific sensor arrays called "sights", which generate targeting solutions for employment of aircraft weapon systems.

Four sights are available to the AH-64D crew, but only one sight may be used within a crewstation at any given time. These sights are the Pilot's Helmet-Mounted Display (HMD), the Copilot's HMD, the Target Acquisition Designation Sight (TADS), and the Fire Control Radar (FCR). Each of these sights includes multiple sensors that may be used individually or cooperatively to employ the weapon system selected by the crewmember; and each has its own advantages and disadvantages when deciding how and when to engage the enemy.

Each sight and its corresponding sensors are shown below.

HMD (Pilot and CPG)
Helmet-Mounted Display

- **Visual** Crewmember eyesight
- **NVS** Night Vision System (PNVS or TADS)
- **NVG** Night Vision Goggles*

TADS (CPG only)
Target Acquisition Designation Sight

- **FLIR** Forward-Looking Infrared
- **DTV** Daytime Television
- **LRFD** Laser Rangefinder/ Designator
- **LST** Laser Spot Tracker

FCR (Pilot or CPG)
Fire Control Radar

- **FCR** Fire Control Radar
- **RFI** Radar Frequency Interferometer

* Night vision goggles may aid either crewmember in detecting weapons fire or IR pointers on the battlefield, but they are not intended to be used for direct targeting when using HMD as a sight. They may be used to direct the TADS to an area for subsequent targeting or observation. (See Night Vision Goggles for more information.)

Helmet-Mounted Display (HMD)

The HMD may be used to rapidly direct weapons toward enemy locations at close range. When selected as the crewmember's sight, weapon solutions are generated for the crewmember's actioned weapon based on the crewmember's helmet position and their current range source.

NVS mode may be used in conjunction with the HMD to augment the crew's ability to engage targets at night.

(See the Helmet-Mounted Display chapter for more information.)

Target Acquisition Designation Sight (TADS)

The TADS uses a combination of electro-optical sensors in the visible and infrared spectrums to detect and target enemy forces at long range or perform reconnaissance, during day or night. When selected as the Copilot/Gunner's sight, weapon solutions are generated for the CPG's actioned weapon based on the TADS turret position and the CPG's current range source.

(See the Target Acquisition Designation Sight chapter for more information.)

Fire Control Radar (FCR)

The FCR mast-mounted assembly consists of an active radar antenna to rapidly scan large areas of the battlefield (or the airspace above it) and a passive radar detection antenna array to target radar-emitting air defense systems. When selected as the crewmember's sight, weapon solutions are generated for the crewmember's actioned weapon based on the location of the Next-To-Shoot (NTS) target on the FCR page.

(See the Fire Control Radar chapter for more information)

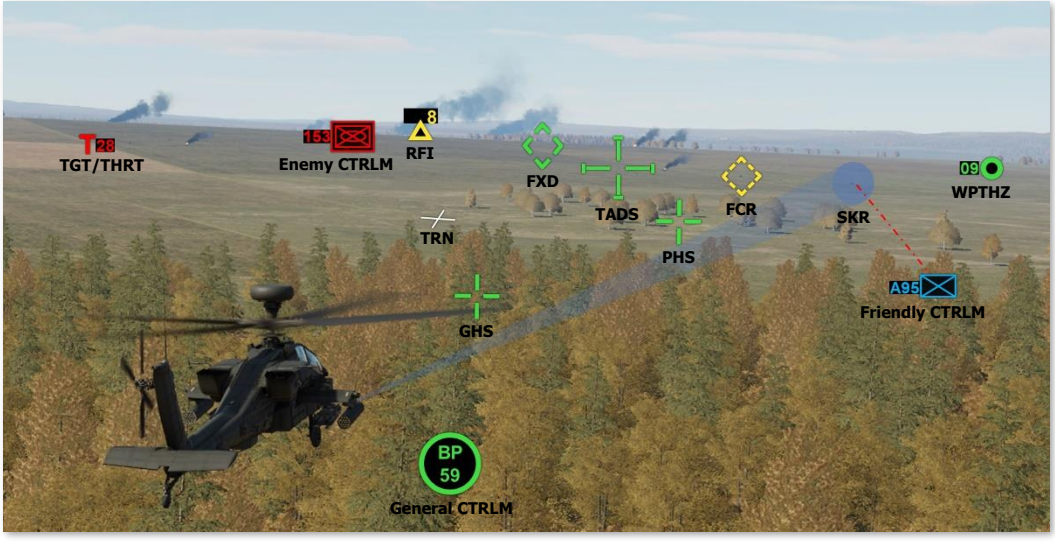
Sight Selection Logic

Sight selection logic is outlined below.

- Both crewmembers may select their respective HMD as their sight at any time since each crewmember's helmet position is tracked independently of the other; but they cannot select the opposite crewmember's HMD as their sight.
- Only the CPG may select TADS as a sight, however either crewmember may utilize TADS as their selected NVS sensor. (See Night Vision System for more information.)
- Either crewmember may select FCR as their sight, however only one crewmember may do so at any given time. If the CPG's selected sight is FCR and the Pilot selects FCR, the CPG's sight will automatically be set to HMD and any actioned weapon in the CPG crewstation will be de-actioned. If the Pilot's selected sight is FCR and the CPG selects FCR, the Pilot's sight will automatically be set to HMD and any actioned weapon in the Pilot crewstation will be de-actioned.
- The TADS may be linked to the FCR Next-To-Shoot (NTS) target. If the Pilot's selected sight is FCR and the CPG's selected sight is TADS, when the Pilot links the TADS to the FCR the CPG's sight will automatically be set to HMD and any actioned weapon in the CPG crewstation will be de-actioned.
- The FCR may be linked to the TADS line-of-sight. If the CPG's selected sight is TADS and the Pilot's selected sight is FCR, when the CPG links the FCR to the TADS the Pilot's sight will automatically be set to HMD, and any actioned weapon in the Pilot crewstation will be de-actioned.

ACQUISITION (ACQ) SOURCES

Acquisition sources increase aircrew efficiency in orienting their sights to locations on the battlefield, whether it be to slave a sight to a target detected or tracked by another sensor onboard the aircraft (to include visual detection by either crewmember), or to slave their sight to a set of three-dimensional coordinates. The purpose of the acquisition source is to automate or reduce the need to manually search and acquire a target with the selected sight; acquisition sources do not directly affect the weapon aiming solution for any weapon system.



Acquisition sources on the battlefield

In the case of the TADS or FCR, these sights will physically slew to the location of the acquisition source selected within the crewstation. In the case of the HMD, the crewmember will receive cueing indications within their helmet symbology of which direction they must direct their head to acquire the selected acquisition source (in lieu of a robotic arm physically grabbing their head and forcibly turning it in the correct direction). As several examples, the Copilot/Gunner (CPG) could select the Pilot's helmet as the acquisition source to slave the TADS turret to a target that the Pilot is looking at, the Pilot could select TADS as the acquisition source to monitor the direction the CPG is aiming the TADS, or either crewmember could select a target point stored within the database to slave their sight to that 3-dimensional location.

Each crewmember may select an acquisition (ACQ) source from the following list:

- **PHS** – Pilot Helmet Sight
- **GHS** – Gunner Helmet Sight
- **SKR** – Tracking missile seeker
- **RFI** – Radar Frequency Interferometer
- **FCR** – Fire Control Radar
- **FXD** – Fixed forward (0° in azimuth/-4.9° elevation)
- **TADS** – Target Acquisition Designation Sight
- **W##, H##, C##, T##** – Waypoint, Hazard, Control Measure, or Target/Threat
- **TRN** – Cursor-selected terrain location on the TSD

As is the case with sight selections, choosing the best acquisition source in any given situation is key to reducing the time needed to search, acquire, and engage enemy targets. In most circumstances, the most important factors in choosing the correct acquisition source are proper coordination and communication between crewmembers; so that each crewmember is aware of how the other is using their selected sight, and whether a target should be handed off from one crewmember to the other for engagement by the appropriate sight/weapon combination.

ACQ Selection Logic

In most cases, any of the available sights (HMD, TADS, or FCR) may serve as an acquisition source for another sight. However, a crewmember cannot select an acquisition source that is already selected as the sight within the same crewstation. For example, the CPG cannot simultaneously select TADS as a sight and an acquisition source, because the TADS cannot be slaved to itself (the TADS is already looking where it is currently looking). As such, some acquisition sources will be contextually removed from the acquisition selection menu if already selected as the crewmember's sight (e.g., "TADS" will be removed from the CPG's acquisition selection menu if the CPG has selected TADS as a sight).

- If the Pilot's selected sight is HMD, PHS will be removed from the Pilot's ACQ selection menu.
- If the Pilot's selected sight is FCR, FCR will be removed from the Pilot's ACQ selection menu.
- If the CPG's selected sight is HMD, GHS will be removed from the CPG's ACQ selection menu.
- If the CPG's selected sight is TADS, TADS will be removed from the CPG's ACQ selection menu.
- If the CPG's selected sight is FCR, FCR will be removed from the CPG's ACQ selection menu.
- If the FCR mast-mounted assembly is not installed, FCR and RFI will not be available within either crewmember's ACQ selection menu.
- If the TADS is being used as an NVS sensor, TADS will be removed from the ACQ selection menu within the same crewstation in which it is being used. (See Night Vision System for more information.)

Acquisition sources may be selected from the WPN, TSD, or FCR pages by opening the ACQ selection menu (VAB R6). Acquisition sources that are available for selection will be displayed, with the current ACQ selection boxed.

Acquisition (ACQ) Selection Menu

In many instances, an acquisition source may be available for selection, but the acquisition may be invalid and cannot provide cueing to a crewmember's sight. When this occurs, the acquisition source will be displayed in white and annotated with a "?". As an example, if a crewmember has not created a Terrain point on their TSD, "?TRN" will be displayed within the ACQ selection menu but will be invalid until the crewmember creates a Terrain point.

ACQ Slave Logic

Once an acquisition source is selected within the CPG crewstation, the CPG's sight must be "slaved" to it. The CPG may selectively enable ("slaved") or disable ("de-slaved") the Slave function using the SLAVE button located on the TEDAC Right Handgrip.

- If the CPG selects a different sight, SLAVE is automatically disabled.
- If the CPG selects a different acquisition source, SLAVE is automatically disabled.

The Pilot does not have an option to selectively enable/disable the Slave function. The Pilot's sight is always "slaved" to the Pilot's acquisition source.

- If the Pilot's selected sight is FCR, the FCR will be slaved to the Pilot's ACQ at all times.
- The Pilot may selectively remove ACQ cueing from the HMD Flight symbology. (See WPN Utility sub-page for more information.)

In the case of setting the acquisition source to a point within the database (Waypoint, Hazard, Control Measure, or Target/Threat) or to a cursor-selected terrain location on the TSD (Terrain point), this action will also set that crewmember's range source to a Navigation range when SLAVE is subsequently enabled.

- If the CPG's acquisition source is set to a Waypoint, Hazard, Control Measure, Target/Threat, or Terrain point, the slant range to that point will be entered as a Navigation range when the SLAVE button is pressed on the TEDAC Right Handgrip.
- If the Pilot's acquisition source is set to a Waypoint, Hazard, Control Measure, Target/Threat, or Terrain point, the slant range to that point will be entered as a Navigation range immediately upon selection from the ACQ selection menu.

Typically, during training flights outside of a combat area, each crewmember selects the opposite crewmember's helmet (GHS/PHS) as their acquisition source to facilitate traffic and obstacle advisories.

During combat, it may be useful for the CPG to be slaved to GHS to remain "heads out" while searching for targets, and then de-slaving when a target or point of interest is acquired. The Pilot may often use TADS as the acquisition source to maintain situational awareness of where the TADS is oriented. This is particularly useful for the Pilot since it provides the Cued LOS Dot within the HMD Field-Of-Regard (FOR), which assists the Pilot in monitoring the position of the TADS turret so that he or she may maneuver the aircraft to avoid the turret slew limits.

NIGHT VISION GOGGLES (NVG)

The AN/AVS-6 Aviator Night Vision Imaging System (ANVIS) provides aircrews with a high-fidelity, binocular, 40° field-of-view under extreme low-light conditions. The AVS-6 NVG's amplify light in the visible and near-infrared spectrum to enable aircrews to operate at NOE altitudes near terrain and other natural or man-made obstacles, under all but the darkest, moonless nights.

The HDU physically interferes with the proper wear of NVG's (and can incur misalignments within the HDU symbology when viewed through the NVG's) and may not be used simultaneously. If the NVG's are enabled, the HDU will be rotated away from the crewmember's face prior to the NVG's being lowered into view. The IHADSS will continue to track the helmet position and aircraft sensors may be cued to the crewmember's approximate line-of-sight, but NVG's should not be used as a means of targeting due to the lack of precise aiming symbology.

HELMET-MOUNTED DISPLAY (HMD)

US Army photo
by Dustin Senger

HELMET-MOUNTED DISPLAY (HMD)

The Helmet-Mounted Display is part of the Integrated Helmet And Display Sighting System (IHADSS) which allows either crewmember to employ aircraft weapons, cue other aircraft sensors to specific locations, or even direct the opposite crewmember to locations seen outside the cockpit.

Unlike many helmet cueing systems that were post-production modifications to fixed-wing combat aircraft, the AH-64's helmet sight was designed from the beginning to function as both the primary display for flight information and as an independent but integrated targeting system.

The overall IHADSS consists of several subcomponents that must be defined.

- **IHU.** Integrated Helmet Unit; the crewmember's flight helmet with integrated helmet position tracking sensors.
- **HDU.** Helmet Display Unit; the physical device that is clipped to the crewmember's IHU that projects symbology and video onto a combiner lens in front of the right eye.
- **HMD.** Helmet-Mounted Display; the method of sighting through aiming symbology projected onto the HDU combiner lens for generating weapon solutions.
- **IHADSS.** Integrated Helmet And Display Sighting System; the entire system that tracks the position of each crewmember's IHU, generates symbology for display on the HDU, and processes weapon solutions based on sighting through the HMD.

HMD Sighting

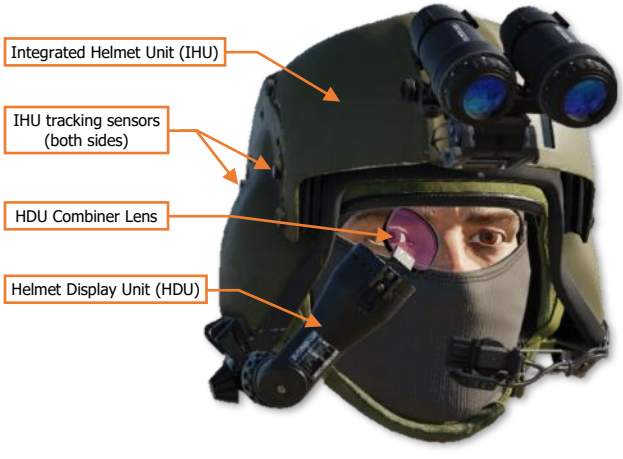
HMD Activation

Both crewmembers' individual Helmet Display Units (HDU) receive symbology and video data from the aircraft Display Processors (DP); however the CPG's HDU also requires the TADS to be powered in order to function. As such, the HDU's in each cockpit are automatically initialized when the APU is powered on. If the TADS is powered off from the CPG's WPN Utility sub-page (shown at right), or from either crewstation on the DMS Shutdown sub-page, the CPG's HDU will blank completely.

The IHADSS can be selectively powered on or off from either crewstation by pressing VAB L1 on the WPN Utility sub-page, but disabling this system will affect the HDU's in both crewstations. When the IHADSS is disabled, helmet-tracking in both crewstations is disabled and symbology displayed within the HDU's will be lost, although sensor video may still be present.

Integrated Helmet Unit (IHU) & Helmet Display Unit (HDU)

The Integrated Helmet Unit uses a combination of infrared tracking sensors integrated into the helmet itself and Sensor Surveying Units (SSU) mounted within the crewstation to determine the helmet position in azimuth and elevation.



The helmet position is processed by the aircraft electronics, which updates symbology projected into the Helmet Display Unit in real-time. If the crewmember's selected sight is HMD, the aircraft electronics calculates weapon solutions for the crewmember's current weapon based on the selected range source along the HMD line-of-sight.

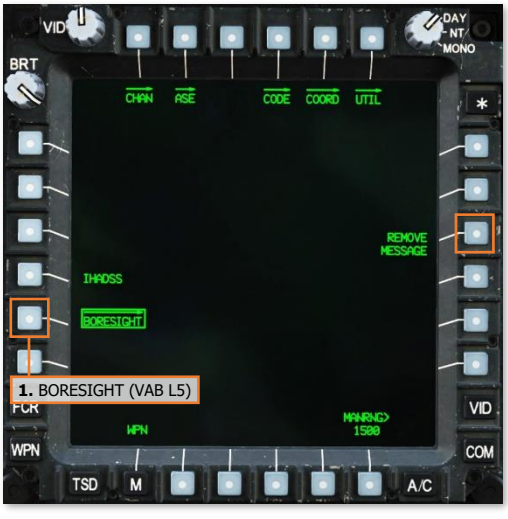
During initialization of aircraft systems prior to takeoff, each crewmember performs a boresight of their IHU after mounting the HDU to their helmet.

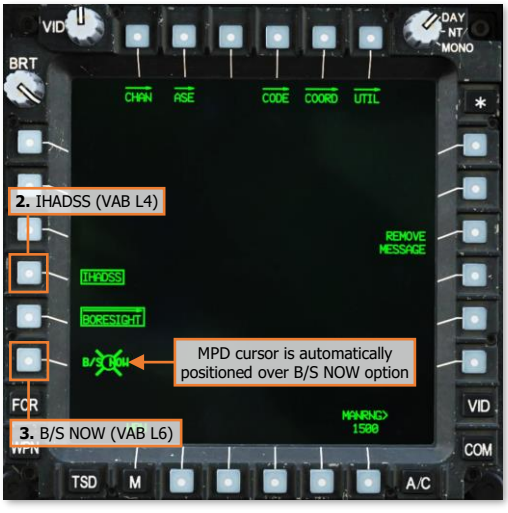
(See IHADSS Boresight on the following page for more information.)

IHADSS Boresight

During aircraft start-up, the helmet within each crewstation must be boresighted to provide the IHADSS with accurate azimuth and elevation position data of each crewmember's helmet. Until a successful boresight has been performed, the Sight Status field of the High Action Display will alternate between displaying "IHADSS" and "B/S REQUIRED" status messages, and the Cueing Dots will flash around the HMD LOS Reticle. (See HMD High Action Display for more information.)

The IHADSS boresight procedure is performed by accessing the BORESIGHT sub-page by pressing VAB L5 on the WPN page. After entering the BORESIGHT sub-page, the crewmember selects IHADSS (VAB L4) to enable the IHADSS boresight logic and activate the Boresight Reticle Unit (BRU) mounted on top of the instrument panel (below, left). When IHADSS is pressed and the text is boxed, B/S NOW is displayed at VAB L6 and the MPD cursor is automatically positioned over the option (below, right).





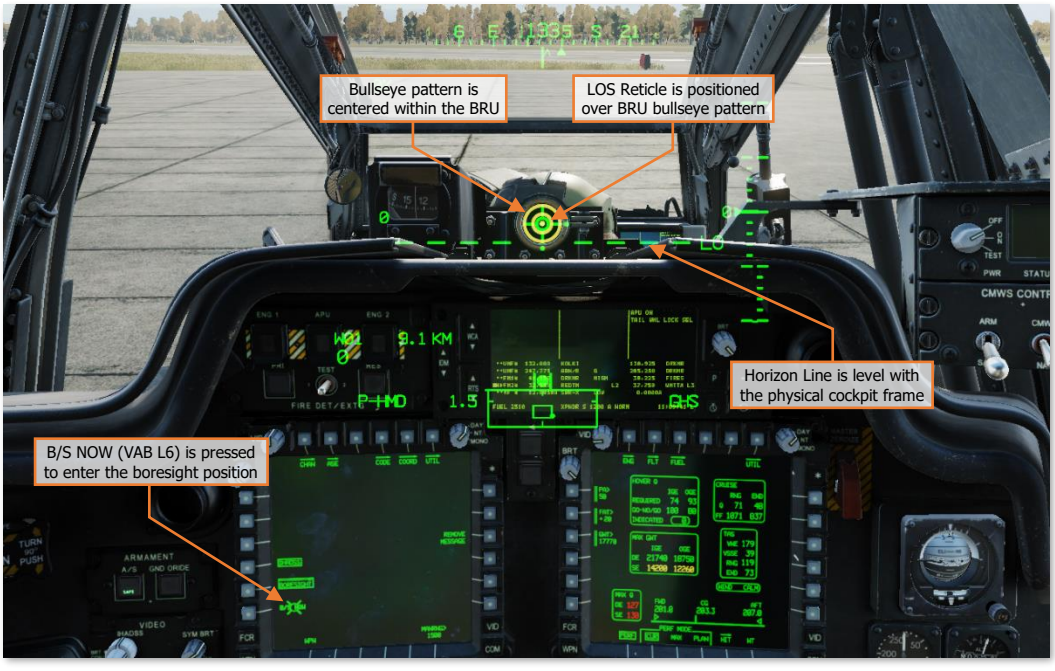
If desired, REMOVE MESSAGE (VAB R3) may be pressed to remove the "IHADSS B/S REQUIRED" message from the Sight Status field of the High Action Display.

When the IHADSS boresight logic is enabled, a bullseye pattern is displayed within the BRU, the brightness of which is controlled by the PRIMARY lighting knob on the EXTLT/INTR LT panel on the Pilot's Left Console, or the INTR LT panel on the CPG's Left Console.

Pilot (Left) and CPG (Right) PRIMARY lighting knobs

After the BRU has been activated and is adjusted to the appropriate brightness, the position and orientation of the helmet should be adjusted so that the bullseye pattern is centered within the BRU and the LOS Reticle is aligned with the center of the bullseye, as shown below. If necessary, Transition or Cruise symbology modes should be selected to ensure the Horizon Line is level with the cockpit frame.

NOTE: If the aircraft is parked on an uneven surface or slope, the Horizon Line within the HMD symbology cannot be used as a level reference plane. The Heading Tape along the top of the symbology may be used instead.



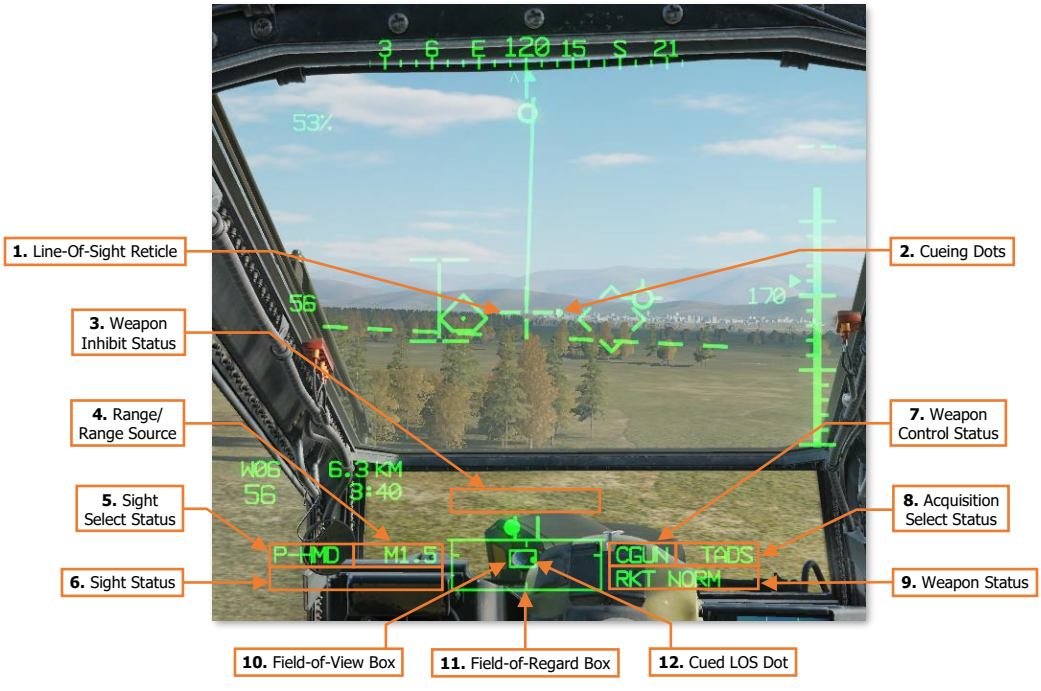
When the HMD LOS Reticle and the BRU bullseye pattern are properly aligned, the B/S NOW is commanded by pressing VAB L6 or by using the MPD Cursor-Enter option on the Collective Mission Grip (or the TEDAC Left Handgrip in the CPG crewstation). If the boresight position is accepted, the bullseye pattern within the BRU will extinguish, the B/S NOW option (VAB L6) will be removed, and IHADSS (VAB L4) on the BORESIGHT sub-page will be un-boxed.

The IHADSS boresight process may be aborted at any time by re-selecting IHADSS (VAB L4), which will remove the B/S NOW option and extinguish the bullseye pattern within the BRU.

HMD HIGH ACTION DISPLAY

If the crewmember's selected sight is HMD, Flight symbology is displayed on the crewmember's HDU; and specifically in the case of the Copilot/Gunner (CPG), HMD Weapon symbology is displayed on the CPG's TDU.

The pertinent targeting- and weapon-related symbology when using HMD as the selected sight is the Line-Of-Sight (LOS) Reticle, LOS Reticle Cueing Dots, and the High Action Display (HAD) data fields shown below.



1. **Line-Of-Sight Reticle.** Indicates the HMD line-of-sight (LOS). When the crewmember's selected sight is HMD, the LOS Reticle is used as an aiming crosshair for weapons employment and laser designation.

   The LOS Reticle flashes when the selected sight's LOS is invalid or has reached its slew limit.

2. **Cueing Dots.** Indicates the quadrant direction of the selected acquisition source to "cue" the crewmember's helmet position to the location of the Cued LOS Reticle. The dots are removed when the Cued LOS Reticle is with 4° of that quadrant relative to the LOS Reticle.

   All four dots flash when the "IHADSS B/S REQUIRED" message is present within the Sight Status field of the High Action Display, indicating the crewmember needs to boresight their IHADSS.

3. **Weapon Inhibit Status.** Displays any pertinent safety or performance inhibits that may affect weapons employment, based on the currently actioned weapon within the crewstation. (See the Weapon Employment chapter for more information.)

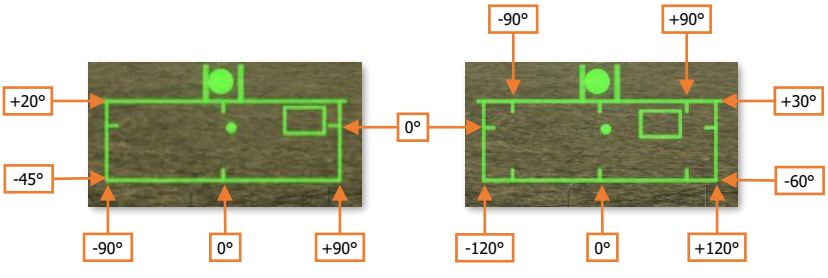
4. **Range Source/Range.** Displays the range source in use and the current range in tenths of kilometers, or meters if the range source is the LRFD.

   - **Default range.** Default range is selected upon initial aircraft power-on, or any time the crewmember's current range source is no longer valid. The Default range for the Pilot is 1.5 km, and 3.0 km for the CPG (displayed as "1.5" and "3.0" respectively).

- **Manual range.** Manual range may be selected and modified on the WPN page and may be set in 1-meter increments between 100 and 50,000 meters (displayed as "M0.1" to "M50.0").
- **Automatic range.** Auto range may be selected on the WPN page and provides dynamic range calculations between 0.1 km and 50 km (displayed as "A0.1" to "A50.0").
- **Navigation range.** Navigation range is automatically entered as the range source any time the crewmember's sight is slaved to an acquisition source that has been set to a stored point within the navigational database. A Nav range is dynamically updated to reflect the current slant range between the aircraft and the point set as the acquisition source, between 0.1 km and 32 km (displayed as "N0.1" to "N32.0").
- **Radar range.** Radar range is automatically entered as the range source any time the crewmember's selected sight is set to FCR. A radar range is dynamically updated to reflect the current slant range between the aircraft and the Next-To-Shoot FCR target, between 0.0 km and 9.9 km (displayed as "R0.0" to "R9.9").
- **Laser range.** Laser range is automatically entered as the range source any time the CPG fires the LRFD. The laser range is displayed in 1-meter increments between 500 and 9,999 meters (displayed as 500 to 9999). An asterisk (∗) is displayed to the left of the laser range any time the LRFD is firing and processing a stable laser return from the object or surface within the TADS Line-of-Sight Reticle.

5. **Sight Select Status.** Indicates the sight currently selected within the crewstation.
   - **P-HMD**. Displayed in the Pilot's symbology when the Pilot's selected sight is HMD.
   - **P-FCR.** Displayed in the Pilot's symbology when the Pilot's selected sight is FCR.
   - **P-FCRL.** Displayed in the Pilot's symbology when the Pilot's selected sight is FCR with the TADS linked to the FCR Next-To-Shoot (NTS) target location.
   - **C-HMD.** Displayed in the CPG's symbology when the CPG's selected sight is HMD.
   - **C-FCR.** Displayed in the CPG's symbology when the CPG's selected sight is FCR.
   - **C-FCRL.** Displayed in the CPG's symbology when the CPG's selected sight is FCR with the TADS linked to the FCR Next-To-Shoot (NTS) target location.
   - **TADS.** Displayed in the CPG's symbology when the CPG's selected sight is TADS.
   - **TADSL.** Displayed in the CPG's symbology when the CPG's selected sight is TADS with the FCR linked to the azimuth of the TADS line-of-sight.
6. **Sight Status.** Displays status messages regarding the currently selected sight within the crewstation and the employment of laser-guided AGM-114 missiles when launched in a Remote Fire mode.
7. **Weapon Control Status.** Indicates the opposite crewmember's actioned weapon system. If the Weapon Control Status field is blank, no weapon system is actioned by the opposite crewmember.
   - **PGUN.** Displayed in the CPG's symbology to indicate the Pilot's actioned weapon is the gun.
   - **PRKT.** Displayed in the CPG's symbology to indicate the Pilot's actioned weapon is rockets.
   - **PMSL.** Displayed in the CPG's symbology to indicate the Pilot's actioned weapon is missiles.
   - **CGUN.** Displayed in the Pilot's symbology to indicate the CPG's actioned weapon is the gun.
   - **CRKT.** Displayed in the Pilot's symbology to indicate the CPG's actioned weapon is the rockets.
   - **CMSL.** Displayed in the Pilot's symbology to indicate the CPG's actioned weapon is the missiles.
   - **COOP.** Displayed in both crewmember's symbology to indicate both crewmembers' actioned weapon is rockets, in Cooperative mode.

8. **Acquisition Select Status.** Indicates the acquisition source currently selected within the crewstation.
   - **PHS.** When slave is enabled, the currently selected sight will slave to the azimuth and elevation of the Pilot's Helmet Sight.
   - **GHS.** When slave is enabled, the currently selected sight will slave to the azimuth and elevation of the Copilot/Gunner's Helmet Sight.
   - **SKR.** If the next-to-shoot AGM-114 is tracking a laser designation or target in LOBL mode when slave is enabled, the currently selected sight will slave to the azimuth and elevation of the missile seeker.
   - **FCR.** When slave is enabled, the currently selected sight will slave to the location of the Next-To-Shoot (NTS) target detected by the Fire Control Radar. This option is only displayed if the FCR mast-mounted assembly is installed and the FCR is powered.
   - **FXD.** When slave is enabled, the currently selected sight will slave to a fixed forward direction along the Armament Datum Line (ADL, 0° in azimuth/-4.9° in elevation).
   - **W##, H##, C##, T##.** When slave is enabled, the currently selected sight will slave to the location of the Waypoint, Hazard, Control Measure, or Target/Threat point set as the acquisition source within the crewstation, and the range source will switch to a Navigation range equal to the slant range between the aircraft and the selected point. ## indicates the specific point number to which the Waypoint, Hazard, Control Measure, or Target/Threat point has been stored.
   - **TRN.** When slave is enabled, the currently selected sight will slave to the location of the terrain location cursor-selected on the TSD within the crewstation, and the range source will switch to a Navigation range equal to the slant range between the aircraft and the Terrain point.
9. **Weapon Status.** Displays status messages regarding the currently actioned weapon within the crewstation.
10. **Field-Of-Regard (FOV) Box.** The FOV box indicates the relative position of the crewmember's helmet line-of-sight within the larger Field-of-Regard box. The FOV box represents a 30° x 40° field of view and is driven by the crewmember's helmet orientiation as detected by helmet sensors within each resepective cockpit.
11. **Field-Of-Regard (FOR) Box.** The FOR box indicates azimuth limits for the crewmember's Night Vision System (NVS) sensor turret. The format of the FOR box is determined by the NVS sensor (PNVS or TADS) assigned to that crewstation. Tick marks around the edges of the PNVS FOR box mark 0° in azimuth and elevation. Tick marks around the edges of the TADS FOR box mark 0° and ±90° in azimuth, and 0° elevation.



PNVS Format (Left) & TADS Format (Right)

12. **Cued Line-Of-Sight Dot.** Indicates the relative location of the selected acquisition source within the Field-of-Regard box.

HMD Sight Status Messages

The following status messages pertain to the use of the HMD as the selected sight within the crewstation and when using the PNVS or TADS as an NVS (Night Vision System) sensor during operations at night.

SIGHT STATUS	CONDITION	CORRECTIVE ACTION
IHADSS B/S REQUIRED	A boresight of the IHADSS has not been performed within the crewstation following initialization of the IHADSS.	Perform IHADSS boresight procedures or select REMOVE MESSAGE on WPN Boresight sub-page.
IHADSS FAIL	The IHADSS has failed within the corresponding crewstation.	The IHADSS line-of-sight for the affected crewstation is set to fixed forward. The HMD should not be used for weapon employment.
IHADSS LOS INVALID	The IHADSS line-of-sight is no longer valid due to a failure of an IHADSS component or the IHADSS being powered off.	The IHADSS is frozen at the last position that was detected as valid. If using NVS for piloting under low-visibility conditions or darkness, set NVS mode to FIXED.
LIMITS	The NVS sensor (PNVS or TADS FLIR) that has been assigned to the crewstation encountered a slew limitation.	Adjust the helmet position to within the slew limits of the assigned NVS sensor (PNVS or TADS).
NVS FIXED	NVS has been enabled and set to FIXED mode.	None required.
NVS FAIL	The NVS sensor (PNVS or TADS FLIR) that has been assigned to the crewstation has failed.	If using NVS for piloting under night conditions, transfer flight controls to opposite crewmember and switch to night vision goggles.
NVS NORM	NVS has been enabled and set to NORM mode.	None required.

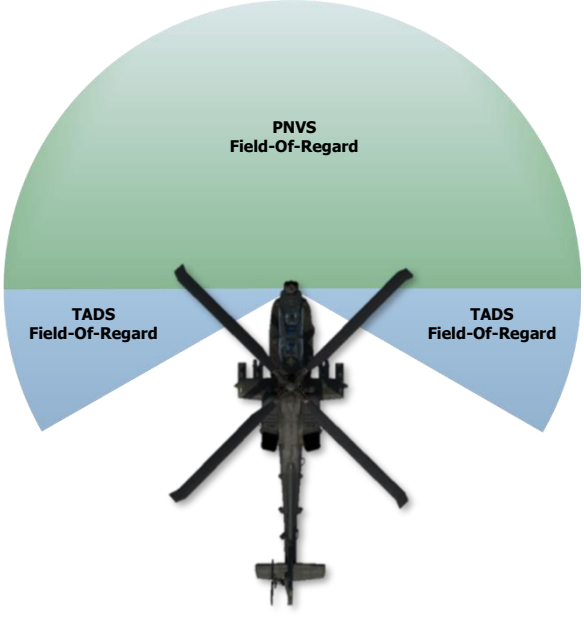
HMD ACQUISITION AND RANGING

Detecting, acquiring, and engaging targets with the HMD is fairly straightforward, in that the HMD simply needs to be pointed toward the target to generate an appropriate weapon solution. Unlike the TADS, the HMD does not include additional targeting modes to assist the crewmember in stabilizing their HMD line-of-sight onto a target position. As such, when using HMD as the selected sight, the aircraft electronics do not provide the same levels of ballistic compensation as compared to using the TADS. Ballistic compensation for aircraft movement or lead angle compensation for target movement is not provided; however ballistic compensation for range is provided, subject to the crewmember's selected range source.

When operating at night, using Night Vision System (NVS) in NORM mode allows either crewmember to utilize their respective FLIR system to detect and acquire targets, even those that may otherwise be obscured by the cockpit structure or canopy frames. However, it is important to understand each sensor (PNVS and TADS) is subject to different slew values.

(See Night Vision System for more information.)

The format of the Field-Of-Regard (FOR) Box displayed within the HMD High Action Display is indicative of not only the slew limitations of the currently assigned NVS sensor, but which sensor is assigned to the crewstation. If the LOS Reticle has exceeded the slew limitations of the NVS sensor currently assigned to the crewstation, even if the NVS mode is set to OFF, the HMD LOS Reticle will flash and "LIMITS" will be displayed within the Sight Status field of the High Action Display.



Acquisition Sources

The use of acquisition sources can reduce the time necessary to bring the HMD onto an intended target. When a target is detected using another sensor onboard the aircraft (to include visual detection by either crewmember), setting that sensor as the acquisition source and enabling the SLAVE function increases the efficiency of target acquisition within the HMD field-of-view.

However, since the HMD line-of-sight is solely directed by the crewmember's helmet position, "cueing" indications are displayed within the HMD symbology. When a valid acquisition source is selected, cueing dots will appear around the HMD LOS Reticle to cue the crewmember's head position to the corresponding direction of where the acquisition source is located.

HMD cueing is enabled within a crewstation any time the HMD is the selected sight and SLAVE is enabled. Within the CPG crewstation, SLAVE is toggled from the TEDAC Right Handgrip. However, since the Pilot crewstation does not have an option to selectively enable SLAVE, SLAVE is permanently enabled for the Pilot. The Pilot does have an option to disable the display of cueing dots within the HMD symbology from the WPN Utility sub-page.

Acquisition sources also reduce the amount of verbal communications and coordination of sensors that must occur between the crewmembers, which also increases combat efficiency. By replacing the verbal description of a target (or threat) using a verbose "description, direction, distance" with a concise "sight to source" command, target handovers between crewstations may become near instantaneous with a proficient aircrew. In addition,

cueing the opposite crewmember's helmet line-of-sight directly to the location of the acquisition source reduces the effects of inaccurate range estimations and removes the need for verbal descriptions of the intended target, obstacles or hazards to flight, or visual reference points.

An example of an inefficient obstacle handover during flight operations at night is shown below:

"Tower obstacle at 11 o'clock, approximately 2 kilometers, on our flight route along the right side of the valley."

The Pilot must look toward the approximate direction, visually trace their projected flight path along the right side of the valley and then locate the obstacle amongst any background clutter seen within the NVS FLIR video.

Examples of efficient handovers of obstacles or hazards utilizing HMD cueing to an acquisition source (such as the opposite crewmember's helmet sight) are shown below:

"Tower obstacle in 2 kilometers, my line-of-sight."

"Aircraft, my line-of-sight, on the horizon, come right to avoid."

In either case, the crewmember simply follows the cueing within their HMD symbology until the Cued LOS Reticle becomes visible, at which point they can see the precise location that is being referenced by the other crewmember's helmet sight, removing most of any ambiguity that exists.

Acquisition sources that will cue the HMD to a specific azimuth and elevation relative to the aircraft nose are listed below.

- **PHS.** Pilot Helmet Sight; cues the HMD to the line-of-sight of the Pilot's helmet. May be used to direct the CPG's HMD line-of-sight to the location designated by the Pilot's HMD LOS Reticle.
- **GHS.** Gunner Helmet Sight; cues the HMD to the line-of-sight of the Copilot/Gunner's helmet. May be used to direct the Pilot's HMD line-of-sight to the location designated by the CPG's HMD LOS Reticle.
- **SKR.** Seeker; cues the HMD to the line-of-sight of the next-to-shoot AGM-114 missile seeker. May be used to direct the crewmember's HMD line-of-sight to the target location that is currently being tracked by the next-to-shoot AGM-114 missile, possibly to confirm target identification prior to weapons release.
- **FXD.** Fixed forward; cues the HMD to align with the Armament Datum Line (ADL) at 0° in azimuth and -4.9° in elevation.
- **TADS.** Target Acquisition Designation Sight; cues the HMD to the line-of-sight of the TADS turret. May be used to monitor the TADS sensor position for situational awareness or coordinating weapon engagements.

Acquisition sources that will cue the HMD to a 3-dimensional location relative to the ownship position are listed below.

- **FCR.** Fire Control Radar; cues the HMD to the location of the next-to-shoot target designated on the FCR page. May be used to direct the crewmember's HMD line-of-sight to the location of the designated target for situational awareness or to engage the designated target while using HMD as the sight.
- **W##, H##, C##, T##.** Waypoint, Hazard, Control Measure, or Target/Threat point; cues the HMD to the coordinates of the selected point within the navigation database. May be used to direct the crewmember's HMD line-of-sight to a pre-planned, stored, or transmitted location for reconnaissance, visual identification, weapons engagement, or re-acquisition if line-of-sight was lost.
- **TRN.** Terrain point; cues the HMD to the coordinates of the selected terrain point within the navigation database. May be used to direct the crewmember's HMD line-of-sight to a cursor-selected location on the TSD that is not associated with an existing Waypoint, Hazard, Control Measure, or Target/Threat point for reconnaissance, visual identification, or weapons engagement.

Range Sources

Once a target has been visually acquired by the crewmember, the next and perhaps most critical step in ensuring a successful weapon engagement is determining an appropriate range source for the engagement. As the HMD line-of-sight can only determine a target's relative azimuth and elevation with respect to the aircraft's attitude, measuring the range to the target along the HMD line-of-sight provides the third dimension needed to determine the target's 3-dimensional position relative to the ownship.

Among the three sights (HMD, TADS, and FCR) that may be employed by the AH-64D aircrew for targeting, the HMD is roughly comparable to the TADS with regards to the available methods of ranging that may be employed. When a method of ranging is employed, this is called a "range source", and is displayed within the High Action Display in both Flight Symbology and Weapon Symbology.

The range sources that are available to either crewmember when using the HMD as the selected sight are shown below, from the most accurate to the least accurate.

- **Laser range (COOP mode).** Laser range is automatically entered as the range source any time the CPG fires the TADS LRFD to measure the slant range between the ownship and the target using reflected laser energy. Laser range is only displayed in the Pilot's HMD when employing rockets in a Cooperative mode.
- **Navigation range.** Navigation range is automatically entered as the range source any time the HMD is cued to a Waypoint, Hazard, Control Measure, Target/Threat, or a Terrain point. The slant range between the ownship and the corresponding point's navigational coordinates are calculated and is subject to the position confidence of the aircraft.
- **Automatic range.** Automatic range is selected from the WPN page by pressing MANRNG> (VAB B6) and entering "A" on the Keyboard Unit (KU) in place of a numerical value. Auto-range is determined by the radar altitude of the aircraft over the ground and the elevation "look-down" angle of the HMD line-of-sight.
- **Manual range.** Manual range is selected from the WPN page by pressing MANRNG> (VAB B6) and entering a numeric value on the Keyboard Unit.
- **Default range.** Default range is selected upon initial aircraft power-on, or any time the crewmember's current range source is no longer valid.

NOTE: When transitioning from using the TADS as the selected sight to using the HMD, it is possible for the Copilot/Gunner (CPG) to retain a static laser range as the range source. When the gun is actioned while the HMD is the selected sight, the range source will automatically revert to the Manual range within the crewstation. However, if intending to employ rockets using the HMD, a different range source should be considered that is appropriate for the given situation.

When determining which range source to utilize when the HMD is the selected sight, the common deciding factor will be whether the engagement is "deliberate" or "hasty" in nature. When conducting a deliberate engagement, the crew will typically have time to reliably calculate and/or store the target location, determine a reasonably accurate range from the intended weapon release point to the target, and employ a weapon system while the target is directly in front of the aircraft in optimal release parameters. In such situations, a dynamic range source such as a Navigation range to the target location or (when employing unguided rockets) Cooperative TADS laser ranging will provide a more accurate targeting solution. Automatic range is another dynamic range source that may be used but may not always be appropriate depending on the terrain the aircraft is operating over, or the resulting oscillations in calculated range caused by rapid head and/or aircraft movements.

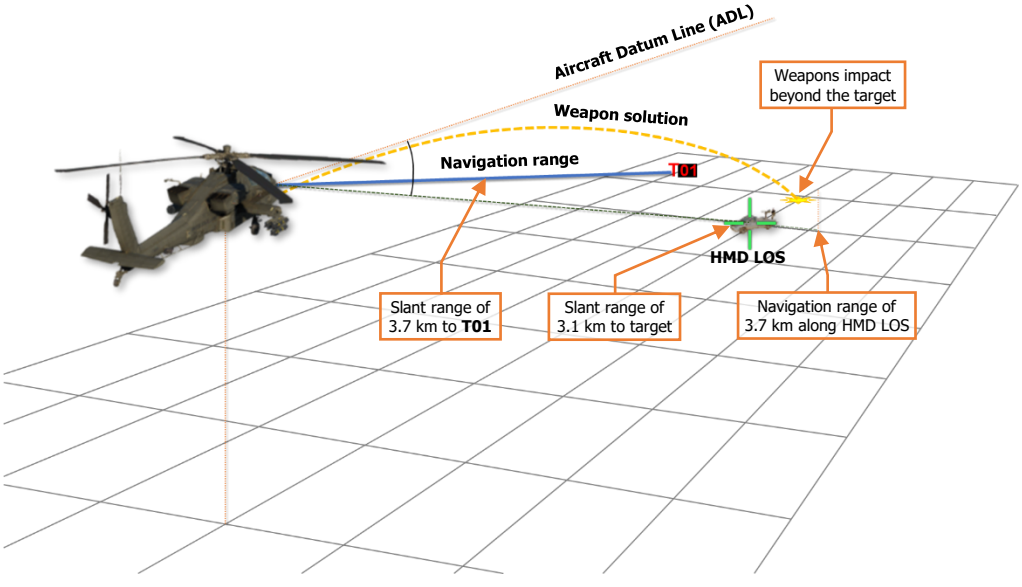
In many situations in which a crewmember is using the HMD as the selected sight to engage a close-range target in a hasty manner, a static range source such as Manual range is typically more appropriate since it allows the crewmember to rapidly adjust rounds onto the target without needing to change the acquisition source to employ a Nav range; nor is it subject to the errors with Auto-ranging when operating over un-even terrain or when the crewmember is rapidly moving his/her head. A Manual range is not dynamic and represents a fixed point in space to which weapon solutions are calculated. As such, the HMD elevation relative to the target will need to be manually adjusted to account for rounds that impact prior to or beyond the target (also referred to as landing "short" or "long").

Navigation Range

Navigation range is calculated by simply measuring the slant range between the ownship position and the coordinates of a point stored within the navigational database. Although a Nav range is more accurate than using Auto-ranging or Man-ranging, in that it is dynamically updated with aircraft movement and does not rely on flat terrain as is the case with Automatic range, Nav range may be somewhat inflexible when using the HMD as the selected sight for targeting.

Any time the acquisition source is set to a Waypoint, Hazard, Control Measure, Target/Threat, or Terrain point, the slant range to the corresponding point is entered as a Nav range (the SLAVE button must be pressed to update the HMD range source to a Nav range in the CPG crewstation). When employing weapons while using the HMD as the selected sight, a Navigation range is only preferred if the intended target is within close proximity to the coordinates of the point being referenced by the Nav range, or if employing area effect weapons against the general area surrounding the point.

In the figure below, the intended target is at a range to the ownship that is substantially closer than the point being referenced (T01) for the Nav range. In such a situation, rockets would impact beyond the target due to the equivalent slant range being applied along the HMD line-of-sight, placing the weapon solution beyond the target and below the surface plane. The HMD LOS Reticle would need to be displaced below the target within the HMD field-of-view to adjust the weapon solution in such a manner so that the weapon trajectory would intersect with the target location.



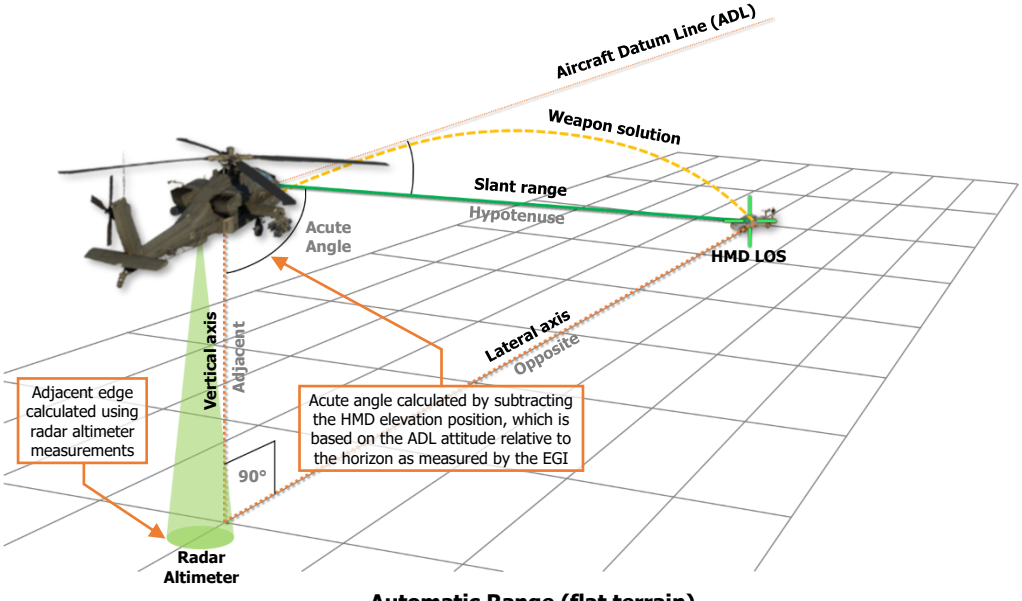
Navigation Range (ACQ set to T01)

The most common use cases for employing a Nav range are when the Pilot is employing unguided rockets with variable time delay fuzes independently of the CPG. Rocket types such as the M255A1 or M261 are dependent on an accurate range to target for their warheads to be effective. Unless fired in Cooperative mode with the CPG's TADS supplying an accurate laser range, the most accurate range source that can be used by the Pilot to achieve the desired warhead effects is a Nav range.

Automatic Range

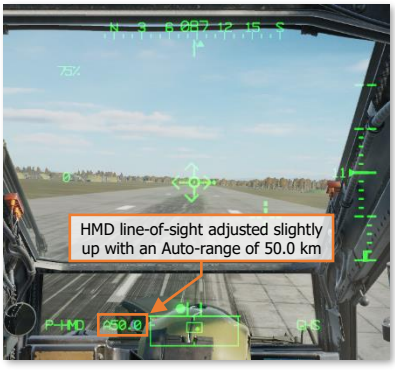
Automatic range is calculated using trigonometric ratios of right triangles, where the HMD look-down angle relative to the vertical axis between the aircraft and the surface below it is the acute angle; and the altitude above ground level (as measured by the radar altimeter) is the adjacent edge of the right triangle.

Using these two variables, along with an assumption the target is at an elevation equal to the that of the surface directly below the aircraft along a lateral axis that represents the opposite edge of the right triangle, the hypotenuse is calculated to determine the slant range to target. This calculation is performed continuously based on the HMD line-of-sight elevation and the radar altitude of the aircraft.



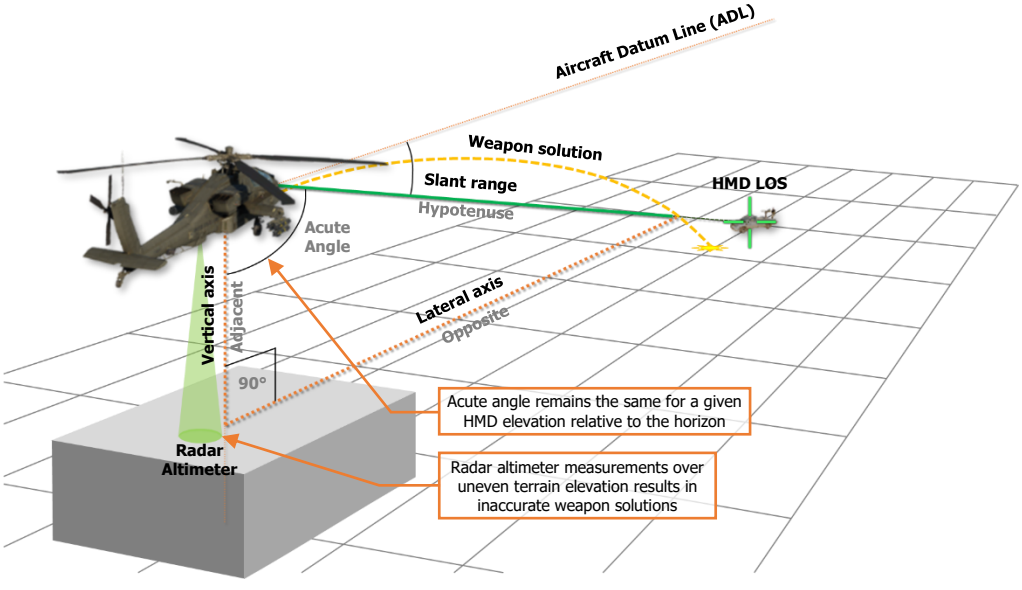
Automatic Range (flat terrain)

As the HMD line-of-sight (LOS) approaches the horizon and the look-down angles become quite shallow, the Auto-range calculations will become increasingly less precise due to the trigonometric ratios becoming quite large which is exacerbated if the aircraft is operating at very low altitudes over the surface.



Automatic range relies upon a functioning radar altimeter and will only be usable when the aircraft's altitude above ground level (AGL) is less than 1,428 feet (the maximum altitude that is capable of being measured by the radar altimeter).

It is important to note that the accuracy of Automatic range is predicated on the assumption that the target is at the same elevation as the surface directly below the aircraft. As this may not always be the case, using Auto-range for weapon engagements should only be performed in areas with minimal terrain relief, such as open plains, non-mountainous deserts, large plateaus, or basins. Auto-range should not be used when operating over mountains, rolling hills, or complex urban areas.

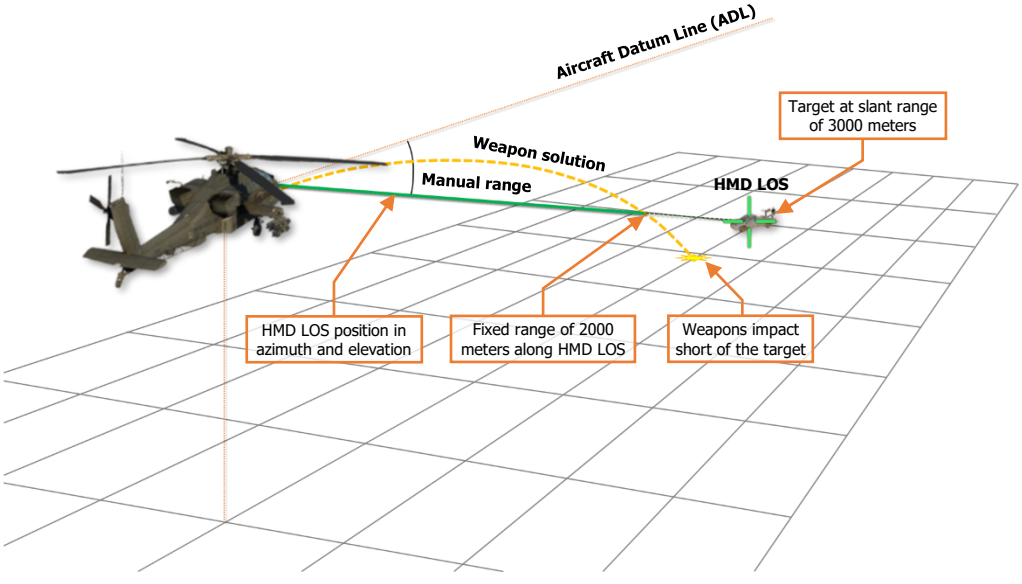


Automatic Range (elevation difference)

In situations where the terrain directly below the aircraft is at a significantly higher elevation than that of the intended target, it should be expected that any weapon solution generated using Auto-range will result in unguided, ballistic munitions such as rockets or gun rounds landing short of the target location. Likewise, in situations where the terrain directly below the aircraft is at a significantly lower elevation than that of the intended target, it should be expected that rockets or gun rounds will land long beyond the target location.

Manual/Default Range

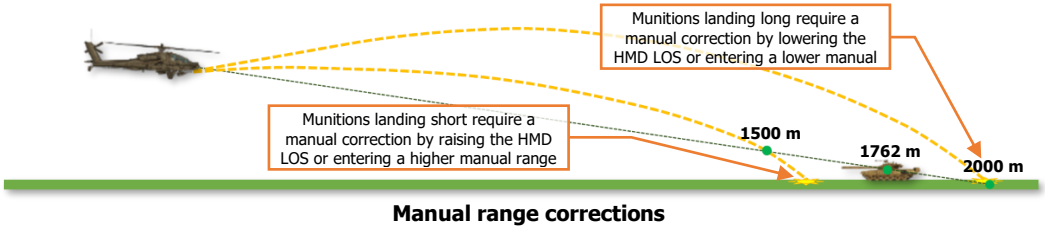
Manual range is the most inaccurate form of ranging when using the HMD. However, it is the most flexible ranging option when needing to engage targets in a hasty manner, and as a result is typically the preferred range source. When a manual range value is entered, the weapon solution will continue to update based on the HMD line-of-sight (LOS), but the range value will be to a fixed point in space along the LOS at the range entered on the WPN page.



Manual/Default Range

A Man-range is analogous to zeroing a rifle at a specific distance, and manually compensating for bullet drop by manually elevating the weapon sight higher or lower depending on the estimated range to the target relative to the range to which the rifle was zeroed.

- If the intended target is estimated to be at a range greater than the manual range value, the HMD LOS Reticle must be aimed above the target to compensate for the additional bullet (or rocket) drop.
- If the intended target is estimated to be at a range less than the manual range value, the HMD LOS Reticle must be aimed below the target to compensate for the reduced bullet (or rocket) drop.



Manual range corrections

NOTE: Default ranges for the Pilot and CPG are 1,500 and 3,000 meters respectively (displayed as "1.5" and "3.0"), but are essentially the same as using a corresponding manual range (displayed as "M1.5" and "M3.0").

HMD HAND CONTROLS

Either crewmember may use their respective Helmet Mounted Displays for targeting and engagement of enemy targets independently of the other crewstation. In addition, the CPG may use the HMD for storing points through the TSD Point sub-page. Night Vision System (NVS) controls are shown as PNVS (or TADS in NVS mode) would be required to employ the HMD as a sight during operations at night, although NVS mode in itself is not a sight.

Cyclic & Collective Controls

Either crewmember may select HMD as his or her sight on the Collective Mission Grip, with additional controls for selecting Flight symbology modes on the cyclic and NVS sensor controls on the Collective Flight Grip.

TEDAC Controls

When the CPG is not using the flight controls, TEDAC controls may be used in conjunction with the HMD to avoid interfering with the Pilot's operation of the cyclic and collective.

TARGET ACQUISITION DESIGNATION SIGHT (TADS)

US Army photo
by SSG Thomas Mort

AN/ASQ-170 MODERNIZED TARGET ACQUISITION DESIGNATION SIGHT

The AN/ASQ-170 TADS was originally designed by Martin Marietta and was selected to provide the primary sighting and sensor system for the AH-64A, and remained in use by the AH-64D during the early years of its service. The subsequent upgrade to the M-TADS standard by Lockheed Martin includes targeting enhancements that increase the range and resolution that the AH-64D can detect and engage targets.

The Direct View Optics (DVO) sensor was subsequently removed during later development of the AH-64D, although the corresponding aperture within the sensor turret itself remains.

TADS Activation

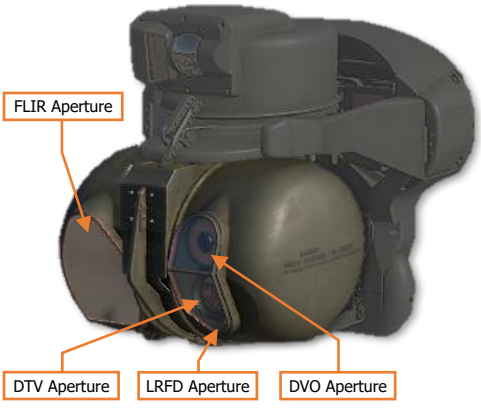
The TADS is automatically initialized when the APU is powered on. If necessary, the TADS can be selectively powered on or off from the CPG station by pressing VAB L4 on the WPN Utility sub-page (shown at right), or from either crewstation on the DMS Shutdown sub-page.

Although the TADS is automatically initialized on APU power, the laser rangefinder/designator (LRFD) requires manual activation by pressing VAB L6. The FLIR camera may be independently powered on or off by pressing VAB L5, and the TADS turret may be stowed by pressing VAB R4.

Forward-Looking Infrared (FLIR)

The FLIR camera enables the AH-64 to detect, identify and engage enemy targets in any lighting conditions. Although primarily used during night operations, the FLIR is equally capable during daylight hours. The Modernized-TADS (MTADS) upgrade replaced the legacy FLIR sensor with a modern FLIR with improved resolution and range.

The TADS FLIR camera includes three optical fields-of-view (Wide, Medium, and Narrow) with incrementally increased magnification. A fourth field-of-view (Zoom) is available that electronically enlarges the Narrow field-of-view by 50%. The Zoom field-of-view (FOV) does not provide increased resolution but does facilitate better aiming precision of the laser rangefinder/designator (LRFD) at longer ranges.



TADS Sensor Turret

Daytime Television (DTV)

The DTV is a monochromatic (black and white) television camera that enables the AH-64 to engage targets at long-range during daylight hours only. Although the DTV only includes two optical fields-of-view (Wide and Narrow) and is less versatile than the FLIR camera, the magnification levels of the DTV surpass those of the FLIR, allowing the DTV to identify and designate targets at a further distance than what is possible with the FLIR. Like the FLIR, the DTV includes an additional Zoom field-of-view that electronically enlarges the Narrow field-of-view by 50%.

Laser Rangefinder/Designator (LRFD)

The LRFD uses focused laser energy to precisely measure range to target locations, and employs crew-selectable pulsed repetition frequencies (PRF) to designate targets for laser-guided munitions, such as the AGM-114 missile. Laser returns from the TADS LRFD are processed between a minimum range of 500 meters to a maximum range of 9,999 meters. In addition to providing ranging data for ballistics computations, continuous laser designations may be used to employ lead-angle compensation when engaging moving targets with the 30mm Area Weapon System (AWS) or unguided rockets in Cooperative rocket mode.

The LRFD may be employed in range-finding mode by pulling the LRFD trigger on the TEDAC Right Handgrip to the 1st detent, or in ranging and designation mode by pulling the LRFD trigger to the 2nd detent.

(See the WPN Code and WPN Frequency sub-pages in the Weapon Employment chapter for more information regarding setting the LRFD laser code.)

Laser Spot Tracker (LST)

The LST may be employed in lieu of the LRFD to detect other laser designations within a tactical environment when using known PRF codes. Like the LRFD, the specific laser PRF code the LST will scan for is crew-selectable from the cockpit at any time during the mission, and may be used as an efficient method for handing over target locations to the AH-64 from ground-based designators or other aircraft, such as the AH-64's own team members.

(See TADS Targeting Modes for more information regarding LST operation. See the WPN Code and WPN Frequency sub-pages in the Weapon Employment chapter for more information regarding setting the LST laser code.)

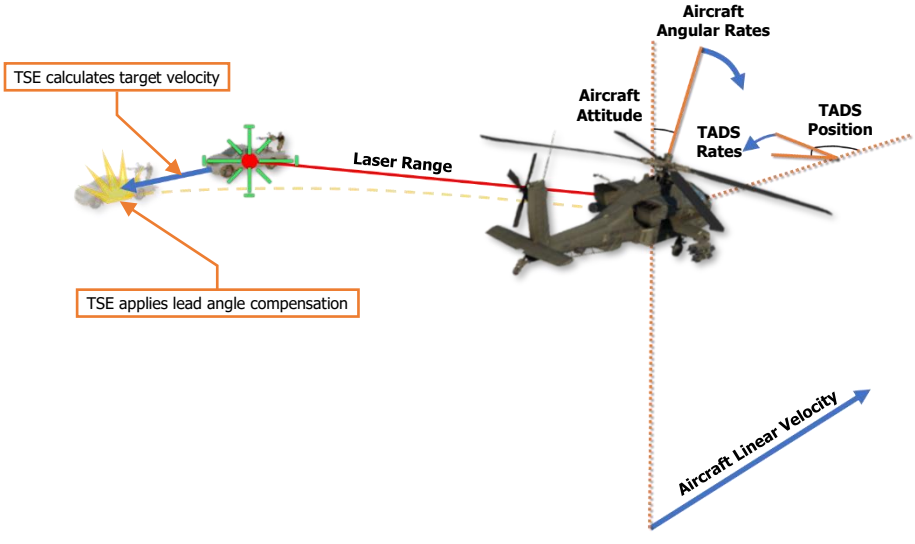
Sight Stabilization and Slew Rate Damping

The TADS electronics provide automatic sight stabilization to compensate for aircraft angular rates. In addition, angular slew rates of the TADS turret itself are dampened based on the currently selected optical/electronic field-of-view to enhance precision targeting. As the Copilot/Gunner (CPG) incrementally steps through each successive field-of-view from Wide to Zoom, the angular rate gains from Sight Manual Tracker (MAN TRK) inputs are incrementally reduced to compensate for the higher magnification levels of TADS video.

Target State Estimator (TSE)

Although the Target State Estimator calculations are performed by the AH-64D's targeting systems and is not technically part of the TADS itself, the TSE is a key element when the TADS is being used to employ unguided, ballistic munitions against moving targets on the battlefield.

The TSE utilizes linear velocities and attitude rates from the aircraft EGI's, TADS turret position and angular slew rates, and laser range data to calculate and separate true target velocities from the aircraft velocities and rates. Once the true target velocity is calculated, the TSE can determine the appropriate lead-angle compensation for the selected weapon system. This automatic lead angle compensation requires the Copilot/Gunner to simply maintain the TADS line-of-sight on the target and perform a continuous laser designation to accurately employ the Area Weapon System or provide accurate rocket steering for the Pilot when in Cooperative rocket mode.



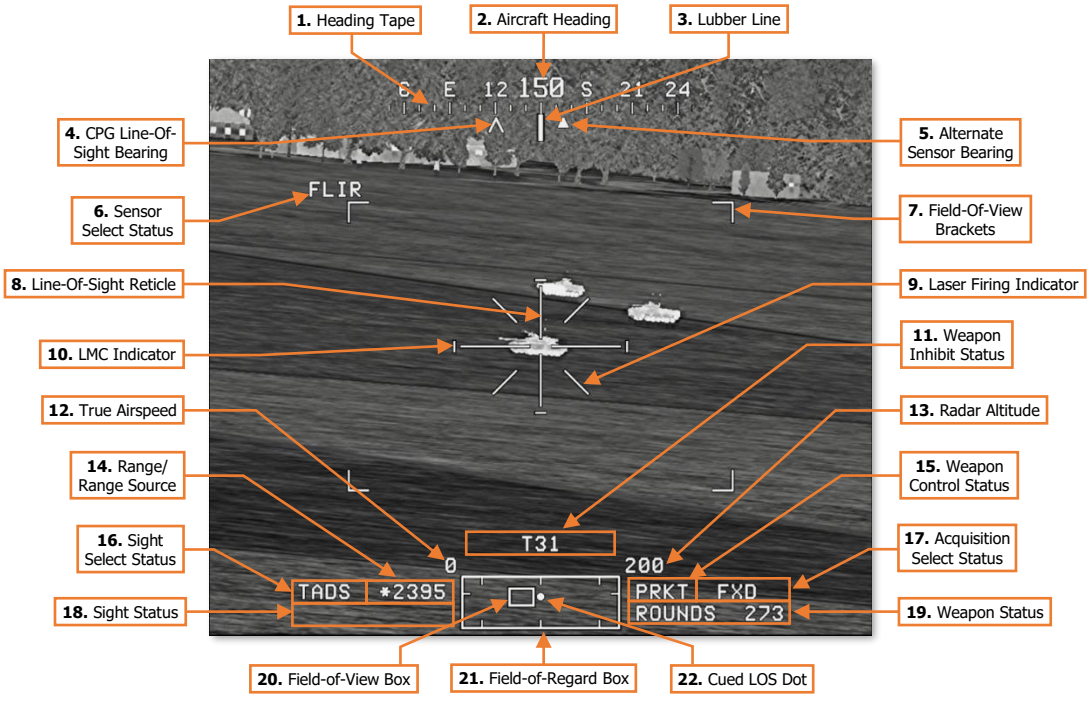
Target State Estimator (TSE) Lead Angle Compensation

When the laser ceases designation, the TSE will enter a "laser memory" mode for 14 seconds. During this period, the mean rate of change of ranging measurements that existed prior to the termination of laser designation are dynamically maintained to permit the TSE to continue providing lead angle compensation. All other variables such as linear velocities and angular rates are utilized by the TSE in real-time to calculate the true target velocity.

After the 14 seconds has elapsed, the laser range value will become static until the LRFD is fired again or a different range source is utilized. Any time a dynamic laser range is not available, whether the 1st detent of the LRFD trigger is used or 14 seconds has elapsed since the 2nd detent of the LRFD trigger was used, or if any other range source is utilized, TSE lead angle compensation will be unavailable. However, regardless of whether the TSE is providing lead angle compensation or not, ballistic compensation will always be provided for factors such as range to target and aircraft movement when the TADS is being used as the selected sight.

TADS WEAPON SYMBOLOGY

If the Copilot/Gunner's selected sight is TADS, TADS sensor video is displayed on the CPG's HDU and TDU, overlaid with TADS Weapon symbology. Weapon symbology includes several symbology elements that are common with HMD Flight symbology, such as the HMD High Action Display.



1. **Heading Tape.** Displays a 180° hemisphere of magnetic headings. Major tick marks are displayed in 30° increments and marked by a cardinal direction or heading in the tens value. Minor tick marks are displayed in 10° increments.
2. **Aircraft Heading.** Displays a digital readout of the aircraft's current magnetic heading in 1° increments, superimposed over the Heading Tape.
3. **Lubber Line.** The Lubber Line is aligned to the centerline of the aircraft and serves as a reference for the aircraft heading.
4. **CPG Line-of-Sight Bearing.** Displays the bearing of the Copilot/Gunner's selected sight on the Heading Tape when the CPG's selected sight is HMD or TADS.
5. **Alternate Sensor Bearing.** Displays the bearing of the Pilot's helmet sight on the Heading Tape when the Pilot's selected sight is set to HMD.
6. **Sensor Select Status.** Indicates the selected TADS sensor when the CPG's selected sight is TADS.
   - **FLIR.** The Forward-Looking Infrared camera is selected as the current TADS sensor.
   - **DTV.** The Daytime Television camera is selected as the current TADS sensor.

7. **Field-Of-View Brackets.** Indicates the relative area that can be seen by the currently selected TADS sensor if the next narrower field-of-view is selected. If Zoom FOV is selected, no further fields-of-view are available and the Field-Of-View Brackets are removed from the TADS video.

8. **Line-Of-Sight Reticle.** Indicates the TADS sensor line-of-sight (LOS). When the CPG's selected sight is TADS, the LOS Reticle is used as an aiming crosshair for weapons employment and laser designation.

   The LOS Reticle flashes when the selected sight's LOS is invalid or has reached its slew limit.

9. **Laser Firing Indicator.** Displayed continuously any time the Laser Rangefinder/Designator (LRFD) is firing.

10. **LMC (Linear Motion Compensation) Indicator.** Displayed when Linear Motion Compensation is enabled.

11. **Weapon Inhibit Status.** Displays any pertinent safety or performance inhibits that may affect weapons employment, based on the currently actioned weapon within the crewstation.

    If the CPG stores a Waypoint or Target point by placing the STORE/UPDT switch on the TEDAC Left Handgrip to the STORE position, "W##" or "T##" (respectively) will be displayed in the Weapon Inhibit Status field for 4 seconds, where ## indicates the specific point number to which the Waypoint or Target location has been stored.

12. **True Airspeed.** Indicates the true airspeed (TAS) of the aircraft in 1 knot increments, from 0 to 210 knots.

13. **Radar Altitude.** Indicates the radar-detected altitude above ground level from 0 to 1,428 feet. The Radar Altitude is displayed in increments of 1 foot from 0 to 50 feet in altitude, and increments of 10 feet between 50 feet and 1,428 feet in altitude.

    The Radar Altitude is not displayed when the altitude exceeds 1,428 feet above ground level.

14. **Range Source/Range.** Displays the range source in use and the current range in tenths of kilometers, or meters if the range source is the LRFD.

    - **Default range.** Default range is selected upon initial aircraft power-on, or any time the crewmember's current range source is no longer valid. The Default range for the Pilot is 1.5 km, and 3.0 km for the CPG (displayed as "1.5" and "3.0" respectively).
    - **Manual range.** Manual range may be selected and modified on the WPN page and may be set in 1-meter increments between 100 and 50,000 meters (displayed as "M0.1" to "M50.0").
    - **Automatic range.** Auto range may be selected on the WPN page and provides dynamic range calculations between 0.1 km and 50 km (displayed as "A0.1" to "A50.0").
    - **Navigation range.** Navigation range is automatically entered as the range source any time the crewmember's sight is slaved to an acquisition source that has been set to a stored point within the navigational database. A Nav range is dynamically updated to reflect the current slant range between the aircraft and the point set as the acquisition source, between 0.1 km and 32 km (displayed as "N0.1" to "N32.0").
    - **Radar range.** Radar range is automatically entered as the range source any time the crewmember's selected sight is set to FCR. A radar range is dynamically updated to reflect the current slant range between the aircraft and the Next-To-Shoot FCR target, between 0.0 km and 9.9 km (displayed as "R0.0" to "R9.9").
    - **Laser range.** Laser range is automatically entered as the range source any time the CPG fires the LRFD. The laser range is displayed in 1-meter increments between 500 and 9,999 meters (displayed as 500 to 9999). An asterisk (∗) is displayed to the left of the laser range any time the LRFD is firing and processing a stable laser return from the object or surface within the TADS Line-of-Sight Reticle.

15. **Weapon Control Status.** Indicates the opposite crewmember's actioned weapon system. If the Weapon Control Status field is blank, no weapon system is actioned by the opposite crewmember.

- **PGUN.** Displayed in the CPG's symbology to indicate the Pilot's actioned weapon is the gun.
- **PRKT.** Displayed in the CPG's symbology to indicate the Pilot's actioned weapon is rockets.
- **PMSL.** Displayed in the CPG's symbology to indicate the Pilot's actioned weapon is missiles.
- **CGUN.** Displayed in the Pilot's symbology to indicate the CPG's actioned weapon is the gun.
- **CRKT.** Displayed in the Pilot's symbology to indicate the CPG's actioned weapon is the rockets.
- **CMSL.** Displayed in the Pilot's symbology to indicate the CPG's actioned weapon is the missiles.
- **COOP.** Displayed in both crewmember's symbology to indicate both crewmembers' actioned weapon is rockets, in Cooperative mode.

16. **Sight Select Status.** Indicates the sight currently selected within the crewstation.

- **P-HMD**. Displayed in the Pilot's symbology when the Pilot's selected sight is HMD.
- **P-FCR.** Displayed in the Pilot's symbology when the Pilot's selected sight is FCR.
- **P-FCRL.** Displayed in the Pilot's symbology when the Pilot's selected sight is FCR with the TADS linked to the FCR Next-To-Shoot (NTS) target location.
- **C-HMD.** Displayed in the CPG's symbology when the CPG's selected sight is HMD.
- **C-FCR.** Displayed in the CPG's symbology when the CPG's selected sight is FCR.
- **C-FCRL.** Displayed in the CPG's symbology when the CPG's selected sight is FCR with the TADS linked to the FCR Next-To-Shoot (NTS) target location.
- **TADS.** Displayed in the CPG's symbology when the CPG's selected sight is TADS.
- **TADSL.** Displayed in the CPG's symbology when the CPG's selected sight is TADS with the FCR linked to the azimuth of the TADS line-of-sight.

17. **Acquisition Select Status.** Indicates the acquisition source currently selected within the crewstation.

- **PHS.** When slave is enabled, the currently selected sight will slave to the azimuth and elevation of the Pilot's Helmet Sight.
- **GHS.** When slave is enabled, the currently selected sight will slave to the azimuth and elevation of the Copilot/Gunner's Helmet Sight.
- **SKR.** If the next-to-shoot AGM-114 is tracking a laser designation or target in LOBL mode when slave is enabled, the currently selected sight will slave to the azimuth and elevation of the missile seeker.
- **FCR.** When slave is enabled, the currently selected sight will slave to the location of the Next-To-Shoot (NTS) target detected by the Fire Control Radar. This option is only displayed if the FCR mast-mounted assembly is installed and the FCR is powered.
- **FXD.** When slave is enabled, the currently selected sight will slave to a fixed forward direction along the Armament Datum Line (ADL, 0° in azimuth/-4.9° in elevation).
- **W##, H##, C##, T##.** When slave is enabled, the currently selected sight will slave to the location of the Waypoint, Hazard, Control Measure, or Target/Threat point set as the acquisition source within the crewstation, and the range source will switch to a Navigation range equal to the slant range between the aircraft and the selected point. ## indicates the specific point number to which the Waypoint, Hazard, Control Measure, or Target/Threat point has been stored.
- **TRN.** When slave is enabled, the currently selected sight will slave to the location of the terrain location cursor-selected on the TSD within the crewstation, and the range source will switch to a Navigation range equal to the slant range between the aircraft and the Terrain point.

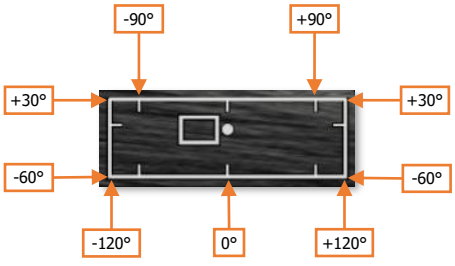
18. **Sight Status.** Displays status messages regarding the currently selected sight within the crewstation and the employment of laser-guided AGM-114 missiles when launched in a Remote Fire mode.

19. **Weapon Status.** Displays status messages regarding the currently actioned weapon within the crewstation.

20. **Field-Of-View (FOV) Box.** The FOV box indicates the relative position of the TADS line-of-sight within the larger Field-of-Regard box. The FOV box represents a 30° x 40° field of view and is driven by the TADS sensor turret position.

21. **Field-Of-Regard (FOR) Box.** The FOR box indicates azimuth limits for the TADS sensor turret. Tick marks around the edges of the TADS FOR box mark 0° and ±90° in azimuth, and 0° elevation.

22. **Cued Line-Of-Sight Dot.** Indicates the relative location of the selected acquisition source within the Field-of-Regard box.



TADS Field-Of-Regard Format

TADS Sight Status Messages

The following status messages pertain to the use of the TADS as the selected sight within the crewstation and when employing AGM-114K SAL missiles in which an offboard source of laser designation is providing terminal guidance.

SIGHT STATUS	CONDITION	CORRECTIVE ACTION
FIXED	The TADS turret has been slaved to fixed forward (FXD)	CPG should press the SLAVE button to de-slave the TADS turret, if required.
FLIR OFF	The TADS FLIR has been powered off.	CPG should power the TADS FLIR on the WPN Utility sub-page, if required for targeting or NVS operations.
LIMITS	The TADS has encountered a slew limitation.	Adjust the TADS turret position to within the slew limits to regain the ability to fire the LRFD.
REMOTE	The SAL missile channel that has been designated as the Priority channel does not match the laser code set to the TADS LRFD.	Set the Priority channel to the same laser code set to the TADS LRFD to perform an autonomous (self-lasing) missile engagement. Coordinate with an offboard source of laser designation to provide terminal guidance for the next SAL missile. Ensure the source is using a laser code that corresponds with that set as the Priority channel.
TARGET DATA?	RF missiles have been actioned while the TADS is the selected sight, but a target handover has not been performed.	Designate the intended target for 3 seconds to perform a target handover to the next RF missile.

TADS Weapon Inhibit Messages

The following conditions will result in momentary TADS-related messages being displayed within the CPG's Weapon Inhibit data field of the High Action Display. These messages are for informational purposes only and have no effect on the function or employment of any weapon systems.

MESSAGE	CONDITION	CORRECTIVE ACTION
ALL TRKS DEL	TADS automatic tracking has been commanded to delete all tracks.	None required.
TRK # DEL	TADS automatic tracking has been commanded to delete the numbered track.	None required.
TRK # DROP	TADS automatic tracking is unable to maintain the numbered track.	None required.
T##	A Target (TG) point has been stored in the numbered index within the TGT/THRT partition.	None required.
W##	A Waypoint (WP) has been stored in the numbered index within the WPTHZ partition.	None required.

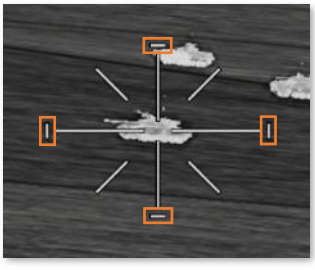
TADS TARGETING MODES

The TADS may be utilized with several targeting modes to assist the Copilot/Gunner (CPG) in performing targeting operations against enemy target locations. Targeting modes consist of Linear Motion Compensation (LMC), Image Auto-Track (IAT), and Laser Spot Track (LST). These targeting modes reduce the workload of the CPG when using the TADS but do not directly affect the operation of any weapon system on the aircraft.

Linear Motion Compensation (LMC)

Linear Motion Compensation provides additional stabilization of the TADS to compensate for linear movement of the aircraft or the target.

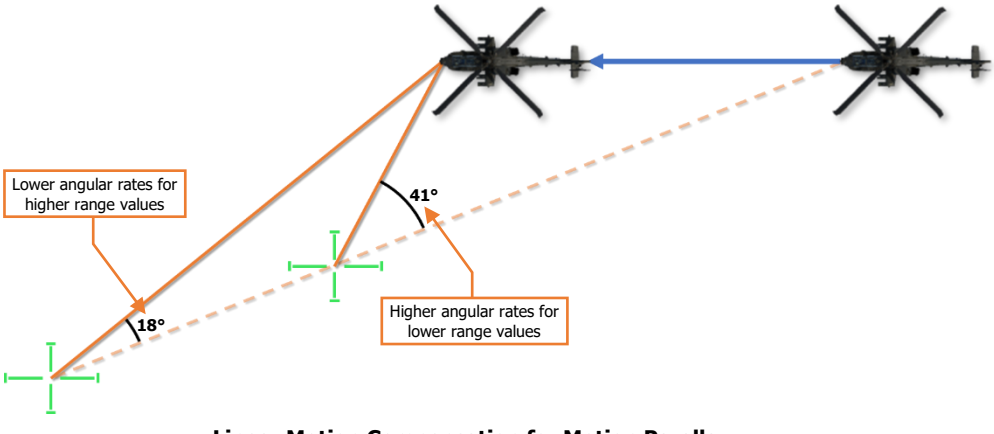
When LMC is disabled, the slew rates of the TADS turret are based on raw input magnitudes received from the force-sensing Sight Manual Tracker (MAN TRK, also called the "thumb force controller") on the TEDAC Right Handgrip. When no force is applied to the Sight Manual Tracker, the angular slew rates of the TADS turret are dampened in azimuth and elevation. When thumb force is applied, the TADS turret slew rate will increase as the force magnitude increases and will correspondingly decrease as force magnitude decreases.



LMC Indicator

When LMC is enabled, indicated by the presence of the LMC Indicator around the TADS Line-Of-Sight Reticle, angular slew rates of the TADS turret are maintained until modified by CPG input or alternate steering commands by the TADS electronics themselves. When no force is applied to the Sight Manual Tracker, the angular slew rates of the TADS turret are maintained. When thumb force is applied, the TADS turret slew rate will increase at a rate corresponding to the force magnitude applied to the Sight Manual Tracker.

LMC automatically converts angular rates based on the current range value utilized by the TADS to compensate for motion parallax. As the range increases or decreases, the LMC will automatically adjust the TADS slew rate to maintain the calculated angular velocity at the corresponding range. As targets that are closer in range will have a higher angular rate compared to targets further away, the LMC will increase the TADS slew rate to compensate. In addition, angular rate gains from Sight Manual Tracker input force magnitudes will accordingly scale based on the current range value.



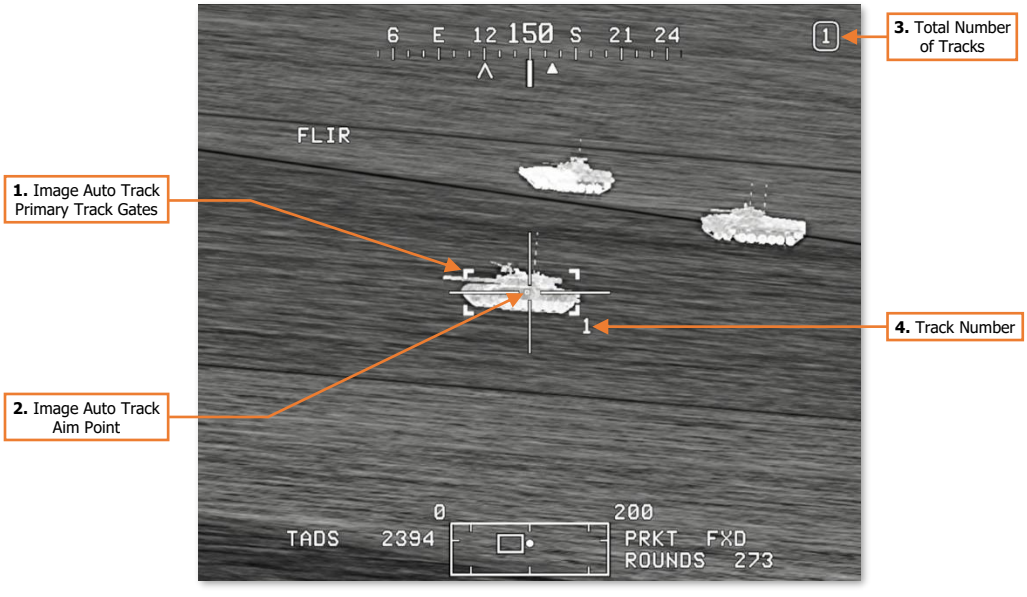
Linear Motion Compensation for Motion Parallax

Image Auto-Track (IAT)

IAT is an automatic tracking mode that allows the TADS to automatically maintain the Line-Of-Sight (LOS) Reticle on battlefield targets. Unlike the previous generation of TADS in which the IAT tracking logic relied purely on object contrast amongst its background, the digital tracking logic within the M-TADS uses the scene content within the video source to lock onto distinct features.

Additionally, the digital IAT will automatically enter an inertial track and "coast" in the event weapons fire, smoke, obscurance, or explosions on the battlefield interfere with its ability to maintain track. This inertial track logic prevents the M-TADS from locking on to an unintended target or nearby object when a break lock occurs, which was characteristic of previous versions of TADS that functioned purely on contrast tracking.

When the IAT/OFS switch on the TEDAC Left Handgrip is momentarily set to the IAT position, an track is initiated on the target underneath the TADS LOS Reticle. When this occurs, a set of four brackets, called the Primary Track Gates, are placed around the tracked object, a Track Number is placed below the tracking gates, and the total number of tracks is updated in the top right corner of the TADS symbology.



1. **Image Auto Track Primary Track Gates.** Indicates the primary tracked target. When the TADS LOS reticle is within the boundaries of the Primary Track Gates, the gates are bolded.
2. **Image Auto Track Aim Point.** Displayed within the Primary Track Gates to indicate the precise location the IAT will maintain the TADS LOS Reticle after the track is established and when returning the LOS Reticle from an offset position.
3. **Track Number.** Indicates the assigned track number for the primary tracked target.
4. **Total Number of Tracks.** Indicates the total number of tracked targets, out of a maximum of 3. (See Multi-Target Tracker for more information.)

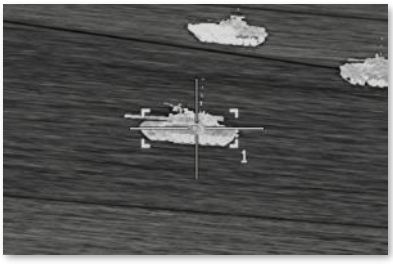
Once a new primary track is established, the TADS will automatically maintain the LOS Reticle over the IAT Aim Point until a slew is commanded. If the Copilot/Gunner (CPG) inputs a slew using the Sight Manual Tracker, the TADS LOS is released from automatic slewing and may be manually slewed until the TADS is commanded to return to the primary track using the OFS position of the IAT/OFS switch.

The specific functionality of the IAT/OFS switch will vary depending on whether the TADS LOS Reticle is within the boundaries of the Primary Track Gates, signified by the gates themselves becoming bolded. Additionally, the commanded function when set to the OFS position is dependent on the duration of the press.

S Short press (<0.5 sec)
L Long press (>0.5 sec)

When the LOS Reticle is within the boundaries of the Primary Track Gates, the following commands apply:

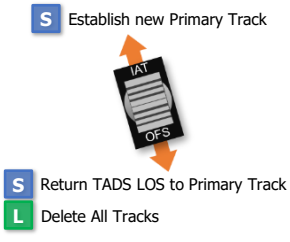
- IAT position will update the Aim Point location within the Primary Track Gates to the current centroid of the TADS LOS Reticle.
- OFS position for less than 0.5 seconds will delete the primary track.
- OFS position for greater than 0.5 seconds will delete all tracks.

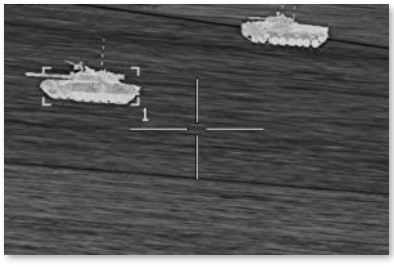


TADS LOS Reticle inside Primary Track Gates

When the LOS Reticle is outside the boundaries of the Primary Track Gates, the following commands apply:

- IAT position will establish a new primary track and initiate automatic slew for target tracking.
- OFS position for less than 0.5 seconds will return the TADS LOS Reticle to the primary track's Aim Point and initiate automatic slew for target tracking. A subsequent press to the OFS position prior to arriving within the Primary Track Gates will revert to manual tracking.





TADS LOS Reticle outside Primary Track Gates

- OFS position for greater than 0.5 seconds will delete all tracks.

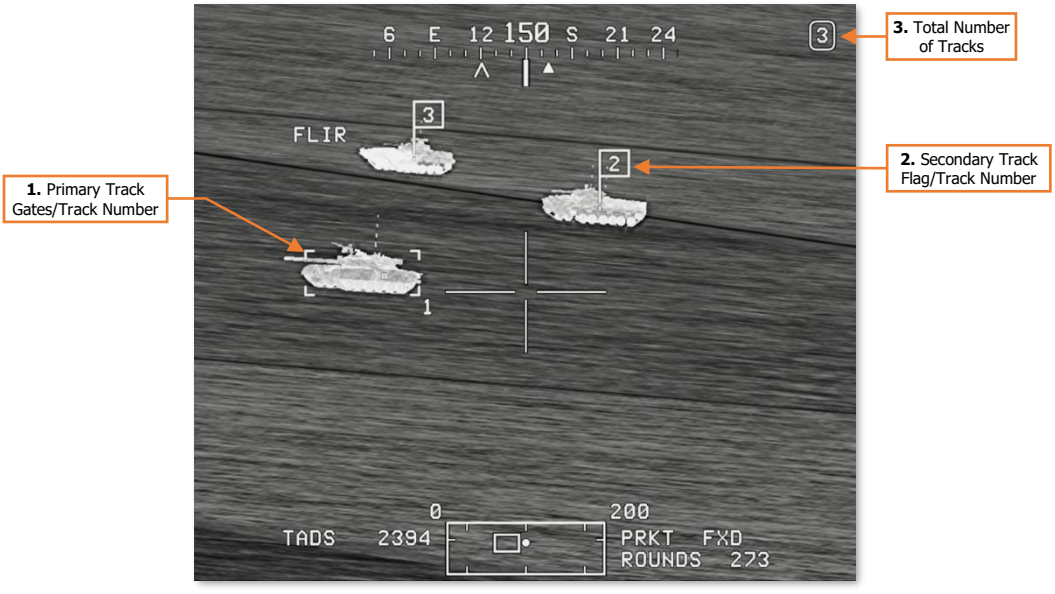
Additional details regarding the Image Auto-Track are shown below.

- Target tracking is only performed in one TADS sensor at a time. If a track is established while the selected TADS sensor is set to FLIR, the track will continue to be tracked within the FLIR camera, even if the CPG selects DTV using the Sensor Select switch on the TEDAC Left Handgrip, and vice versa.
- Once a primary track has been established, the TADS turret may only be slewed to the extent that the primary track can be maintained within the current optical field-of-view of the TADS sensor within which the automatic tracking is being performed.
- Target tracking is limited to objects that occupy between 0.75% to 50% of the tracking sensor's field-of-view. If the object being tracked is too small or too large within the current optical field-of-view, a track cannot be established, and an existing track will switch to inertial tracking.

Due to the combination of these factors, FLIR is better suited for maintaining multiple tracks due to its wider field-of-view, especially for tracks that are widely spaced on the battlefield, or for retaining the primary track within the field-of-view when a significant offset slew is desired. However, the DTV is better suited for maintaining tracks at longer range due to its higher magnification levels.

Multi-Target Tracker (MTT)

The M-TADS digital tracker is capable of maintaining an image auto-track on up to three separate targets, a single primary track and two secondary tracks. When being used in this manner, the tracking and slew logic and the IAT/OFS switch functions remain the same but are only referenced to primary track.



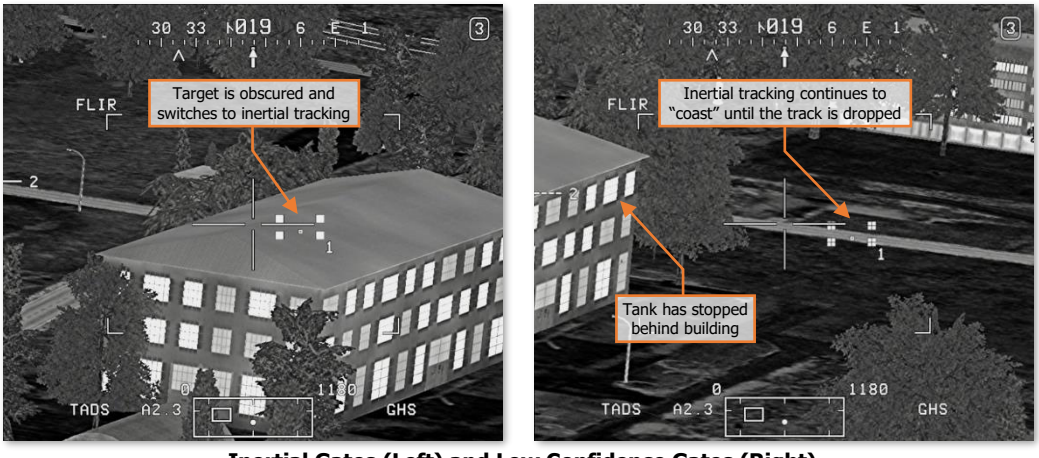
1. **Primary Track Gates/Track Number.** Indicates the primary tracked target and track number.
2. **Secondary Track Flag/Track Number.** Indicates the secondary tracked target(s) and track number(s).
3. **Total Number of Tracks.** Indicates the total number of tracked targets, out of a maximum of 3.

Any time a new track is established, the new track is designated as the primary track, and the existing primary track is demoted to a secondary track. An existing secondary track may be promoted back to primary track at any time using one of two methods.

- Manually slew the LOS Reticle over the desired track and momentarily press the IAT/OFS switch to the IAT position. This will promote the secondary track under the LOS Reticle to primary track, update the Aim Point of the new primary track, and automatic slewing will be performed until another secondary track is promoted or the Copilot/Gunner inputs a slew using the Sight Manual Tracker. (See TEDAC Left Handgrip for more information.)
- Set the MTT Promote switch to the + or – positions to promote the secondary tracks to primary track in a cyclic pattern. When a secondary track is promoted to the primary track using the MTT Promote switch, the TADS LOS Reticle will be slewed to the Aim Point of the new primary track and automatic slewing will be performed until another secondary track is promoted or the Copilot/Gunner inputs a slew using the Sight Manual Tracker. (See TEDAC Right Handgrip for more information.)

Inertial Tracking

In the event weapons fire, smoke, obscurance, or explosions on the battlefield interfere with the automatic tracking of the primary or secondary tracks, the track will enter an inertial tracking sub-mode. In this mode, the track will "coast" along its previous path for a short period before the track is dropped altogether. If the track is reacquired while in inertial track, automatic tracking will resume.



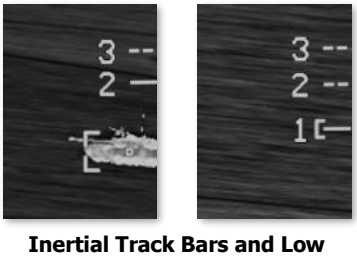
Inertial Gates (Left) and Low Confidence Gates (Right)

- If the primary track has switched to inertial tracking, the Primary Track Gates will be replaced by the Inertial Gates. After 5 seconds of inertial tracking, the Inertial Gates will be replaced by the Low Confidence Gates.
- If a secondary track has switched to inertial tracking, the Secondary Track Flag will become dashed to indicate inertial tracking. After 5 seconds of inertial tracking, the Secondary Track Flag will become dotted to indicate low confidence.
- If the track is not reacquired within 10 seconds of inertial tracking, the track will be dropped and "TRK # DROP" will be displayed in the Weapon Inhibit Status field, where # is the number of the track that has been dropped.

Inertial Track Flag

If the primary or secondary tracks are forced outside the TADS field-of-view, the Primary Track Gates and/or Secondary Track Flags are replaced by bars along the edge of the video to indicate the location of the tracks relative to the TADS field-of-view.

- When a track has been forced outside the TADS field-of-view, a solid bar will be displayed along the edge of the TADS video with the associated track number.
- After 5 seconds of inertial tracking, the bar will become dashed to indicate low confidence.
- A bracket will be displayed next to the bar to indicate which track is the primary track.



Inertial Track Bars and Low Confidence Bars

Laser Spot Track (LST)

The LST may be configured to search for and track pulsed laser designations using standard PRF codes independently of the ownship's LRFD code. The Laser Spot Tracker is enabled using the LT switch on the TEDAC Right Handgrip. When set to the A position, the LST is enabled and set to automatic mode. When set to the M position, the LST is enabled and set to manual mode. When set to the O position, the LST is disabled.

NOTE: The TADS laser rangefinder/designator (LRFD) cannot be fired while the LST is enabled.

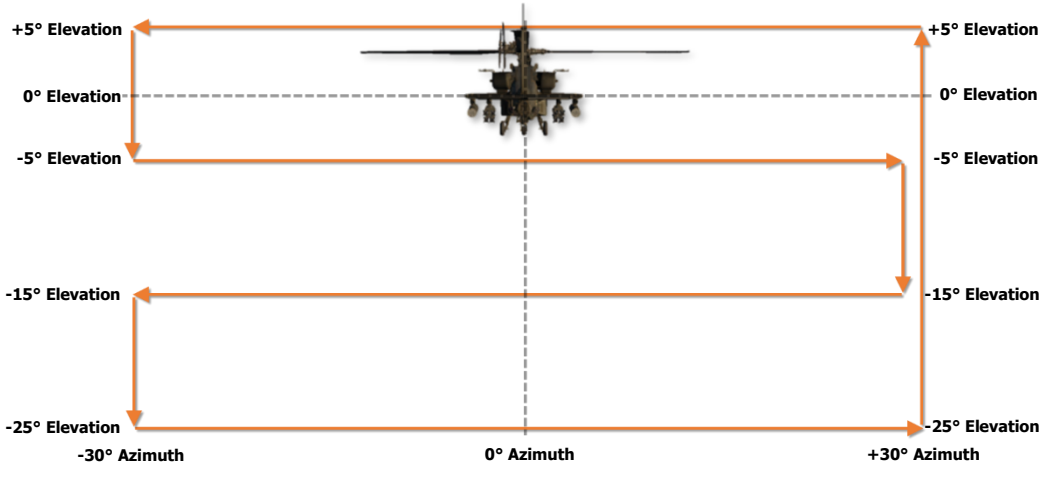
When the LST is employed, the Multi-Target Tracker will continue to perform automatic tracking of the primary and secondary tracks if the respective tracks remain within the optical field-of-view of the TADS sensor. However, if the tracks are forced outside the TADS field-of-view while LST operations are being performed, the tracks will enter inertial track, and may eventually be dropped.

Automatic Mode

When the LST is enabled in the automatic mode, the TADS will enter a continuous, 4-bar azimuth/elevation scan pattern until a laser designation matching the PRF code assigned to the LST is detected, or the LST is disabled. Once a matching laser designation is detected, the TADS will slew to and track the laser designation. If the laser designation is lost, the TADS will resume the 4-bar scan.

NOTE: It is advisable that the LST be disabled prior to instructing the designating platform to cease lasing. If the laser designation is lost before the LST is disabled, the TADS turret will resume the 4-bar scan pattern.

In addition, when slaving the TADS to an acquisition source, the LST should be disabled prior to disabling the SLAVE function to ensure the TADS is not inadvertently slewed from the intended location by the 4-bar scan in automatic mode, or if a matching laser designation is detected in automatic or manual mode.



LST 4-bar Automatic Scan Pattern

Manual Mode

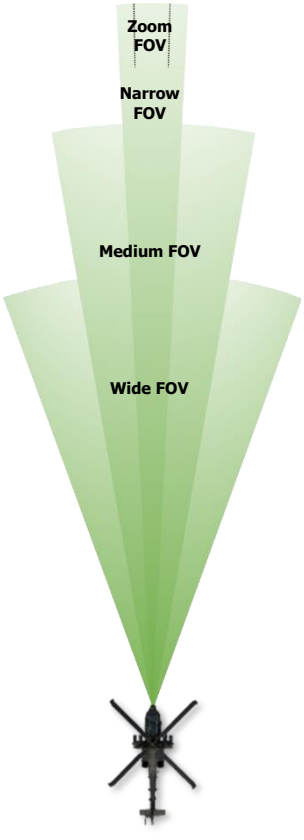
When the LST is enabled in the manual mode, the Copilot/Gunner retains manual slew control of the TADS turret until a laser designation matching the PRF code assigned to the LST is detected. Once a matching laser designation is detected, the TADS will slew to and track the laser designation. If the laser designation is lost, manual slew control of the TADS turret is restored.

TADS ACQUISITION AND RANGING

In similar fashion to using the HMD as the selected sight, detecting, acquiring, and engaging targets with the TADS is fairly straightforward, in that the TADS simply needs to be directed toward and stabilized on the target to generate an appropriate weapon solution. TADS targeting modes such as LMC and IAT assist the Copilot/Gunner (CPG) in target tracking, and the LST assists the CPG in acquiring an offboard laser designation, but autonomously and efficiently acquiring targets using the TADS and performing an accurate ranging of the target location is critical in achieving a successful target engagement.

Generally speaking, TADS sensors and fields-of-view (FOV) are best used in the following manner.

- Initial detection of targets on the battlefield: FLIR Wide/Medium FOV.
- Individual target acquisition: FLIR Wide/Medium FOV or DTV Wide FOV.
- Target identification: FLIR Narrow FOV or DTV Narrow FOV.
- Target tracking: FLIR Narrow/Zoom FOV; DTV Narrow/Zoom FOV.



As with most tactical situations, many variables may determine the ideal sensor and field-of-view. Factors such as target size, range to target, time of day, and movement of the aircraft or target will play significant roles in determining which sensor or field-of-view should be. For example, a company of tanks will be much easier to detect and acquire in Wide FOV, whereas a squad of infantry at the same range may not be detected until Narrow FOV is utilized. In addition, the reduced slew rates and narrow fields-of-view of Narrow or Zoom FOV levels may make them unsuitable for engaging targets at close range, depending on whether the intended targets (or the aircraft) are moving at a high angular velocity.

If a target is lost or inadvertently exits the TADS field-of-view, it is normally wise to "back out" to the previous field-of-view to re-acquire the target within the center of the TADS video, stabilize the TADS movement as necessary, and then "step in" to the next field-of-view to resume tracking as desired.

It is important to note that the Zoom FOV is simply an electronic magnification of the video received from the TADS sensors and will not provide an increase in target resolution or detail. However, the larger video image may aid in precision tracking against long-range targets in which precise placement of the TADS laser beam is critical in accurate ranging or designation of the target.

Acquisition Sources

The use of acquisition sources can reduce the time necessary to bring the TADS onto an intended target. When a target is detected using another sensor onboard the aircraft (to include visual detection by either crewmember), setting that sensor as the acquisition source and enabling the SLAVE function increases the efficiency of target acquisition within the TADS.

Acquisition sources also reduce the amount of verbal communications and coordination of sensors that must occur between the crewmembers, which also increases combat efficiency. By replacing the verbal description of a target (or threat) using a verbose "description, direction, distance" with a concise "sight to source" command, target handovers between crewstations may become near instantaneous with a proficient aircrew. In addition, slaving the selected sight directly to the location of the acquisition source reduces the effects of inaccurate range estimations and removes the need for verbal descriptions of the intended target, or visual reference points to aid in locating the correct target amongst many.

An example of an inefficient target handover from the Pilot's HMD to the CPG's TADS is shown below:

"Gunner, target tank at 11 o'clock, approximately 4 kilometers, dug-in along the north-south running treeline."

The CPG must manually slew the TADS to the approximate direction, visually identify the correct treeline along that general direction (assuming the Pilot's range estimate was accurate) and then locate the correct tank in that vicinity.

Examples of efficient target handovers utilizing acquisition sources are shown below:

"Gunner, target, Pilot helmet sight. Tank in the treeline."

"Gunner, target, FCR. Tracked vehicle, range 4.6."

In either case, the CPG simply selects the announced source of target information as the acquisition source and enables SLAVE, slewing the TADS line-of-sight directly to the location of the intended target, removing most of any targeting ambiguity that exists.

Acquisition sources that will command the TADS to a specific azimuth and elevation relative to the aircraft nose are listed below.

- **PHS.** Pilot Helmet Sight; commands the TADS to the line-of-sight of the Pilot's helmet. May be used to direct the TADS to the location designated by the Pilot's HMD LOS Reticle.
- **GHS.** Gunner Helmet Sight; commands the TADS to the line-of-sight of the Copilot/Gunner's helmet. May be used to direct the TADS to the location designated by his/her own HMD LOS Reticle.
- **SKR.** Seeker; commands the TADS to the line-of-sight of the next-to-shoot AGM-114 missile seeker. May be used to direct the TADS to the target location that is currently being tracked by the next-to-shoot AGM-114 missile, possibly to confirm target identification prior to weapons release.
- **FXD.** Fixed forward; commands the TADS to align with the Armament Datum Line (ADL) at 0° in azimuth and -4.9° in elevation.

Acquisition sources that will command the TADS to a 3-dimensional location relative to the ownship position are listed below.

- **FCR.** Fire Control Radar; commands the TADS to the location of the next-to-shoot target designated on the FCR page. May be used to direct the TADS to the location of the designated target to perform visual identification prior to weapons release, or to engage the designated target while using TADS as the sight.
- **W##, H##, C##, T##.** Waypoint, Hazard, Control Measure, or Target/Threat point; commands the TADS to the coordinates of the selected point within the navigation database. May be used to direct the TADS to a pre-planned, stored, or transmitted location for reconnaissance, visual identification, weapons engagement, or re-acquisition if line-of-sight was lost.
- **TRN.** Terrain point; commands the TADS to the coordinates of the selected terrain point within the navigation database. May be used to direct the TADS to a cursor-selected location on the TSD that is not associated with an existing Waypoint, Hazard, Control Measure, or Target/Threat point for reconnaissance, visual identification, or weapons engagement.

Range Sources

Once a target has been successfully acquired and is being tracked within the TADS field-of-view, the next and perhaps most critical step in ensuring a successful weapon engagement is determining an accurate range to the intended target. As the TADS line-of-sight can only determine a target's relative azimuth and elevation with respect to the aircraft's attitude, measuring the range to the target along the TADS line-of-sight provides the third dimension needed to determine the target's 3-dimensional position relative to the ownship.

Among the three sights (HMD, TADS, and FCR) that may be employed by the AH-64D aircrew for targeting, the TADS facilitates the most options when determining what method of ranging may be employed. When a method of ranging is employed, this is called a "range source", and is displayed within the High Action Display in both Flight Symbology and Weapon Symbology.

The range sources that are available to the Copilot/Gunner (CPG) when using the TADS as the selected sight are shown below, from the most accurate to the least accurate.

- **Laser range.** Laser range is automatically entered as the range source any time the CPG fires the TADS LRFD to measure the slant range between the ownship and the target using reflected laser energy.
- **Navigation range.** Navigation range is automatically entered as the range source any time the TADS is slaved to a Waypoint, Hazard, Control Measure, Target/Threat, or a Terrain point. The slant range between the ownship and the corresponding point's navigational coordinates are calculated and is subject to the position confidence of the aircraft.
- **Automatic range.** Automatic range is selected from the WPN page by pressing MANRNG> (VAB B6) and entering "A" on the Keyboard Unit (KU) in place of a numerical value. Auto-range is determined by the radar altitude of the aircraft over the ground and the elevation "look-down" angle of the TADS turret.
- **Manual range.** Manual range is selected from the WPN page by pressing MANRNG> (VAB B6) and entering a numeric value on the Keyboard Unit.
- **Default range.** Default range is selected upon initial aircraft power-on, or any time the crewmember's current range source is no longer valid.

When manually tracking a target while utilizing Linear Motion Compensation (LMC), it is best to use a dynamic range source to minimize "range jumps", which increases the CPG's workload in maintaining the TADS crosshairs on the intended target. As LMC will automatically convert TADS angular rates based on the current range value to compensate for motion parallax, the greater the difference between the previous range value and the next will cause a greater jump in TADS slew rates.

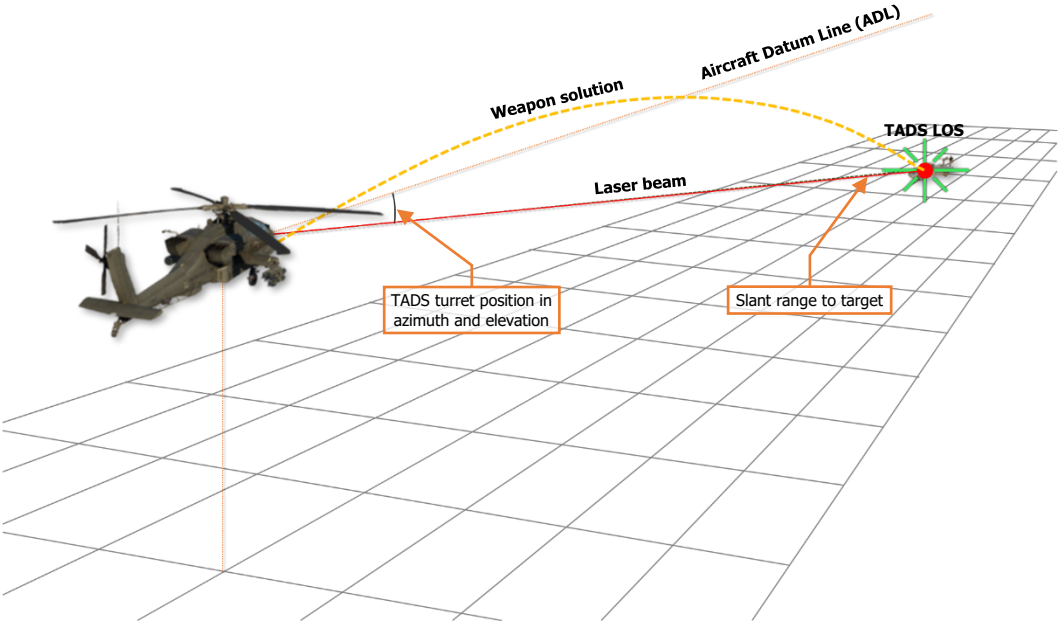
Dynamic range sources include a laser range when a continuous laser designation is employed (2nd detent of the laser trigger), a navigation range to a point stored in the vicinity of the target, or an automatic range when operating over relatively flat terrain. As these range sources may not always be practical depending on the specific tactical situation or the terrain over which the aircrew is operating, the range source that is best suited for the situation should be chosen to reduce the CPG workload during targeting operations.

Static range sources include a laser range when a single range-finding pulse is employed (1st detent of the laser trigger), a manual range entered on the WPN page, or the default range which is displayed upon initial power-up of the aircraft or if the current range source is rendered invalid. Such range sources are not dynamic and represent fixed points in space to which weapon solutions are calculated. As such, the TADS elevation relative to the target will need to be manually adjusted to account for rounds that impact prior to or beyond the target (also referred to as landing "short" or "long").

Laser Range

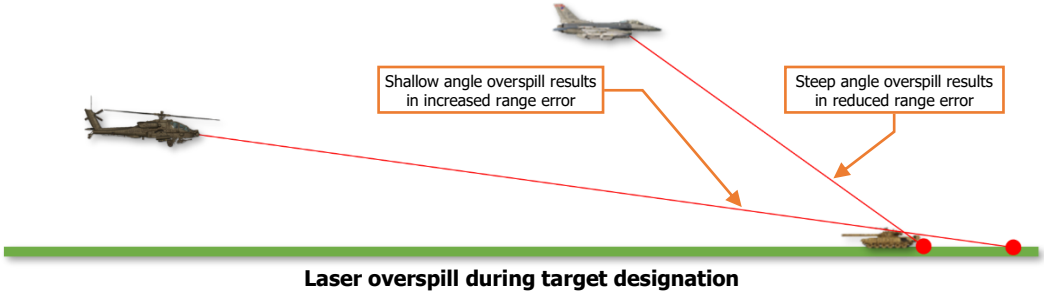
The TADS laser rangefinder/designator (LRFD) provides the most precise range source available when using the TADS as the selected sight. Based on the TADS line-of-sight (LOS) and the slant range measured by the LRFD, a weapon solution is generated based on the selected weapon system (gun or rockets) and, in the specific case of the rockets, the selected warhead type.

If the aircraft and/or the target is moving, a continuous laser designation using the 2nd detent of the laser trigger should be employed. This will continuously update the precise slant range to the target and will also engage the Target State Estimator in calculating lead angle compensation against targets that are moving across the battlefield.



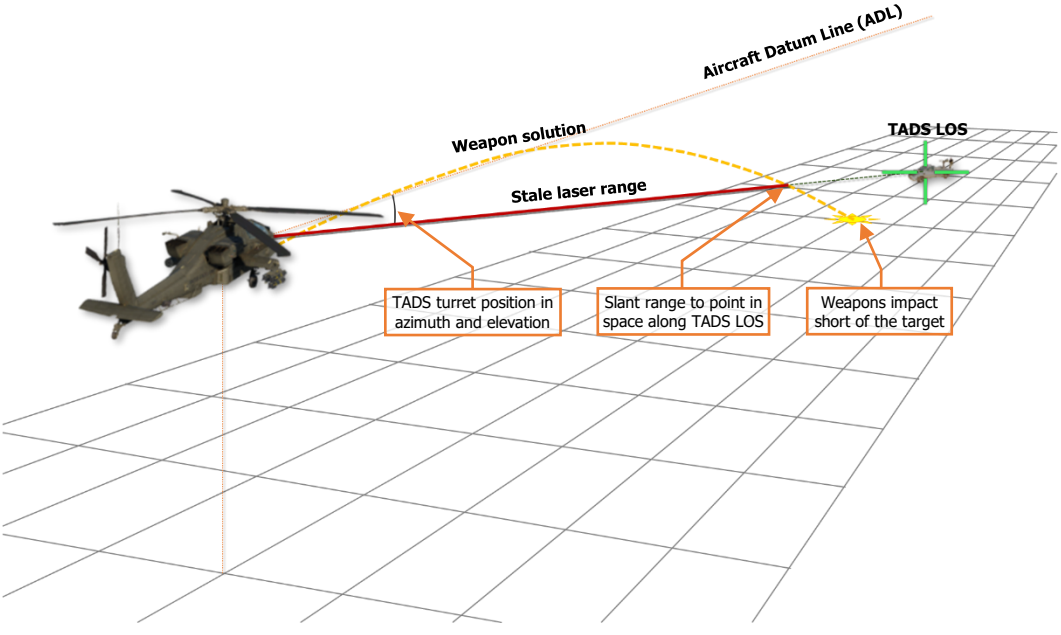
Laser Range (2nd detent designation)

It is important to note that lasing accuracy is more critical when employed by attack helicopters due to the shallow targeting angles compared to fixed-wing strike aircraft. Laser designations should be focused precisely onto the target to prevent the laser beam from impacting the ground prior to the target (laser underspill) or beyond the target (laser overspill). Due to the greater difference in slant range calculations when such events occur, weapons accuracy is significantly affected when lasing at shallow angles.



Laser overspill during target designation

When the LRFD is fired using the 1st detent of the laser trigger, or 14 seconds has elapsed since the LRFD stopped firing using the 2nd detent of the laser trigger, the laser range will become "stale", and will remain at a fixed range value. When this occurs, the weapon solution will continue to update based on the TADS line-of-sight (LOS), but the range value will be to a fixed point in space along the LOS and may not represent the true slant range to the target.



Laser Range (stale range)

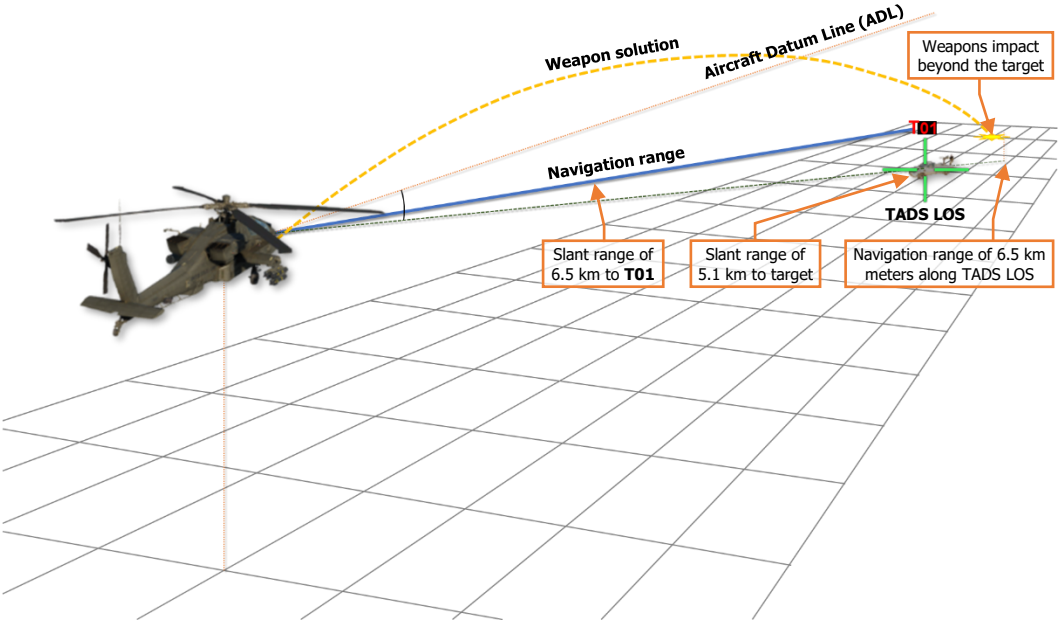
If the selected weapon is employed while using a stale laser range, the weapons will likely impact prior to or beyond the target (also referred to as landing "short" or "long"). If necessary, manual aiming adjustments may be made by adjusting the TADS LOS higher above the target to correct for rounds landing short, or adjusting the TADS LOS further below the target to correct for rounds landing long.

Navigation Range

Navigation range is calculated by simply measuring the slant range between the ownship position and the coordinates of a point stored within the navigational database. Although a Nav range is more accurate than using Auto-ranging or Man-ranging, in that it is dynamically updated with aircraft movement and does not rely on flat terrain as is the case with Automatic range, Nav range is not as accurate as using a laser range.

Any time the SLAVE button is pressed when the Copilot/Gunner's acquisition source is set to a Waypoint, Hazard, Control Measure, Target/Threat, or Terrain point, the slant range to the corresponding point is entered as a Nav range. This may be particularly useful when using "indirect fire" techniques, such as firing unguided rockets from behind cover against a set of coordinates or when employing laser-guided Hellfire missiles in a "Remote Fire" engagement method. However, when employing weapons against targets within the TADS line-of-sight, a Navigation range is only preferred if the intended target is within close proximity to the coordinates of the point being referenced by the Nav range, or if employing area effect weapons against the general area surrounding the point.

In the figure below, the intended target is at a range to the ownship that is substantially closer than the point being referenced (T01) for the Nav range. In such a situation, rockets would impact beyond the target due to the equivalent slant range being applied along the TADS line-of-sight, placing the weapon solution beyond the target and below the surface plane. The TADS LOS Reticle would need to be displaced below the target within the TADS field-of-view to adjust the weapon solution in such a manner so that the weapon trajectory would intersect with the target location.



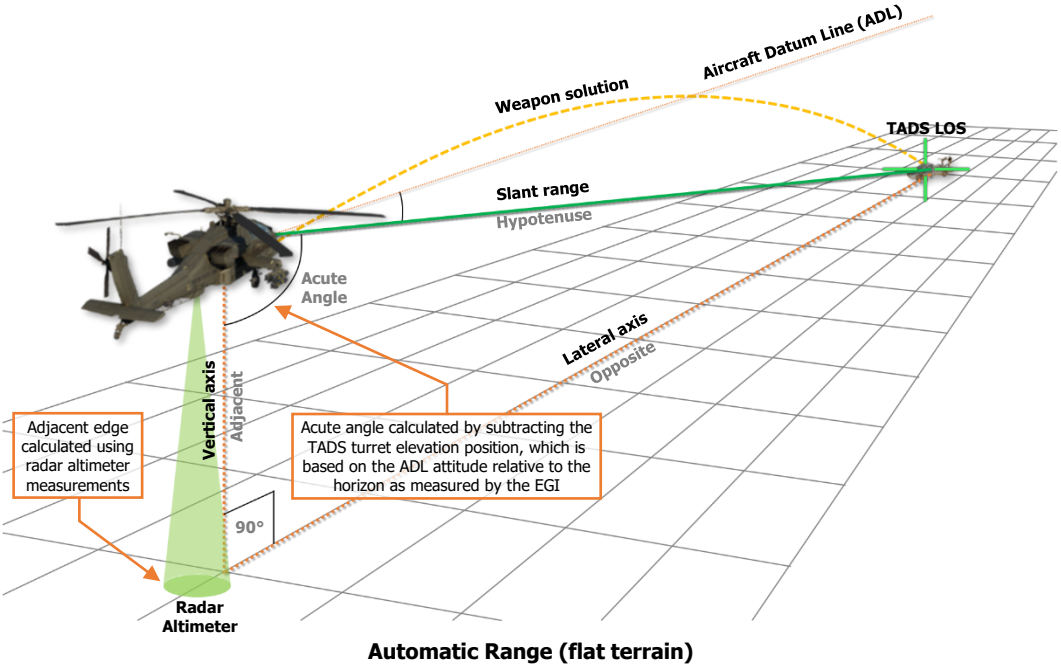
Navigation Range (ACQ set to T01)

Aside from long-range, indirect fire techniques, the most common use cases for employing a Nav range are when the CPG desires a smooth transition to a laser range source when firing the LRFD while LMC is enabled, or when the Pilot is employing unguided rockets with variable time delay fuzes independently of the CPG. Rocket types such as the M255A1 or M261 are dependent on an accurate range to target for their warheads to be effective. Unless fired in Cooperative mode with the CPG's TADS supplying an accurate laser range, the most accurate range source that can be used by the Pilot to achieve the desired warhead effects is a Nav range.

Automatic Range

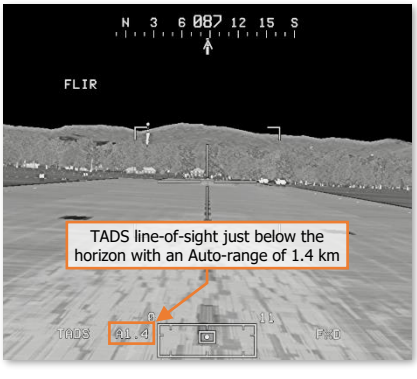
Automatic range is calculated using trigonometric ratios of right triangles, where the TADS look-down angle relative to the vertical axis between the aircraft and the surface below it is the acute angle; and the altitude above ground level (as measured by the radar altimeter) is the adjacent edge of the right triangle.

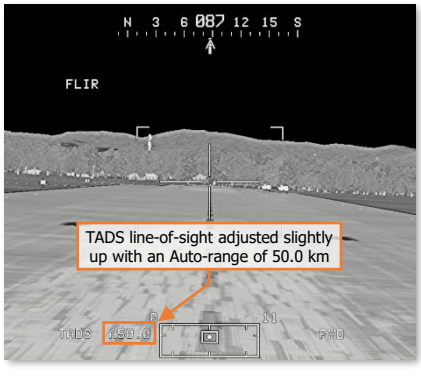
Using these two variables, along with an assumption the target is at an elevation equal to the that of the surface directly below the aircraft along a lateral axis that represents the opposite edge of the right triangle, the hypotenuse is calculated to determine the slant range to target. This calculation is performed continuously based on the TADS turret elevation and the radar altitude of the aircraft.



Automatic Range (flat terrain)

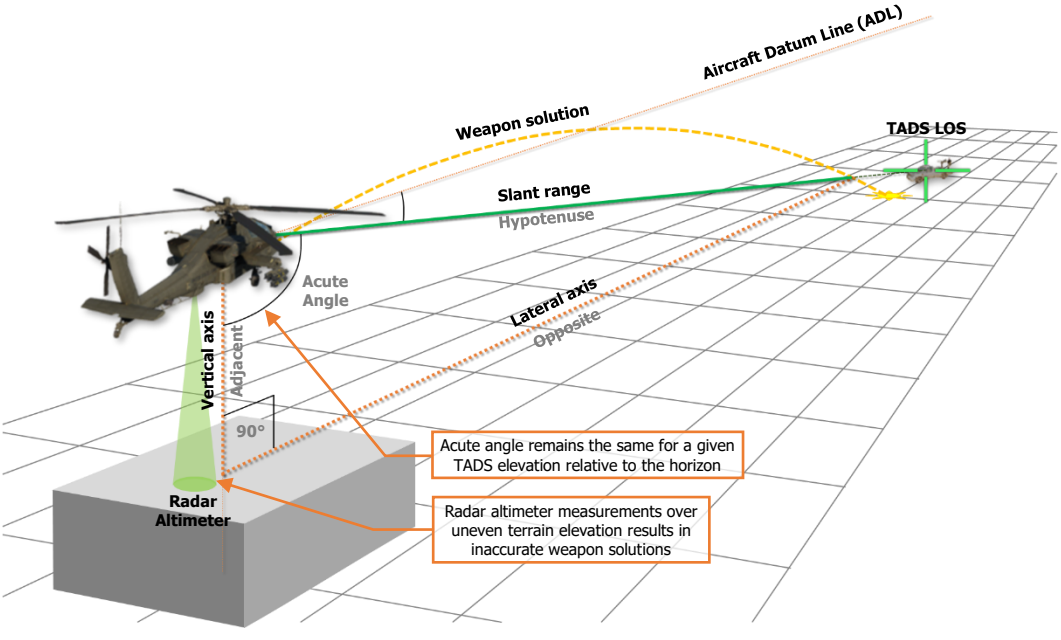
As the TADS line-of-sight (LOS) approaches the horizon and the look-down angles become quite shallow, the Auto-range calculations will become increasingly less precise due to the trigonometric ratios becoming quite large which is exacerbated if the aircraft is operating at very low altitudes over the surface.





Automatic range relies upon a functioning radar altimeter and will only be usable when the aircraft's altitude above ground level (AGL) is less than 1,428 feet (the maximum altitude that is capable of being measured by the radar altimeter).

It is important to note that the accuracy of Automatic range is predicated on the assumption that the target is at the same elevation as the surface directly below the aircraft. As this may not always be the case, using Auto-range for weapon engagements should only be performed in areas with minimal terrain relief, such as open plains, non-mountainous deserts, large plateaus, or basins. Auto-range should not be used when operating over mountains, rolling hills, or complex urban areas.

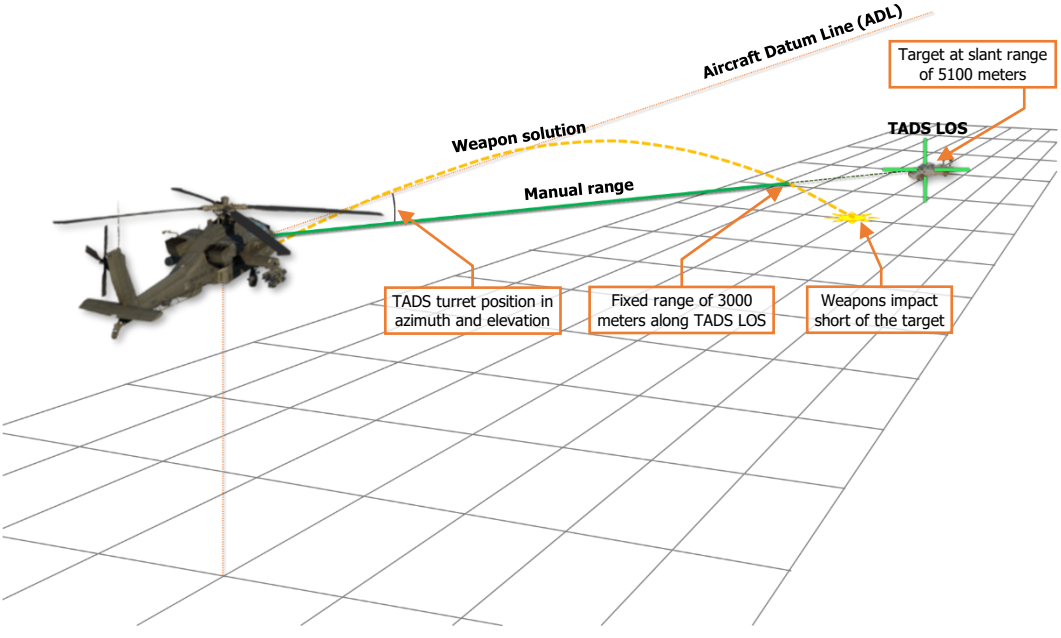


Automatic Range (elevation difference)

In situations where the terrain directly below the aircraft is at a significantly higher elevation than that of the intended target, it should be expected that any weapon solution generated using Auto-range will result in unguided, ballistic munitions such as rockets or gun rounds landing short of the target location. Likewise, in situations where the terrain directly below the aircraft is at a significantly lower elevation than that of the intended target, it should be expected that rockets or gun rounds will land long beyond the target location.

Manual/Default Range

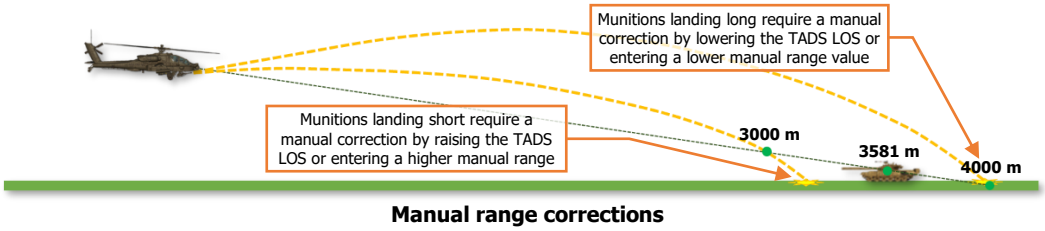
Manual range is the most inaccurate form of ranging when using the TADS. When a manual range value is entered, the weapon solution will continue to update based on the TADS line-of-sight (LOS), but the range value will be to a fixed point in space along the LOS at the range entered on the WPN page.



Manual/Default Range

A Man-range is analogous to zeroing a rifle at a specific distance, and manually compensating for bullet drop by manually elevating the weapon sight higher or lower depending on the estimated range to the target relative to the range to which the rifle was zeroed.

- If the intended target is estimated to be at a range greater than the manual range value, the TADS LOS Reticle must be aimed above the target to compensate for the additional bullet (or rocket) drop.
- If the intended target is estimated to be at a range less than the manual range value, the TADS LOS Reticle must be aimed below the target to compensate for the reduced bullet (or rocket) drop.



Manual range corrections

NOTE: Default range for the Copilot/Gunner (CPG) is 3,000 meters (displayed as "3.0"), but the Default range source is essentially the same as using a corresponding manual range (displayed as "M3.0").

TADS HAND CONTROLS

The Copilot/Gunner is the only crewmember that may use the Target Acquisition Designation Sight for targeting and engagement of enemy targets.

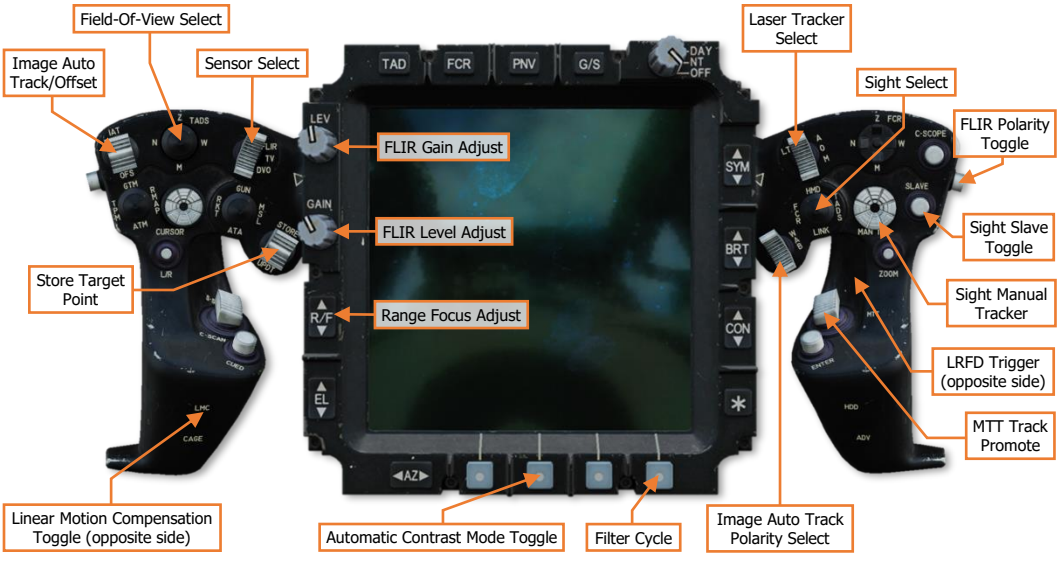
Cyclic & Collective Controls

The CPG may select TADS as his or her sight on the Collective Mission Grip, but controls for employing the TADS itself are only located on the TEDAC.

CPG crewstation only

TEDAC Controls

All TADS controls are located in the CPG cockpit on the TEDAC. TADS use by the Pilot is limited to using it as a backup NVS sensor or by linking the TADS to the FCR Next-To-Shoot (NTS) target.



FIRE CONTROL RADAR (FCR)

US Army photo
by SSG Thomas Mort

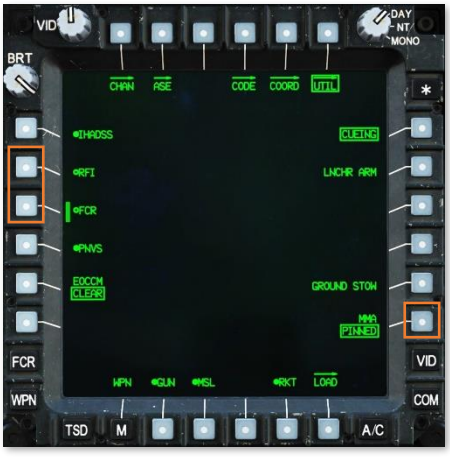
AN/APG-78 FIRE CONTROL RADAR

The AN/APG-78 is a short-range fire control radar system that utilizes a high resolution, millimeter-wave radar antenna shrouded within an aerodynamic radome atop the AH-64D's rotor mast. The APG-78 FCR was designed for anti-armor missions and is optimized for detecting moving vehicles on the battlefield, but is also quite capable of detecting stationary battlefield targets as well as low-flying aircraft.

As the FCR is a sight like the HMD and the TADS, the FCR may be used to employ all three weapon systems of the AH-64D. However, it is not capable of providing guidance to the AGM-114K laser-guided missiles and can only provide target data to the AGM-114L radar-guided missile variants.

FCR Activation

The FCR may be powered from the FCR Utility sub-page or the WPN Utility sub-page (shown to the right) in either crewstation. When powered, the FCR system will perform a Built-In-Test (BIT) for approximately 1 minute, after which it will be available for selection as a sight.

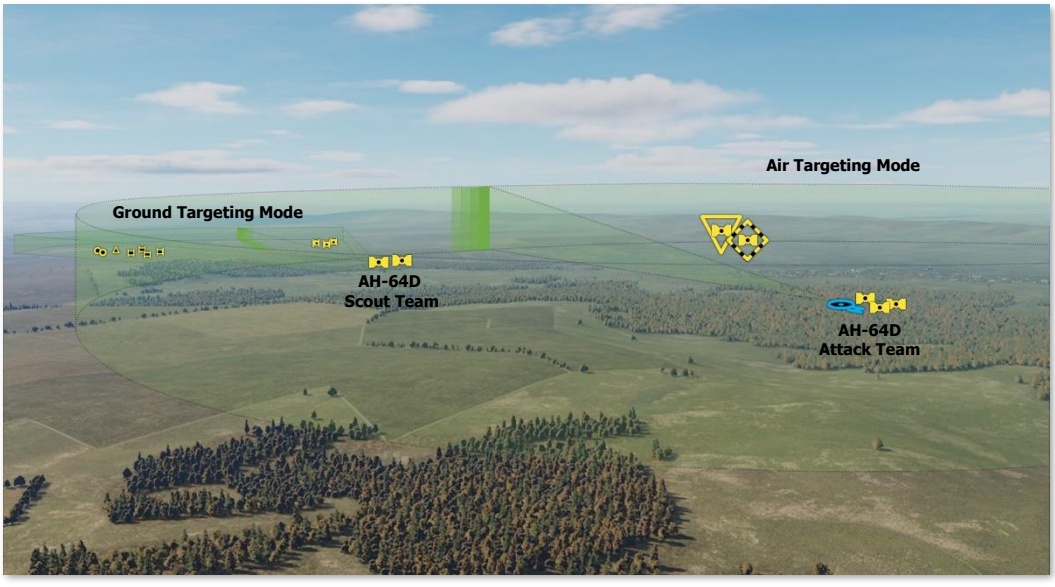


During initial start-up of the aircraft, the state of the Mast-Mounted Assembly (MMA) on the FCR Utility or WPN Utility sub-pages will be set to PINNED. This is to ensure that the external pin that physically locks the MMA in place is confirmed to be in the unlocked position prior to applying power to the FCR. When the MMA state is toggled from PINNED to NORM, the FCR and RFI will automatically perform their respective power-on sequences.

While set to PINNED, FCR power will be inhibited. However, the AN/APR-48 RFI may still be powered to provide warning of air defense radar threats independently of FCR operation.

Employment of the Fire Control Radar in the Battlespace

The APG-78 provides the AH-64D attack helicopter battalion with an organic "aeroscout" capability. By leveraging the AH-64D's datalink capabilities, multiple teams of AH-64D helicopters can be combined into a unified maneuver force distributed across a large area, which can rapidly gain and maintain situational awareness of the battlefield.



AN/APG-78 Detection and Classification Process

The FCR may be used for targeting, reconnaissance, or low-level obstacle avoidance using one of four modes.

Ground Targeting Mode (GTM). The FCR scans a 90° sector of the battlefield, processes ground and low-flying air targets to a range of 8 kilometers, and displays targets in a PPI format.

Radar Map Mode (RMAP). The FCR scans a 90° sector of the battlefield, processes ground and low-flying air targets to a range of 8 kilometers, and displays targets over a radar-generated surface map in a B-scope format.

Air Targeting Mode (ATM). The FCR scans 360° over the battlefield, processes air targets to a range of 8 kilometers, and displays targets in a PPI format.

Terrain Profile Mode (TPM). The FCR scans a 180° or 90° sector of the terrain directly in front of the aircraft to a range of 2.5 kilometers, and displays terrain obstructions and obstacles in a PPI format.

When searching for ground targets, the FCR can scan up to 50 square kilometers of the battlefield, which could potentially result in more targets than a single crew could prioritize themselves within a reasonable amount of time in combat. The FCR automates the target acquisition process by detecting, classifying, and prioritizing up to 256 targets within seconds of initiating a scan using a single button push by either crewmember. The FCR will scan the selected area of the battlefield, compare any radar signatures it detects with a library of vehicles and aircraft, assign the appropriate target type to each processed target, and then present the 16 highest priority targets to the crew as a "shoot list", based on the parameters for prioritization the crew has selected.

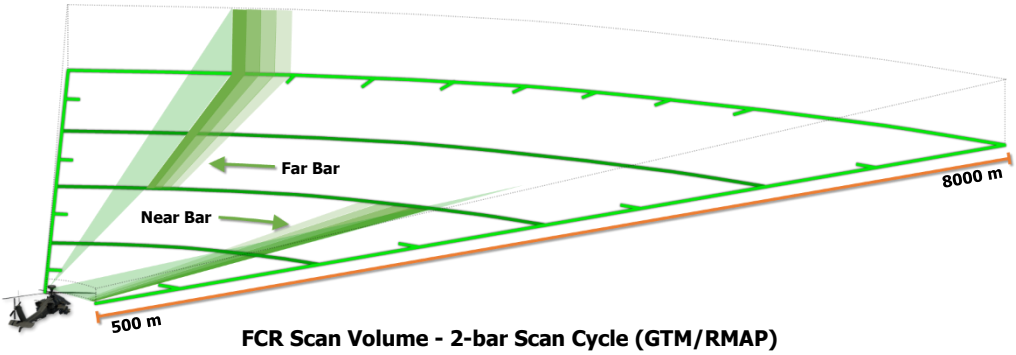
Although the FCR may be used for autonomous targeting, it is most effective when combined with the other sensors and data onboard the AH-64D. The automated detection and classification process allows the crew to highlight areas of the battlefield for subsequent observation through the TADS for the purposes of target identification. This is particularly useful in avoiding fratricide ("friendly fire") when operating along the Forward Edge of the Battle Area (FEBA). (See FCR Acquisition and Ranging for more information.)

Scans and Scanbursts

Like many radar systems, the FCR antenna is mechanically steered to direct the radar beam. As the radar beam is steered in azimuth and elevation, a given volume of 3-dimensional space may be systematically scanned by the radar beam within each scan cycle. This is known as the FCR scan volume and may vary based on the selected FCR mode, selected scan size, and azimuth and elevation settings within the cockpit.

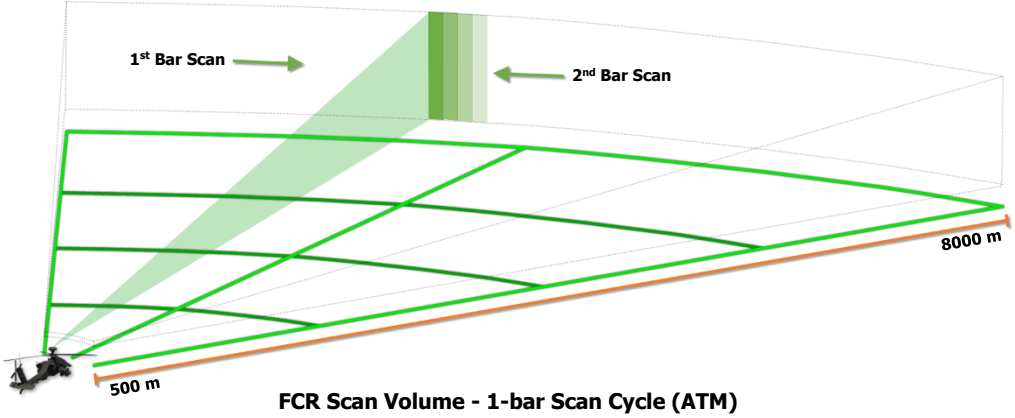
The pattern in which the FCR performs each scan cycle of the FCR scan volume will also vary based on the selected FCR mode, as either a 2-bar scan cycle or a 1-bar scan cycle.

2-bar Scan. When the FCR is set to Ground Targeting Mode (GTM) or Radar Map (RMAP) mode, each individual scan cycle consists of a Near bar scan from left to right followed by a Far bar scan from right to left.



FCR Scan Volume - 2-bar Scan Cycle (GTM/RMAP)

1-bar Scan. When the FCR is set to Air Targeting Mode (ATM) and the scan size set to Wide, a single scan cycle consists of a 1-bar scan performed in a 360° clockwise circle around the ownship. When the FCR is set to ATM and any other scan size is selected, or if the FCR is set to Terrain Profile Mode (TPM), a single scan cycle consists of a 1-bar scan from left to right followed by a 1-bar scan from right to left.



FCR Scan Volume - 1-bar Scan Cycle (ATM)

Multiple scan cycles of the entire FCR scan volume are performed sequentially in scanbursts, which may be thought of as a series of radar-generated "photographs" of the battlespace. By processing each individual radar scan, or "photograph", and comparing it to the previous scans within the scanburst, the FCR is capable of accurately correlating targets such as tanks, armored vehicles, trucks, helicopters, or fixed-wing aircraft as they move across the battlefield or within the airspace above it. In addition, radar data correlated between each scan allows the FCR to detect and classify stationary targets more reliably, albeit at a slightly reduced range compared to moving targets. (See FCR Acquisition and Ranging for more information.)

As the selected sight, the FCR may be commanded to perform a single scanburst (S-SCAN) or a continuous scanburst (C-SCAN) using the FCR Scan switch on the Collective Mission Grip or the TEDAC Left Handgrip. Each time the FCR is commanded to perform a new scanburst, the previous radar data of the battlespace is discarded, and new data is generated.

Single Scanburst (S-SCAN). Multiple scans of the FCR scan volume are performed when the FCR Scan switch is momentarily pressed forward to the S-SCAN position. The FCR will only transmit for the duration of a single scanburst and then automatically cease scanning. The number of scan cycles performed within a single scanburst is dependent on the selected scan size.

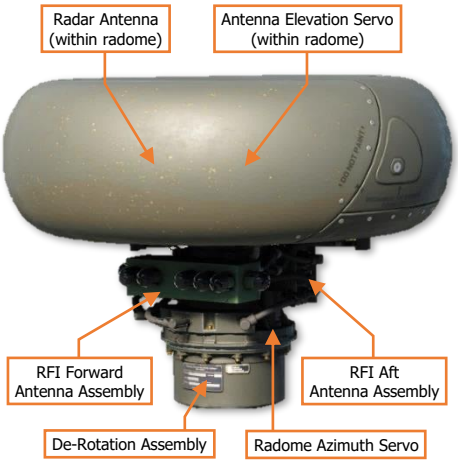
- **Wide Scan Size.** 2 scans are performed within a single scanburst; unless the FCR mode is set to ATM and the FCR Scan Size is set Wide, in which case 1 scan will be performed within a single scanburst.
- **Medium Scan Size.** 2 scans are performed within a single scanburst.
- **Narrow Scan Size.** 3 scans are performed within a single scanburst.
- **Zoom Scan Size.** 4 scans are performed within a single scanburst.

Single scanbursts are best used in GTM, RMAP, or ATM when performing target acquisition or engagements.

Continuous Scanburst (C-SCAN). Multiple and continuous scans of the FCR scan volume are performed when the FCR Scan switch is momentarily pressed aft to the C-SCAN position. The FCR will continuously transmit within the selected scan volume until the FCR Scan switch is momentarily pressed to either position to cease scanning, or the crewmember selects a different sight.

Continuous scanbursts are best used in ATM when performing overwatch of the local airspace; or when using TPM to assist in avoiding obstacles and terrain at low altitude during times of darkness or low-visibility conditions.

Azimuth and Elevation Control



The FCR's radar beam is steered in the horizontal axis by rotating the entire radome left and right using a pair of azimuth servos at the base of the mast-mounted assembly (MMA). The azimuth servo can rotate the entire MMA independently of the de-rotation assembly on which it is mounted through a full 360° range with no restrictions.

The FCR antenna itself is not directly steered in azimuth by the aircrew. The central azimuth of the entire FCR scan volume, known as the "FCR centerline", is steered by either crewmember if the FCR is the selected sight within the respective crewstation. The FCR centerline may be slewed up to 90° to either side of the aircraft centerline in GTM and RMAP, or a full 360° in ATM.

When the FCR is selected as a sight in either crewstation, or when linked to the TADS by the CPG, the azimuth servos rotate the MMA to align the FCR antenna along the left side of the FCR scan volume in preparation for scanning. When the FCR is not in use by either crewmember, the MMA is aligned straight ahead, or toward the tail if FCR STOW (VAB R3) is selected on the FCR Utility sub-page.

The FCR's radar beam is steered in the vertical axis by mechanically adjusting the elevation of the radar antenna itself within the radome housing. The antenna elevation may be adjusted manually in any FCR mode, or it may be set to automatic elevation control when in GTM and RMAP, based on the current altitude above ground level (AGL) as measured by the radar altimeter. However, the antenna elevation may not be adjusted while the FCR is scanning in GTM or RMAP mode.

Pilot FCR Azimuth Controls

As the selected sight in the Pilot crewstation, the FCR centerline is automatically slaved to the Pilot's acquisition source. The Pilot may steer the FCR centerline using one of two methods:

- **Acquisition Source (ACQ).** The Pilot may select a different acquisition source from the ACQ selection menu, depending on the tactical situation. Some examples of practical use with the FCR are listed below.
    - **FXD.** The FCR centerline will be fixed forward and the Pilot may direct the FCR scan volume using the aircraft heading prior to initiating a scanburst.
    - **PHS.** The FCR centerline will be slaved to the Pilot's helmet line-of-sight, allowing the Pilot to look in the direction of the desired scan direction and initiate a scanburst.
    - **TRN.** The FCR centerline will be slaved to a fixed geographical location on the TSD. The Pilot may press CAQ (VAB R5) on the TSD page, cursor-select a map location on the TSD itself, and initiate a scanburst to scan that area of the battlefield (if the location is within the FCR's scanning range).

  (See Acquisition Sources for more information.)

- **Centerline Steering Arrows.** The Pilot may utilize the Centerline Steering Arrows on the FCR page to rotate the FCR scan volume left and right. If the Centerline Steering Arrows are used to rotate the FCR centerline, the FCR will be de-slaved from the Pilot's Acquisition source and will be stabilized relative to the aircraft heading.

  The Pilot may re-enable Slave using either of the following methods:
    - Selecting any acquisition source from the ACQ selection menu, even if the current acquisition source is re-selected.
    - Selecting HMD as the sight using the Sight Select switch on the Collective Mission Grip.

CPG FCR Azimuth Controls

As the selected sight in the CPG crewstation, the FCR centerline may be selectively slaved to the CPG's acquisition source or manually steered using one of three methods:

- **Acquisition Source (ACQ).** The CPG may select a different acquisition source from the ACQ selection menu, depending on the tactical situation, as described above.
- **Centerline Steering Arrows.** The CPG may utilize the Centerline Steering Arrows on the FCR page to rotate the FCR scan volume left and right. If the Centerline Steering Arrows are used to rotate the FCR centerline, the FCR will be de-slaved from the CPG's Acquisition source and will be stabilized relative to the aircraft heading. The CPG may re-enable Slave by pressing the SLAVE button on the TEDAC Right Handgrip.
- **Sight Manual Tracker (MAN TRK).** If the FCR is de-slaved from the CPG's acquisition source, the CPG may manually slew the FCR centerline using the Sight Manual Tracker on the TEDAC Right Handgrip.

FCR Azimuth Stabilization

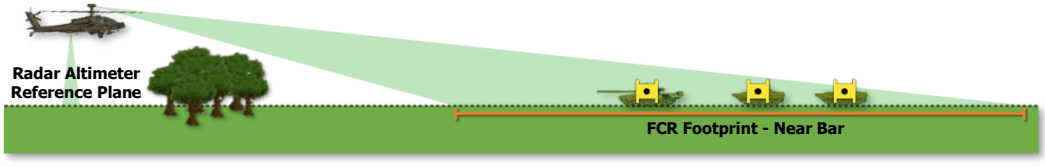
The FCR centerline may be stabilized relative to the aircraft heading or the current azimuth of the FCR centerline itself, depending on the selected FCR mode and whether the FCR is actively scanning.

- **GTM/RMAP.** The FCR centerline will be stabilized relative to the aircraft heading when the FCR is not actively scanning. The aircrew may steer the FCR centerline using any of the methods described above. However, any time the FCR is actively scanning, the FCR centerline will become stabilized in azimuth independently of the aircraft heading, and the FCR centerline cannot be steered until the scanning ceases.
- **ATM.** The FCR centerline will be stabilized relative to the aircraft heading, regardless of whether the FCR is actively scanning. The crew may steer the FCR centerline at any time using any of the methods described above.

FCR Elevation Controls

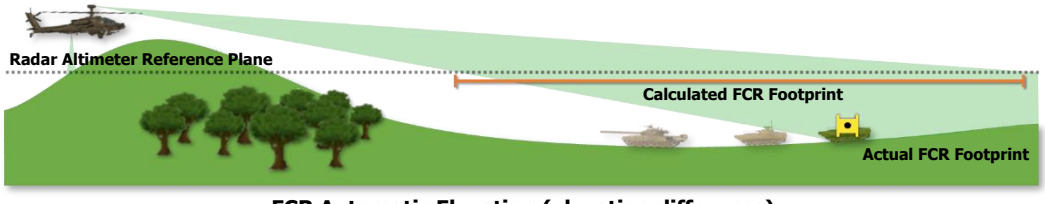
The FCR antenna is stabilized in elevation, which typically allows the radar beam to remain within the intended FCR scan volume at aircraft attitudes of +20° to -15° in pitch or ±20° in roll without a degradation in scan quality. However, depending on the aircraft altitude above the terrain, the contours of the terrain itself, or the elevation settings, portions of the FCR scan volume may not be reached by the radar beam.

To reduce crew workload when using the FCR in GTM or RMAP mode, the FCR elevation control defaults to an automatic mode, based on the current altitude above ground level (AGL) as measured by the radar altimeter. The automatic elevation mode adjusts the antenna elevation to maintain the 2-bar scan pattern between a range of 500 and 8,000 meters, but this may not be possible at higher altitudes.



FCR Automatic Elevation (flat terrain)

It is important to note that the accuracy of the automatic elevation mode is predicated on the assumption that the intended FCR footprint is at the same elevation as the terrain directly below the aircraft. As this may not always be the case, using the automatic elevation mode should only be performed in areas with minimal terrain relief, such as open plains, non-mountainous deserts, large plateaus, or basins. Automatic elevation mode should not be used when operating over mountains or rolling hills.



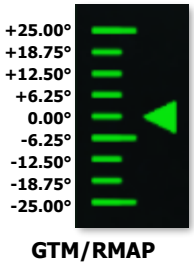
FCR Automatic Elevation (elevation difference)

The FCR elevation control mode may be toggled between automatic (AUTO) and manual (MAN) from the FCR Utility sub-page when the FCR is the selected sight and set to GTM or RMAP modes. When set to AUTO, the ELEV (VAB L5) control mode option is displayed on the FCR page as a shortcut to quickly revert to manual elevation control via the arrow buttons (VAB L5/L6) or the Sight Manual Tracker on the CPG's TEDAC Left Handgrip.

When the FCR mode is set to GTM, RMAP, or ATM, the Elevation Scale is displayed on the main FCR page corresponding with the current antenna elevation setting. The Elevation Scale does not indicate the mechanical position of the elevation servo, but rather the elevation of the FCR scan volume relative to the horizontal plane.

GTM/RMAP. The Elevation Scale corresponds with the relative position of the Near bar within the 2-bar scan cycle. The Far bar will be adjusted automatically based on the elevation setting and elevation control mode.

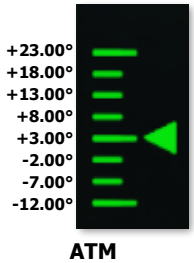
The elevation settings are in 6.25° increments.



GTM/RMAP Elevation Scale

ATM. The Elevation Scale corresponds with the relative position of the 1-bar scan cycle.

The elevation settings are in 5° increments.



ATM Elevation Scale

Target Detection, Classification, and Prioritization

The APG-78 FCR accelerates the process of developing the tactical situation by automatically detecting, classifying, and prioritizing potential targets on the battlefield. In addition, Priority Fire Zones and No Fire Zones may be incorporated within the FCR prioritization process, which seamlessly integrates fire support control measures (FSCM) to distribute or restrict fires within the AH-64D team.

Target Detection

Throughout each scan cycle within a scanburst, radar signatures within the FCR scan volume are determined to be targets of military interest or rejected as false targets due to terrain clutter. This false target rejection uses pre-programmed algorithms based on the terrain characteristics over which the FCR is expected to be operating.

Target Classification

Once a target of military interest is detected, the radar signature is compared to a library of known target types. However, the FCR is not capable of recognizing the target (T-72 or M1A2), nor is it able to identify the coalition affiliation of the target (friend or foe). The target is accordingly classified as one of the following six types:

Tracked Vehicle. T-72, M1A2, BMP-2, M113, etc.

Wheeled Vehicle. BTR-80, M1126, BRDM-2, HMMWV, etc.

Air Defense Vehicle. 2S6, Rapier, ZSU-23-4, Gepard, etc.

Helicopter. Ka-50, AH-64, Mi-8, UH-60, etc.

Fixed-Wing. Su-25, A-10, MiG-29, F-16, etc.

Unknown. Any target that cannot be classified.

(See FCR Target Symbols for more information.)

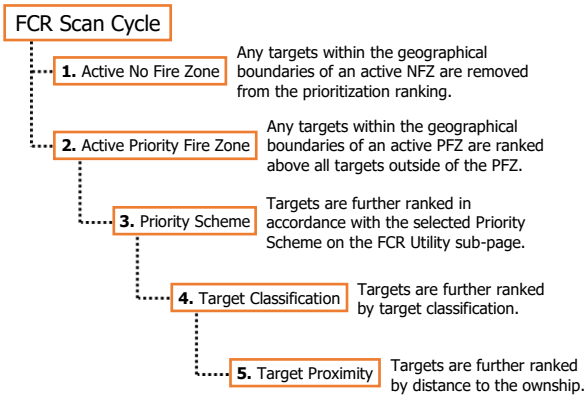
Target Prioritization

Once targets are classified by type, they are ranked according to a series of prioritization parameters, some of which are fixed within the avionics, while others may be adjusted by the crewmembers from within the cockpit. As the targets are ranked, the 16 targets that are ranked at the top of the list are displayed as the "high priority targets" on the FCR and TSD pages, the next 240 ranked targets are displayed on the TSD (when set to ATK phase) as "low priority targets", and any remaining targets ranked below 256 are not shown at all.

Targets are prioritized based on their positions within activated PFZ's or NFZ's, the selected Priority Scheme, target classification, and range from the ownship. The automated target prioritization process consists of 5 parameters and is performed continuously as the FCR scans the battlespace; with target symbol positions updated, added, or removed on each subsequent scan as the High Priority Target List is updated. The first three parameters may be selected by the aircrew, but the last two parameters are fixed within the FCR software.

1. **Active No Fire Zones.** The aircrew may selectively activate, deactivate, draw, or delete individual NFZ's using the TSD Battle Area Management sub-page, which will prevent the FCR from prioritizing any of the targets within the boundaries of the active NFZ's. However, the targets will still be displayed on the TSD when set to ATK phase, if the appropriate show options are enabled.

   NOTE: No Fire Zones take precedence over Priority Fire Zones. Any targets located within an active NFZ *and* an active PFZ will not be prioritized.



FCR Target Prioritization Process

2. **Active Priority Fire Zones.** The aircrew may selectively activate, deactivate, draw, or delete PFZ's using the TSD Battle Area Management sub-page, which will elevate the ranking of any target within the boundaries of the active PFZ above all other targets, even those targets outside the PFZ that may pose a greater threat to the aircraft.

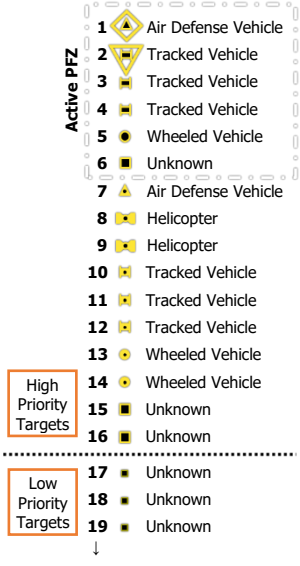
3. **Priority Scheme.** The aircrew may select one of three Priority Schemes on the FCR Utility sub-page. The default Priority Schemes are considered the base level prioritization parameter which are always enabled when employing the FCR in GTM, RMAP, or ATM, even when there are no active PFZ's or NFZ's. The Priority Scheme should be selected based on the current tactical situation. (See Priority Schemes for more information.)

   - **Default Scheme A.** Stationary ground targets and airborne targets will be prioritized over moving ground targets.
   - **Default Scheme B.** Stationary ground targets will be prioritized over moving ground targets or airborne targets.
   - **Default Scheme C.** Moving ground targets and airborne targets will be prioritized over stationary ground targets.

4. **Target Classification.** Targets are ranked by their classification in the following order: Air Defense Vehicle, Helicopter, Fixed-Wing, Tracked Vehicle, Wheeled Vehicle, Unknown.

   (See FCR Target Symbols for more information.)

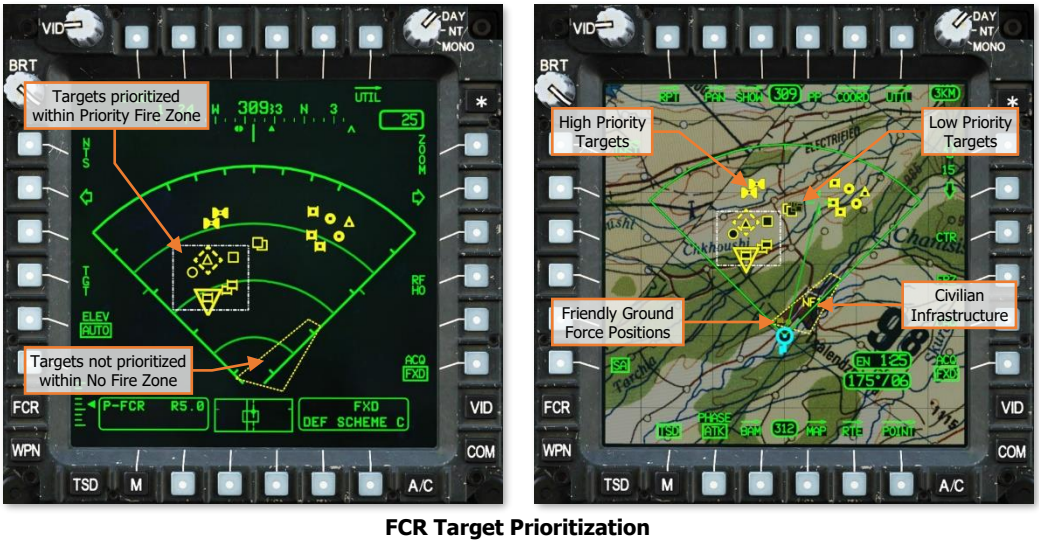
5. **Target Proximity.** Targets that are equally ranked by the first four parameters are ranked in priority by their distance to the ownship. Targets that are closer to the ownship are ranked higher in priority over those that are further away.



Priority Target List

In the example above and to the right (based on the MPD images below), Default Scheme C has been selected, a scanburst has been completed, and a PFZ and an NFZ have been activated within the FCR footprint. Even though the selected Priority Scheme prioritizes moving ground targets and airborne targets over stationary ground targets, the six stationary ground targets within the active PFZ are placed above those outside of the PFZ. The targets inside the active PFZ have been further prioritized by the last three parameters, followed by the targets outside the active PFZ which have been prioritized in the same manner.

When the TSD is set to ATK Phase, low priority targets and any targets within active No Fire Zones are displayed as partial-intensity target symbols, at 50% of the size of high priority target symbols.



FCR Target Prioritization

NTS/ANTS Designation

At the completion of the first scan cycle within the scanburst, or if the first scan is aborted for any reason, the Next-To-Shoot (NTS) and Alternate Next-To-Shoot (ANTS) targets are designated as the first and second priority targets, respectively. The NTS target will be surrounded by a diamond symbol and the ANTS will be surrounded by an inverted triangle symbol.

If the High Priority Target List is updated with new target data as the FCR performs subsequent scan cycles within the scanburst, the NTS and ANTS designations may shift to other targets throughout the scan. However, if a weapon is actioned in the same crewstation that is using the FCR as the selected sight, the NTS designation will become "frozen". If another target is subsequently detected that is determined to be a higher priority while the NTS is frozen, the ANTS triangle will shift to that target and flash for 3 seconds.

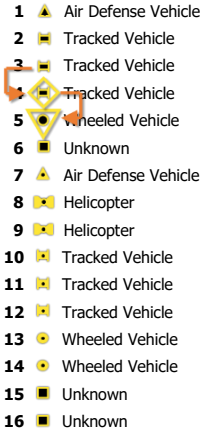
The NTS designates the target handover that will be sent to the next AGM-114L missile, transmitted in the next RF Handover (RFHO), or the 3-dimensional location used to calculate the weapon aiming solution for the Area Weapon System (AWS) or Aerial Rocket Sub-system (ARS).

Next-To-Shoot (NTS)

The NTS diamond will remain dashed unless all three of the following criteria are met.

- The FCR is the selected sight within the crewstation.
- A weapon is actioned within the crewstation in which FCR is the selected sight.
- The A/S button on the Armament Panel is set to ARM.

Alternate Next-To-Shoot (ANTS)



NTS Button (VAB L1)

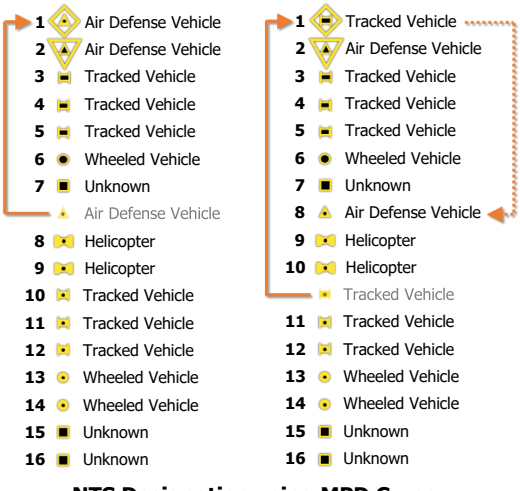
A solid NTS diamond indicates to the crewmember using the FCR as the selected sight that a weapon system is ready to be fired at the current NTS target. Each time an RF missile is fired at the NTS target or an RFHO is transmitted, the NTS and ANTS designations will automatically sequence to the next targets on the High Priority Target List, allowing rapid engagement of the high priority targets by RF missiles fired from the ownship and/or other AH-64Ds receiving RF Handovers.

The NTS and ANTS may be manually sequenced by pressing the NTS button (VAB L1) on the FCR page. Each time this button is pressed, the NTS and ANTS designations will sequence to the next targets on the High Priority Target List in the same manner as when an RF missile is fired or an RFHO is transmitted. When the NTS and ANTS designations reach the end of the High Priority Target List, they will sequence back to the top of the list in a cyclic manner.

(See RF Target Handovers in the Datalink chapter for more information.)

The MPD cursor may also be used to manually designate the NTS target on the FCR page. However, when an NTS target is manually designated in this manner, that target is placed at the top of the High Priority Target List, with every other target shifting down the list as necessary.

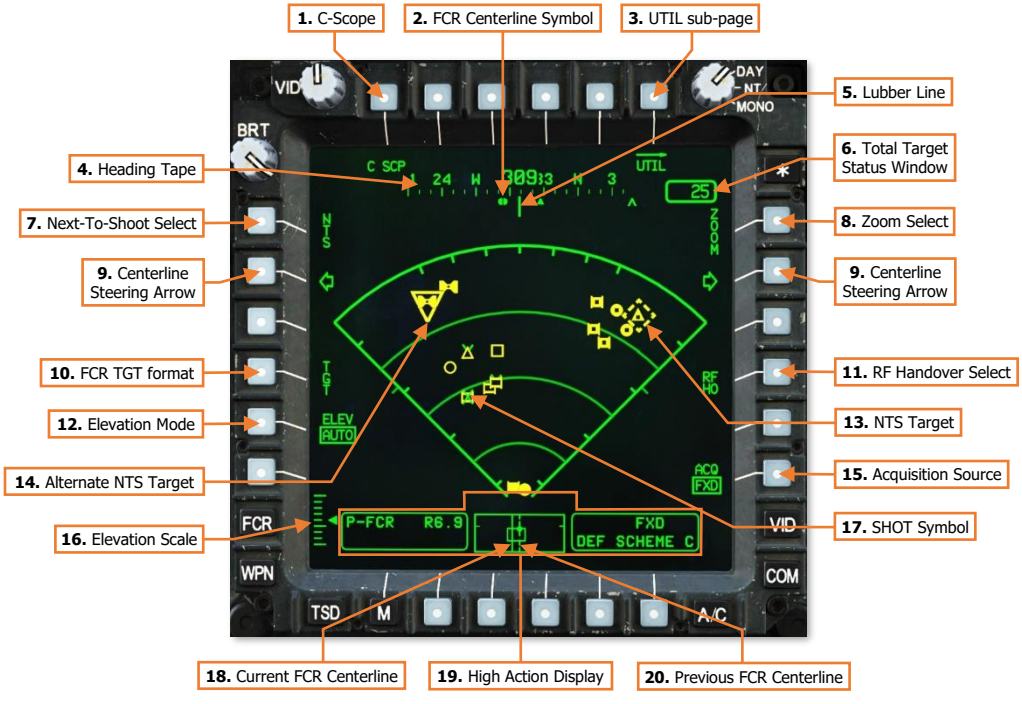
If a different target is manually designated as NTS by the MPD cursor, that target is then placed at the top of the High Priority Target List, and the previous target that had been manually designated as NTS is returned to its previous ranking as necessary.



NTS Designation using MPD Cursor

Fire Control Radar (FCR) Page

The FCR page presents radar targeting data and/or terrain video to the crew in a format that is dependent on the selected FCR mode. When set to GTM, RMAP, or ATM, the FCR page displays the 16 highest priority targets that have been detected by the FCR, any of which may be designated for engagement.



1. **C-Scope (C SCP).** When enabled, FCR symbols are displayed within Flight or Weapon symbology formats in the corresponding crewstation. FCR target symbols, the NTS target symbol, the ANTS target symbol, and SHOT symbols are displayed virtually in azimuth and elevation corresponding with their 3-dimensional positions. This setting is independent between crewstations. (See C-Scope for more information.)

2. **FCR Centerline Symbol.** Indicates the magnetic heading to which the centerline of the FCR scan volume is aligned. The centerline symbol is only displayed when either crewmember has selected FCR as a sight.

3. **FCR Utility sub-page.** Displays the FCR Utility sub-page.

4. **Heading Tape.** Displays a 180° hemisphere of magnetic headings. Major tick marks are displayed in 30° increments and marked by a cardinal direction or heading in the tens value. Minor tick marks are displayed in 10° increments.

5. **Lubber Line.** The Lubber Line is aligned to the centerline of the aircraft.

   NOTE: When set to GTM or RMAP mode, FCR target data is presented from the perspective of the FCR centerline during the most recent FCR scanburst, not the aircraft centerline.

6. **Total Target Status Window.** Indicates the total number of battlefield targets the FCR has detected within the current scan cycle.

7. **Next-To-Shoot (NTS) Select.** Advances the NTS and ANTS target designations through the 16 high priority targets in a descending order before cycling back to the first target on the list.

8. **Zoom Select.** Enables the cursor to designate a location within the FCR footprint to enter ZOOM format. When selected, the MPD cursor will be displayed in Zoom format when positioned within the FCR footprint.

9. **Centerline Steering Arrows.** Rotates the FCR centerline in azimuth, equal to the selected scan size, and de-slaves the FCR centerline from the selected acquisition source.

   - **Wide (W).** The FCR centerline will rotate 90° in azimuth if the FCR mode is GTM or RMAP.
   - **Medium (M).** The FCR centerline will rotate 45° in azimuth if the FCR mode is GTM or RMAP. The FCR centerline will rotate 90° in azimuth if the FCR mode is ATM.
   - **Narrow (N).** The FCR centerline will rotate 30° in azimuth if the FCR mode is GTM or RMAP. The FCR centerline will rotate 90° in azimuth if the FCR mode is ATM.
   - **Zoom (Z).** The FCR centerline will rotate 15° in azimuth if the FCR mode is GTM or RMAP. The FCR centerline will rotate 45° in azimuth if the FCR mode is ATM.

   When set to GTM or RMAP mode, the FCR centerline will be limited to ±90° to either side of the aircraft centerline and cannot be rotated while the FCR is scanning.

10. **FCR TGT format.** Displays the FCR Target format.

11. **RF Handover (RFHO) Select.** Displays a list of Primary members within the selected datalink network that may be selected to receive the RFHO datalink message. (See the RF Target Handovers in the Datalink chapter for more information.)

12. **Elevation Mode (ELEV).** Selects how the FCR antenna elevation will be controlled.

    - **AUTO.** The FCR antenna will automatically adjust its elevation based on the height above terrain as measured by the radar altimeter.

      This mode should be used when operating over relatively flat terrain.
    - **MAN.** The FCR antenna may be manually adjusted within the crewstation in which the FCR is the selected sight. When the mode is set to MAN, arrow buttons will be displayed on the FCR page at VAB L5 and L6 which may be used to adjust the elevation in fixed increments, or the CPG may use the MAN TRK controller on the TEDAC Right Handgrip to smoothly adjust the antenna elevation. However, the antenna elevation may not be adjusted while the FCR is scanning in GTM or RMAP mode.

      This mode should be used when operating over terrain that varies in elevation.

      NOTE: If the FCR elevation mode is set to MAN, the mode may be set back to AUTO on the FCR Utility sub-page.

13. **Next-To-Shoot (NTS) Target.** The NTS target symbol indicates the designated target location to which all sighting functions of the FCR are performed, or which target will be transmitted via an RFHO.

    When the first scan within a scanburst is completed, the NTS target symbol is set to the target the FCR has classified as the highest priority; however, the crewmember may manually designate the NTS target using the NTS Select button (VAB L1) or by selecting a target symbol on the FCR page with the MPD cursor.

    When a weapon is actioned, the NTS target is the target that will be engaged.

    - If the Area Weapon System (AWS) is actioned, the weapon aiming solution for the 30mm gun turret is calculated to the location of the NTS target.
    - If the Aerial Rocket Sub-system is actioned, the Rocket Steering Cursor indicates the weapon aiming solution to the location of the NTS target.
    - If the Hellfire Modular Missile System (HMMS) is actioned, the Missile Constraints Box indicates the target handover position of the NTS target when the RF missile is not tracking the target.

14. **Alternate Next-To-Shoot (ANTS) Target.** The Alternate NTS target symbol indicates the FCR target that will become Next-To-Shoot (NTS) if the NTS Select button (VAB L1) is pressed or an RF missile is fired at the current NTS target.

    When the first scan within a scanburst is completed, the ANTS target symbol is set to the target the FCR has classified as the second highest priority; however, if a crewmember manually designates a different NTS target using the MPD cursor, the ANTS target symbol will be set to the highest priority target as classified by the FCR.

15. **Acquisition (ACQ) Source.** Displays the acquisition source selection menu. (See Acquisition Sources in the Tactical Employment chapter for more information.)

16. **Elevation Scale.** Displays the current elevation setting of the FCR antenna relative to the FCR radome. When set to GTM or RMAP mode, the upper and lower major tick marks correspond to +25° and -25° respectively, the major tick mark in the center corresponds to -6.25°, and each minor tick mark represents an interval of ±6.25°. When set to ATM, the upper and lower major tick marks correspond to +23° and -12° respectively, the major tick mark in the center corresponds to +3°, and each minor tick mark represents an interval of ±5°.

17. **SHOT Symbol.** Missile engagement locations are stored to the ownship SHOT file and displayed on the TSD and FCR pages as green X symbols. Missile engagement locations received via the datalink are displayed as partial-intensity green X symbols on the TSD and FCR pages.

    SHOT symbols are displayed over FCR target symbols if a missile engagement is stored after the FCR scan in which the target was detected. If subsequent FCR scans are performed, the SHOT symbol will be displayed under FCR target symbols.

    SHOT symbols represent locations to which an AGM-114 missile has been fired for the purposes of post-attack battle damage assessment (BDA). These symbols do not indicate whether the AGM-114 successfully hit a target nor what target was actually struck by the missile.

    See TSD SHOT sub-page in the Datalink chapter for more information.

18. **Current FCR Centerline.** Indicates the current azimuth of the FCR centerline when the FCR is powered.

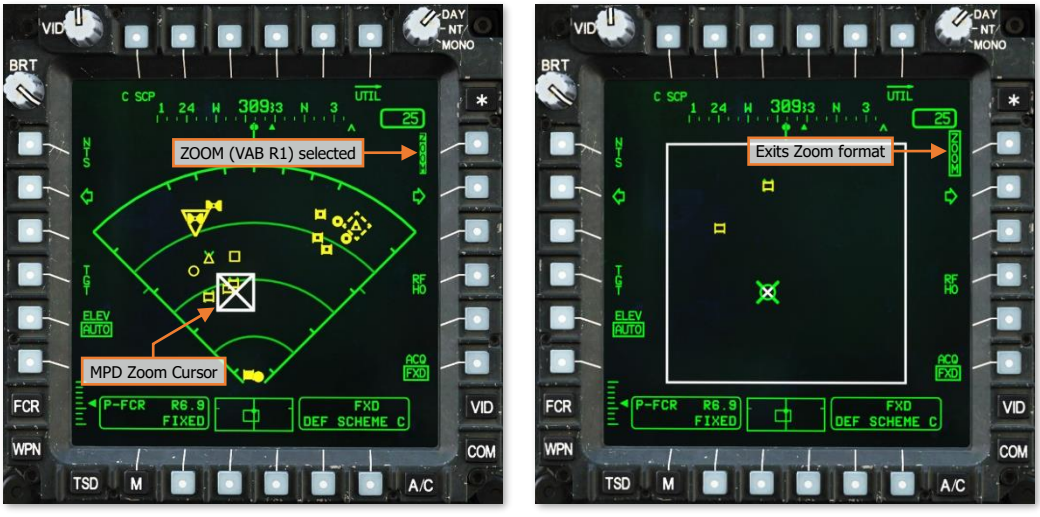
19. **High Action Display (HAD).** The HAD provides prioritized sight and weapon status messages to the crew for targeting and weapons employment. (See High Action Display in the Helmet-Mounted Display chapter for more information.)

20. **Previous FCR Centerline.** Indicates the azimuth of the FCR centerline during the most recent scan when the FCR is powered and not scanning. When a new scan is initiated, the Previous FCR Centerline moves to the location of the Current FCR Centerline until the scan is completed.

FCR Zoom Format

The FCR page may be expanded within a designated sector of the FCR footprint by using the ZOOM function, which displays a closer, more detailed view of FCR target symbols located within a small area. When enabled, the selected area within the FCR footprint is enlarged by a 6:1 ratio.

The ZOOM format may be accessed in either crewstation by pressing the ZOOM button (VAB R1) on the FCR page. When ZOOM is pressed, the MPD Zoom cursor is displayed, which represents the relative area of the FCR footprint that will be expanded. Once the MPD Zoom cursor is placed over the desired location, Cursor-Enter may be pressed to enter the FCR ZOOM format. The ZOOM button (VAB R1) may be subsequently de-selected to exit the FCR ZOOM format.



ZOOM selected on FCR page (Left) and FCR page in Zoom format (Right)

Alternatively, the CPG may directly enter the FCR ZOOM format by pressing the ZOOM button on the TEDAC Right Handgrip. However, this method of entering ZOOM format of the FCR page bypasses the selection of the enlarged area using the MPD Cursor, and the ZOOM format will be centered on the current Next-To-Shoot (NTS) target.

The ZOOM format may only be accessed when all three of the following criteria are met.

- The FCR is the selected sight within the crewstation.
- A Next-To-Shoot (NTS) target has been designated by the FCR.
- The FCR is not scanning.

If an FCR scan is initiated while ZOOM is enabled, the FCR page will exit ZOOM format for the duration of the scan and will re-enter ZOOM format when the FCR scan is completed.

FCR Target Format

Pressing the TGT button (VAB L4) displays the FCR page in Target format. The TGT format of the FCR page allows either crewmember to store FCR target locations as Target points within the TGT/THRT partition of the navigational database.

When the TGT format is displayed, cursor-selecting an FCR target symbol on the FCR page will store a Target (TG) point at that FCR target's location. However, if point indexes T01 through T49 within the TGT/THRT partition are already occupied with point data, Target points can no longer be stored from the FCR TGT format.

Alternatively, the CPG may store the current Next-To-Shoot (NTS) target as a Target (TG) point without entering the FCR TGT format by pressing the STORE/UPDT switch to the STORE position on the TEDAC Left Handgrip while the FCR is the CPG's selected sight.

1. **Store All Targets (ALL).** All FCR targets displayed on the FCR page will be stored as Target (TG) points in TGT/THRT point indexes that are not already occupied with point data.

   If ALL is selected or any FCR target symbol is cursor-selected while the FCR TGT format is displayed, the ALL option is removed.

2. **Next Target Point Status Window.** Displays the next TGT/THRT point index that is available for storing an FCR target.

3. **Stored Target Points Status Window.** Displays the TGT/THRT point indexes of each Target point that has been stored from the FCR TGT format.

FCR Utility (UTIL) Sub-Page

The UTIL sub-page allows either crewmember to toggle power to the FCR or RFI systems, adjust the settings of the mast-mounted radome and/or FCR antenna elevation, or change the parameters for target prioritization.

1. **RFI Power.** Not implemented.
2. **RFI Training Mode.** Not implemented.
3. **RFI Mode.** Not implemented.
4. **FCR Power.** Enables/disables the Fire Control Radar. FCR power will be inhibited if the MMA state (VAB R6) is set to PINNED.
5. **FCR Stow.** Manually commands the FCR radome to the stow position, rotating the mast-mounted assembly 180° toward the rear, facing aft. If either crewmember is using the FCR as their sight, this option will be "barriered" and unavailable for selection. If either crewmember selects FCR as their sight while the FCR radome is stowed, or if the FCR is linked to the TADS, this option will be automatically de-selected.
6. **FCR Lethal Ranges.** Not implemented.
7. **PRIORITY - Scheme.** Selects how the FCR will prioritize targets detected on, or over, the battlefield when the FCR mode is set to GTM, RMAP, or ATM. (See Priority Schemes for more information.)
   - **Default Scheme A.** Stationary ground targets and airborne targets will be prioritized over moving ground targets.
   - **Default Scheme B.** Stationary ground targets will be prioritized over moving ground targets or airborne targets.
   - **Default Scheme C.** Moving ground targets and airborne targets will be prioritized over stationary ground targets.
8. **PRIORITY - Mission.** No function.

9. **Elevation Mode.** Selects the FCR elevation control mode when the FCR mode is set to GTM or RMAP.
   - **AUTO.** The FCR antenna will automatically adjust its elevation based on the altitude above terrain as measured by the radar altimeter.

     This mode should be used when operating over relatively flat terrain.
   - **MAN.** The FCR antenna may be manually adjusted within the crewstation in which the FCR is the selected sight. When the mode is set to MAN, arrow buttons will be displayed on the FCR page which may be used to adjust the elevation in fixed increments, or the CPG may use the MAN TRK controller on the TEDAC Right Handgrip to smoothly adjust the antenna elevation.

     This mode should be used when operating over terrain that varies in elevation.
10. **Terrain Settings.** Configures terrain processing settings for rejecting false targets and ground clutter. (N/I)
11. **Mast-Mounted Assembly (MMA) State.** Sets the current state of the mast-mounted assembly.
   - **NORM.** Permits the FCR to be powered. The MMA may be rotated.
   - **PINNED.** Inhibits the FCR from being powered. The MMA cannot rotate.

   When toggling the MMA state from PINNED to NORM, the FCR and RFI will be initialized automatically.

FCR Sight Status Messages

The following status messages pertain to the use of the FCR as the selected sight within the crewstation.

SIGHT STATUS	CONDITION	CORRECTIVE ACTION
FCR NOT INSTALLED	The FCR is not installed.	None required.
FCR NOT READY	The FCR has been powered and is performing a Built-In-Test.	None required.
FCR XMIT	The FCR is transmitting.	None required.
FIXED	The FCR centerline is slaved to the Fixed forward position.	Use an FCR arrow button or (CPG only) press the SLAVE button to de-slave the FCR turret, if required.
MMA PINNED	The Mast Mounted Assembly is set to a PINNED state; the FCR cannot be powered.	Either crewmember should toggle the MMA to NORM on the FCR Utility or WPN Utility sub-pages, if required to use the FCR for reconnaissance or targeting.

FCR Weapon Status Messages

The following status messages pertain to the use of the FCR as the selected sight within the crewstation.

SIGHT STATUS	CONDITION	CORRECTIVE ACTION
DEF SCHEME A	Default Priority Scheme A has been selected and no weapon is actioned in the crewstation.	None required. Stationary ground targets and airborne targets will be prioritized over moving ground targets.
DEF SCHEME B	Default Priority Scheme B has been selected and no weapon is actioned in the crewstation.	None required. Stationary ground targets will be prioritized over moving ground targets or airborne targets.
DEF SCHEME C	Default Priority Scheme C has been selected and no weapon is actioned in the crewstation.	None required. Moving ground targets and airborne targets will be prioritized over stationary ground targets.

FCR Target Symbols

The following FCR target symbols will be displayed on the FCR page, or within the HMD and TADS symbology when C-Scope is enabled within the crewstation. Each symbol represents an object that the FCR has detected and determined to be of military interest, with the symbol corresponding to the target classification.

TARGET TYPE	MOVING (500-8000 METERS)	STATIONARY (500-1500 METERS)	STATIONARY (1500-8000 METERS)
TRACKED VEHICLE			
WHEELED VEHICLE			
AIR DEFENSE VEHICLE			
UNKNOWN			
HELICOPTER			
FIXED-WING			

FCR target symbols may be displayed in partial-intensity yellow to represent stale FCR targeting data. Stale FCR symbols represent tactical information that has likely changed since the completion of the most recent scan.

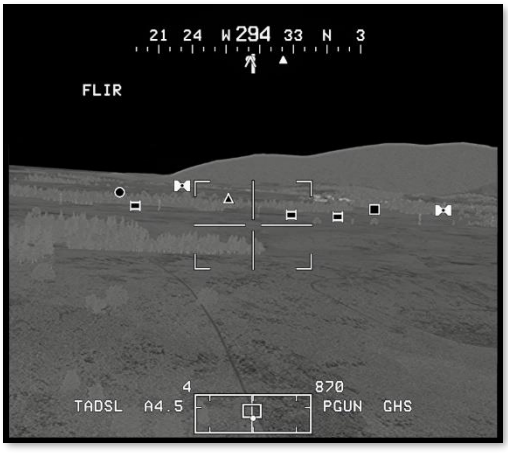
Moving target symbols will become stale 5 seconds after the completion of the most recent scan in which the target was detected.

Stationary target symbols will become stale 30 seconds after the completion of the most recent scan in which the target was detected.

NOTE: The FCR is not capable of target identification, and therefore cannot determine if a target is friendly or enemy. As such, all targets detected by the FCR are displayed as an unknown affiliation. Battlefield intelligence, fire support coordination measures (FSCM), and target identification through other means (such as the TADS) should be utilized before employing munitions against unknown targets on the battlefield.

C-Scope

Selecting the C SCP button (VAB T1) on the FCR page or the C-Scope button on the TEDAC Right Handgrip displays FCR target symbols, NTS and ANTS symbols, and SHOT symbols as virtual symbology elements within the crewmember's symbology overlays. C-Scope symbols will be overlaid within the crewmember's HMD Flight symbology, or within the CPG's Weapon symbology, at their true positions relative to the crewmember's HMD or TADS line-of-sight, as virtual representations of locations "out-the-window".



C-Scope increases the aircrew's situational awareness by fusing FCR target data with TADS sensor video and allowing either crewmember to see a virtual representation of battlefield targets through their helmet displays. This capability is particularly useful when receiving FCR target data through the datalink from an FCR-equipped AH-64D, in which target locations may be viewed while still masked behind terrain, allowing the receiving aircrew to easily gain situational awareness of the battlefield before unmasking their own aircraft from behind cover.

In addition, C-Scope symbols are also overlaid on either crewmember's video sources when viewed on the VID page with VSEL (VAB T6) selected. As an example, if the CPG has enabled C SCP and is viewing a target through the TADS that has also been detected and classified by the FCR, the Pilot will see the corresponding FCR target symbol overlaid within the TADS video while viewing the TADS video source, even if C SCP is not enabled in the Pilot crewstation. Since the TADS is being employed from a crewstation in which C SCP is enabled, the other crewstation will see the video source as represented from the crewstation in which it is being sourced, regardless of whether C SCP is enabled or disabled in the crewstation viewing the video source.

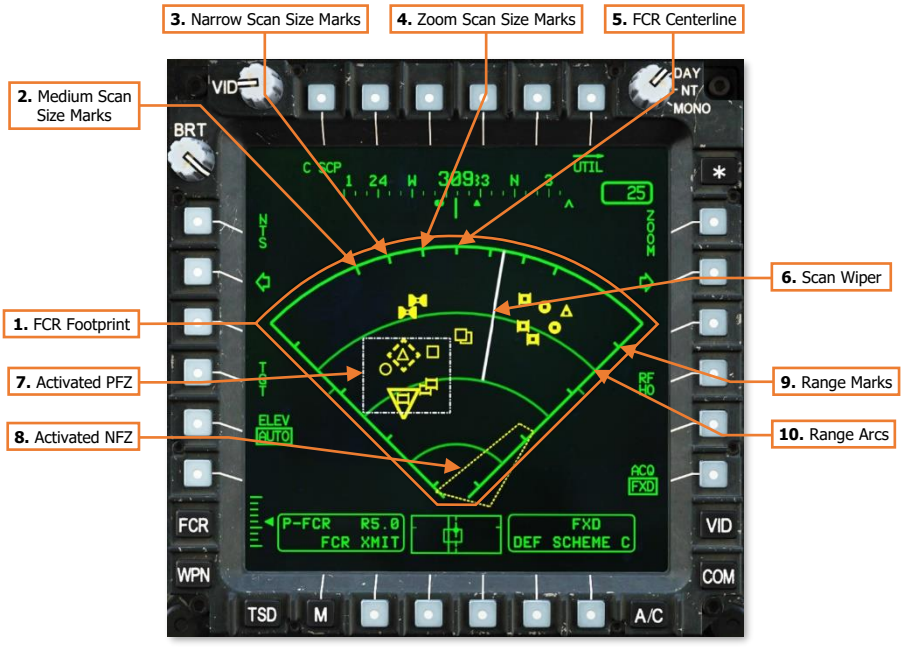
FCR MODES

The four FCR modes leverage the capabilities of the APG-78 radar as a sight for targeting and weapons employment against ground and air targets, reconnaissance of enemy positions, or avoidance of terrain and obstacles during low-visibility conditions. There is no direct indication as to which FCR mode has been selected; however, the FCR page will change format based on the currently selected FCR mode.

Ground Targeting Mode (GTM)

GTM is used to detect and classify ground vehicles and low-flying aircraft, which are displayed in a Plan Position Indicator (PPI) format. When the FCR is scanning in GTM, the FCR centerline will be stabilized in azimuth, independently of the aircraft heading, as indicated by the FCR Centerline Symbol along the bottom of the Heading Tape.

GTM is interchangeable with RMAP mode, in that a scanburst performed in one mode may be viewed in the format of the other after the scanburst is complete. GTM is the default FCR mode upon power-up.



1. **FCR Footprint.** The entire FCR Footprint represents the size of the FCR scan sector if the FCR Scan Size switch were pressed right to the "W" position. A Wide scan size will encompass a 90° sector of the battlefield, 45° to either side of the FCR Centerline, to a maximum range of 8 kilometers.

   In addition, threat radars detected by the RFI will be displayed around the outer edge of the FCR Footprint.

2. **Medium Scan Size Tick Marks.** Indicates the relative azimuth size of the FCR scan sector if the FCR Scan Size switch were pressed down to the "M" position. A Medium scan size will encompass a 45° sector of the battlefield, 22.5° to either side of the FCR Centerline, to a maximum range of 8 kilometers.

3. **Narrow Scan Size Tick Marks.** Indicates the relative azimuth size of the FCR scan sector if the FCR Scan Size switch were pressed left to the "N" position. A Narrow scan size will encompass a 30° sector of the battlefield, 15° to either side of the FCR Centerline, to a maximum range of 8 kilometers.

4. **Zoom Scan Size Tick Marks.** Indicates the relative azimuth size of the FCR scan sector if the FCR Scan Size switch were pressed up to the "Z" position. A Zoom scan size will encompass a 15° sector of the battlefield, 7.5° to either side of the FCR Centerline, to a maximum range of 8 kilometers.

5. **FCR Centerline.** Indicates the center of the FCR scan sector within the FCR Footprint.

6. **Scan Wiper.** Displays the position of the FCR antenna within the FCR scan sector when performing a scan. The FCR Scan Wiper will be displayed in White when performing a single scanburst or displayed in Green when performing a continuous scanburst.

7. **Activated PFZ.** Displays the boundaries of an activated Priority Fire Zone (PFZ) in relation to the FCR footprint. All FCR targets detected within an activated PFZ will out-prioritize any targets detected outside the activated PFZ, regardless of the target classification or the selected Priority Scheme on the FCR Utility sub-page. (See Battle Area Management in the Datalink chapter for more information.)

8. **Activated NFZ.** Displays the boundaries of an activated No Fire Zone (NFZ) in relation to the FCR footprint. All FCR targets detected within an activated NFZ will not be prioritized nor shown on the FCR page. However, targets within activated NFZ's will still be displayed on the TSD page when set to ATK phase, if enabled on the SHOW sub-page. (See Battle Area Management in the Datalink chapter for more information.)

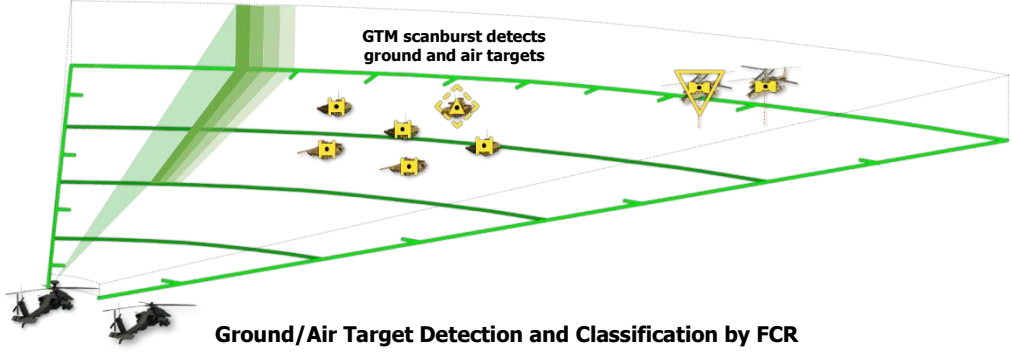
   NOTE: No Fire Zones take precedence over overlapping Priority Fire Zones, in that any FCR targets that are detected within an activated PFZ and an activated NFZ will not be prioritized or shown on the FCR page.

9. **Range Marks.** Indicates the distance from the ownship on either side of the FCR scan sector in 2-kilometer increments, at 1 km, 3 km, 5 km, and 7 km.

10. **Range Arcs.** Indicates the distance from the ownship within the FCR scan sector in 2-kilometer increments, at 2 km, 4 km, and 6 km.

Tactical Employment of GTM

When the FCR is employed using Ground Targeting Mode, targeting information is presented in a decluttered 90° sector PPI format from the perspective of the FCR centerline. This provides an easy to interpret "photograph" of the battlespace within the FCR scan volume, to include a combined prioritization of ground and low-flying air targets, along with any activated Priority Fire Zone (PFZ) and No Fire Zones (NFZ).



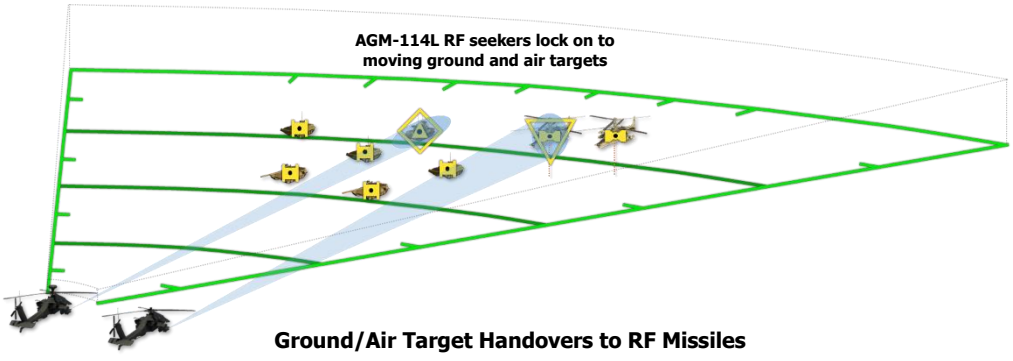
Ground/Air Target Detection and Classification by FCR

However, unlike RMAP, GTM does not provide any indication of radar "dead space" due to terrain obstructions, nor does it provide any direct feedback that the FCR antenna elevation is too high or too low for the intended area to be scanned.

FCR Target Handovers (GTM/RMAP)

When engaging targets with AGM-114L radar-guided missiles, the FCR does not provide direct guidance to the missiles themselves prior to, or after, the missiles are launched. Rather, the FCR provides the missile with a target handover sent to the missile via the launcher umbilical, which includes the target's position and whether it is moving or stationary. The missile's onboard active radar seeker acquires the target using this information, either before launch while still on the launcher rail (LOBL mode), or after launch while already in flight (LOAL mode). (See RF LOBL/LOAL Selection Logic for more information.)

When committing to an engagement of ground or air targets using the FCR as the selected sight, it is ideal to perform a single scanburst to gather an updated "photograph" of the battlefield just prior to actioning a weapon system, especially if presented with stale targeting data on the FCR page, which represents tactical information that has likely changed since the completion of the most recent scan. (See FCR Target Symbols for more information.)



Ground/Air Target Handovers to RF Missiles

When a Next-To-Shoot (NTS) target has been designated by the FCR and missiles are actioned in the same crewstation that is employing the FCR as the selected sight, the next-to-launch AGM-114L missile receives a target handover of the NTS target. Any time the FCR designates a new NTS target, a different NTS target is selected by the crewmember, or the missiles are de-actioned and subsequently actioned again, a new target handover is sent to the next-to-launch AGM-114L missile with the most recent target information.

FCR Priority Schemes (GTM/RMAP)

Three Priority Schemes may be selected on the FCR Utility sub-page which affects how targets are prioritized by the FCR in GTM, RMAP, or ATM. These Priority Schemes reflect different tactical situations that may be encountered by the AH-64D team and allow FCR-equipped aircraft within the team to react to changes on the battlefield in real-time.

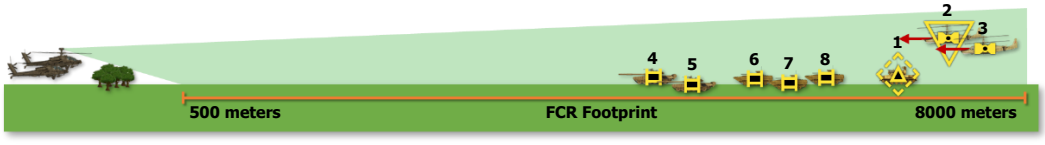
- **Default Scheme A.** Stationary ground targets and airborne targets will be prioritized over moving ground targets.
- **Default Scheme B.** Stationary ground targets will be prioritized over moving ground targets or airborne targets.
- **Default Scheme C.** Moving ground targets and airborne targets will be prioritized over stationary ground targets.

Three tactical scenarios are described on the following page to illustrate the potential applicability of each Priority Scheme when employing the FCR in GTM or RMAP mode. However, these scenarios are generalized and do not encompass the entirety of how the Priority Schemes may be applied to a given tactical situation.

For information regarding Priority Schemes when employing the FCR in ATM, see the Air Targeting Mode section within this chapter.

Scenario 1. Performing an attack against a stationary armor force that is supported by armed helicopters, in which the AH-64D team must provide its own protection against air defense threats and aircraft.

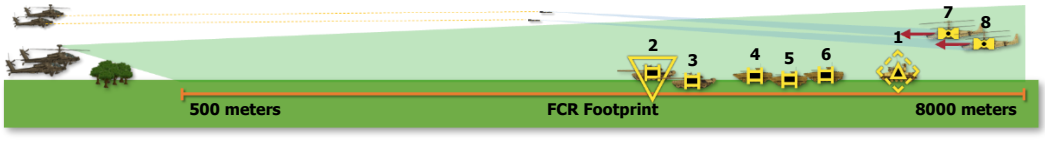
In such a scenario, it is anticipated that any air defense units accompanying the enemy armor force will be deployed in a defensive posture and must be destroyed at the outset of an engagement to ensure the survival of the AH-64D team. If enemy helicopters are detected, these aircraft must be subsequently targeted by the AH-64D team prior to engaging the enemy armor.



Priority Scheme A

Scenario 2. Performing an attack against a stationary armor force in which the AH-64D team must provide its own protection against air defense threats, while supported by friendly counter-air assets or a second AH-64D team that is assigned to provide protection against enemy aircraft.

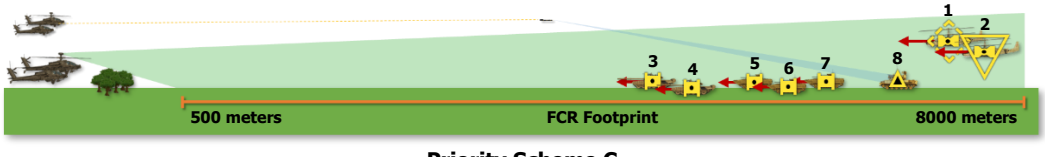
In such a scenario, it is anticipated that any air defense units accompanying the enemy armor force will be deployed in a defensive posture and must be destroyed at the outset of an engagement to ensure the survival of the AH-64D team. If enemy helicopters are present, these units shall be engaged by other friendly aircraft or a second AH-64D team assigned to provide support against such threats, which allows the primary AH-64D team to focus their firepower against the enemy armor.



Priority Scheme B

Scenario 3. Performing an attack against a moving armor force that is supported by air defenses and/or armed helicopters, in which the AH-64D team must provide its own protection against enemy aircraft, while supported by friendly SEAD assets or a second AH-64D team that is assigned to engage stationary air defense threats.

In such a scenario, it is anticipated that air defense units and helicopters will be accompanying the enemy armor force and must be destroyed at the outset of an engagement to ensure the survival of the AH-64D team. If any of the enemy air defenses are deployed in a stationary defensive posture to cover the movement of the enemy armor force, these air defenses shall be engaged by other friendly aircraft or a second AH-64D team assigned to provide support against such threats, which allows the primary AH-64D team to focus their firepower against the enemy armor and/or helicopters.



Priority Scheme C

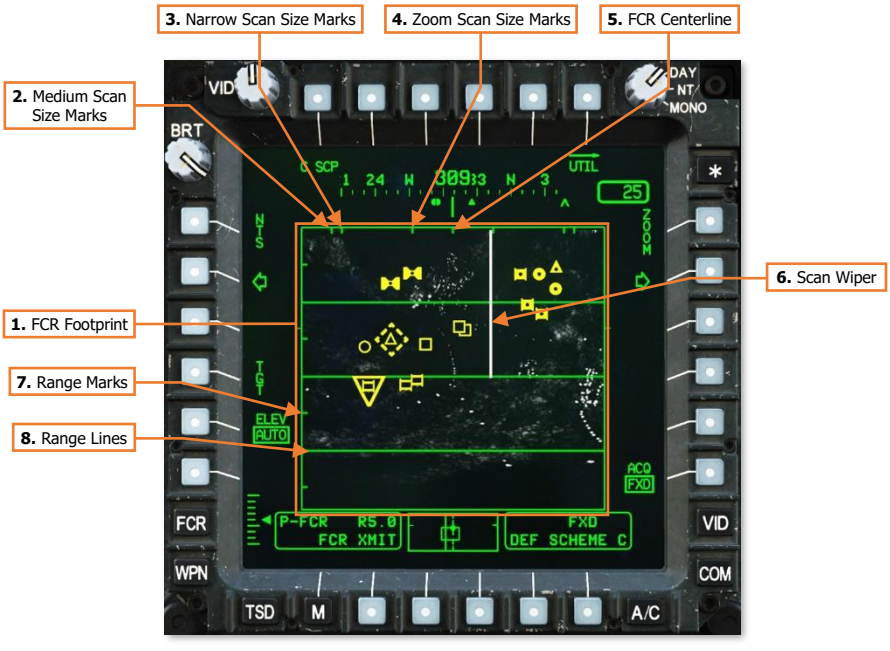
These scenarios are just a few among many potential tactical situations the AH-64D team may face. Depending on the composition of the AH-64D team(s), the engagement plan for the mission, friendly support assets such as artillery or fixed-wing aircraft, and the disposition and actions of the enemy forces, each FCR-equipped AH-64D may need to adjust Priority Schemes during the mission to adapt to the evolving battlefield conditions.

Radar Map Mode (RMAP)

RMAP is used to detect and classify ground vehicles and low-flying aircraft, which are displayed in a B-Scope format along with a radar-generated terrain map underlaid below the FCR target symbols. When the FCR is scanning in RMAP, the FCR centerline will be stabilized in azimuth, independently of the aircraft heading, as indicated by the FCR Centerline Symbol along the bottom of the Heading Tape.

The brightness of the terrain video underlay may be adjusted independently of the primary symbology displayed on the MPD using the VID knob. Re-selecting RMAP using the FCR mode switch on the Collective Mission Grip or the TEDAC Left Handgrip when the FCR mode is already set to RMAP will toggle the terrain video underlay on the FCR page. The RMAP terrain video will take priority over any video underlay that has been selected on the VID page. If the RMAP terrain video is disabled, the video underlay selected on the VID page will be displayed.

RMAP mode is interchangeable with GTM, in that a scanburst performed in one mode may be viewed in the format of the other after the scanburst is complete. When the FCR mode is set to RMAP, activated Fire Zones (PFZ's and NFZ's) are not displayed on the FCR page.



1. **FCR Footprint.** The entire FCR Footprint represents the size of the FCR scan sector if the FCR Scan Size switch were pressed right to the "W" position. A Wide scan size will encompass a 90° sector of the battlefield, 45° to either side of the FCR Centerline, to a maximum range of 8 kilometers.

   In addition, threat radars detected by the RFI will be displayed around the outer edge of the FCR Footprint.

2. **Medium Scan Size Marks.** Indicates the relative azimuth size of the FCR scan sector if the FCR Scan Size switch were pressed down to the "M" position. A Medium scan size will encompass a 45° sector of the battlefield, 22.5° to either side of the FCR Centerline, to a maximum range of 8 kilometers.

3. **Narrow Scan Size Marks.** Indicates the relative azimuth size of the FCR scan sector if the FCR Scan Size switch were pressed left to the "N" position. A Narrow scan size will encompass a 30° sector of the battlefield, 15° to either side of the FCR Centerline, to a maximum range of 8 kilometers.

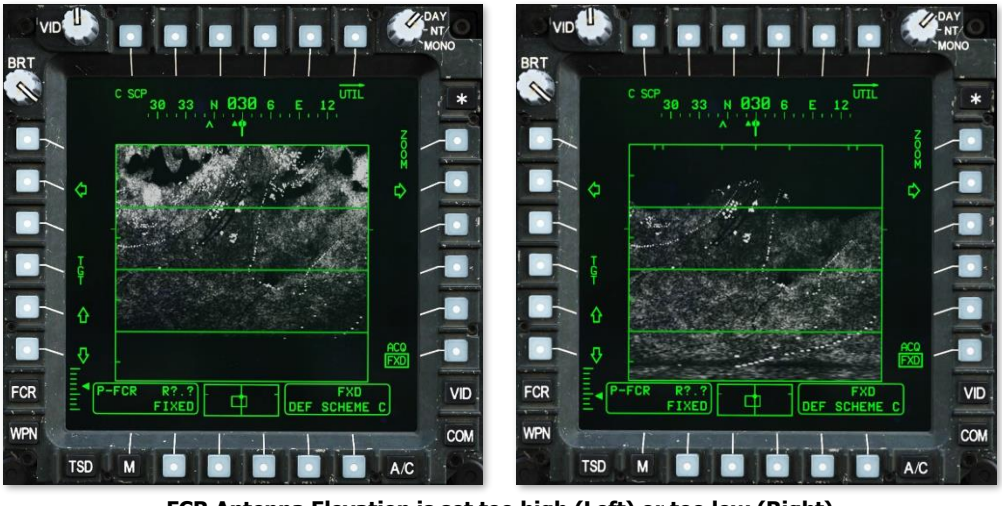
4. **Zoom Scan Size Marks.** Indicates the relative azimuth size of the FCR scan sector if the FCR Scan Size switch were pressed up to the "Z" position. A Zoom scan size will encompass a 15° sector of the battlefield, 7.5° to either side of the FCR Centerline, to a maximum range of 8 kilometers.
5. **FCR Centerline.** Indicates the center of the FCR scan sector within the FCR Footprint.
6. **Scan Wiper.** Displays the position of the FCR antenna within the FCR scan sector when performing a scan. The FCR Scan Wiper will be displayed in White when performing a single scanburst or displayed in Green when performing a continuous scanburst.
7. **Range Marks.** Indicates the distance from the ownship on the left side of the FCR scan sector in 2-kilometer increments, at 1 km, 3 km, 5 km, and 7 km.
8. **Range Lines.** Indicates the distance from the ownship within the FCR scan sector in 2-kilometer increments, at 2 km, 4 km, and 6 km.

Tactical Employment of RMAP

The FCR-generated terrain map displayed in RMAP mode allows the crew to identify significant terrain features or radar-reflective man-made infrastructure that may not be readily visible to the naked eye or optical sensors. In addition, radar "dead space" may be identified, allowing the crew to determine which areas of the battlefield cannot be seen by the aircraft sensors due to high terrain or defilade. This may indicate areas of potential enemy positions that remain unseen, whether it be due to terrain obstructions or because the FCR scan volume is outside the displayed FCR footprint, requiring a manual adjustment of the FCR antenna elevation.

FCR Antenna Elevation

When operating over mountains or rolling hills in which the automatic elevation mode may not result in the intended area of the battlefield being scanned by the FCR, the RMAP terrain video provides the crew with a visual indication as to which areas of the battlefield are actually within the FCR scan volume.

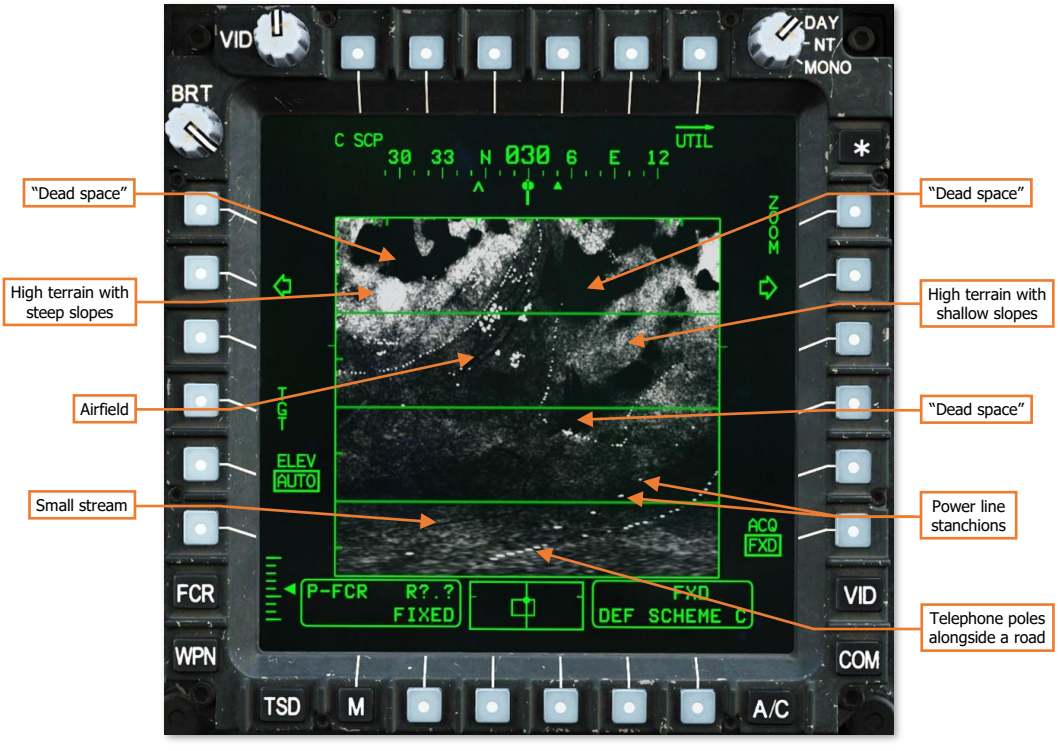


FCR Antenna Elevation is set too high (Left) or too low (Right)

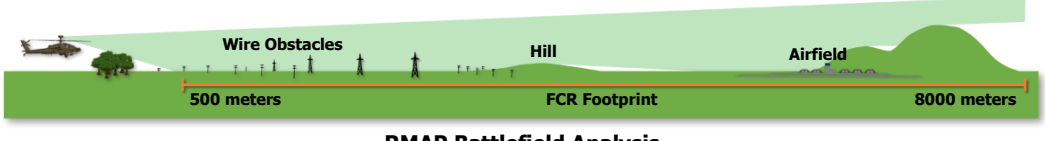
When an FCR scanburst is performed which results in a horizontal band of no terrain video that runs along the bottom of the FCR footprint, the FCR antenna elevation is set too high. If a horizontal band of no terrain video runs along the top of the FCR footprint, the FCR antenna elevation is set too low. In either case, the FCR elevation control should be set to manual mode and manually adjusted before attempting another scanburst. (See FCR Elevation Controls for more information.)

Battlefield Analysis

Radar Map mode allows the crew to view FCR-detected targets within the overall context of the battlefield and perform terrain analysis. When the FCR radome is unmasked and a scanburst is performed, the process of detection, classification, and prioritization of targets is performed in the same manner as with Ground Targeting Mode (GTM), which will present the 16 highest priority targets on the FCR page. However, with the addition of the terrain video underlay in RMAP mode, the crew can gain better understanding as to how the targets are arrayed across the battlefield amongst significant terrain features such as roads, rivers, hills, or urban areas.



Areas of terrain that are not visible to the radar, known as "dead space", will be shaded black like a shadow cast across the terrain. Depending on the amount of intelligence the crew has received prior to the mission regarding the location of enemy positions, these areas should be regarded as potentially unknown enemy positions.



RMAP Battlefield Analysis

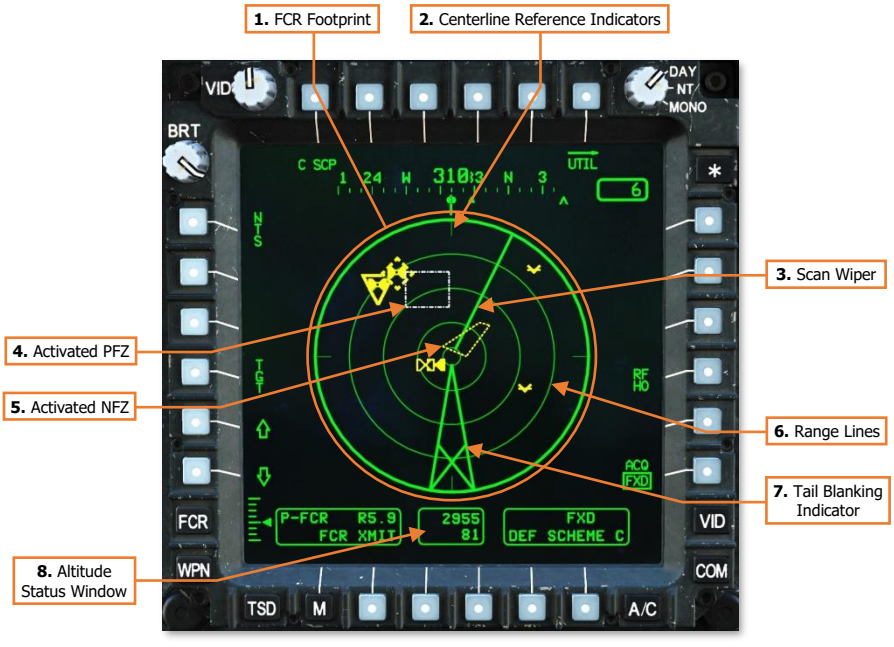
In the example on this page, if the crew intended to advance toward the small hill 3.5 kilometers away, identified by the radar shadow cast beyond the hill itself, the crew could anticipate crossing several sets of wire obstacles while enroute to their next battle position. This real-time terrain analysis, in conjunction with charts, satellite imagery, topographic color banding, and pre-plotted hazards, control measures, and threats on the Tactical Situation Display (TSD) page, provides the crew with a wealth of information within the cockpit for building situational awareness of the battlefield before unmasking to re-position the helicopter or engage enemy targets.

Air Targeting Mode (ATM)

ATM is used to detect and classify helicopters and fixed-wing aircraft, which are displayed in a Plan Position Indicator (PPI) format. When the FCR is scanning in ATM, the FCR centerline will be stabilized to the aircraft heading, as indicated by the FCR Centerline Symbol along the bottom of the Heading Tape.

When the FCR mode is set to ATM mode from GTM or RMAP, any existing FCR targets and/or terrain map data that was generated from GTM or RMAP modes are deleted. Accordingly, when the FCR mode is set to GTM or RMAP mode from ATM, any existing FCR targets generated while in ATM are deleted.

The image below illustrates the FCR page when set to ATM mode and the scan size is set to Wide. When the ATM scan size is set to Medium, Narrow, or Zoom, a solid line will be displayed in the center of the FCR footprint itself to represent the current FCR centerline.



1. **FCR Footprint.** The entire FCR Footprint represents the relative size of the FCR scan sector if the FCR Scan Size switch were pressed right to the "W" position. A Wide scan size will encompass the entire 360° of airspace around the ownship, to a maximum range of 8 kilometers.

   In addition, threat radars detected by the RFI will be displayed around the outer edge of the FCR Footprint.

2. **Centerline Reference Indicators.** Displays reference positions relative to the aircraft centerline at the 12 o'clock, 3 o'clock, 6 o'clock, and 9 o'clock positions.

3. **Scan Wiper.** Displays the position of the FCR antenna within the FCR scan sector when performing a scan. The FCR Scan Wiper will be displayed in White when performing a single scanburst or displayed in Green when performing a continuous scanburst.

4. **Activated PFZ.** Displays the boundaries of an activated Priority Fire Zone (PFZ) in relation to the FCR footprint. All FCR targets detected within an activated PFZ will out-prioritize any targets detected outside the activated PFZ, regardless of the target classification. (See Battle Area Management in the Datalink chapter for more information.)

5. **Activated NFZ.** Displays the boundaries of an activated No Fire Zone (NFZ) in relation to the FCR footprint. All FCR targets detected within an activated NFZ will not be prioritized nor shown on the FCR page. However, targets within activated NFZ's will still be displayed on the TSD page when set to ATK phase, if enabled on the SHOW sub-page. (See Battle Area Management in the Datalink chapter for more information.)

   NOTE: No Fire Zones take precedence over overlapping Priority Fire Zones, in that any FCR targets that are detected within an activated PFZ and an activated NFZ will not be prioritized or shown on the FCR page.

6. **Range Lines.** Indicates the distance from the ownship within the FCR scan sector in 2-kilometer increments, at 2 km, 4 km, and 6 km.

7. **Tail Blanking Indicator.** Indicates the sector of the FCR scan that has been obstructed by the vertical tail.

8. **Altitude Status Window.** Indicates the upper and lower altitudes above ground level (AGL) that the FCR scan volume encompasses at the maximum FCR range of 8 kilometers.

Tactical Employment of ATM

When the FCR is employed using Air Targeting Mode, targeting information is presented in a 360° PPI format centered on the ownship and oriented relative to the aircraft heading. This provides a top-down overlay of the surrounding airspace and any rotary- and fixed-wing aircraft detected within 8 kilometers of the ownship.

When scanning in Air Targeting Mode, the FCR utilizes a 1-bar scan pattern at a constant elevation setting that is stabilized to the horizontal plane. Unlike GTM or RMAP, ATM does not utilize an automatic elevation mode. As such, when ATM mode is selected, the FCR elevation mode will be set to manual (MAN) on the FCR Utility sub-page and cannot be changed. Additionally, the FCR centerline remains stabilized relative to the aircraft heading while scanning, allowing the crew to scan a specific airspace sector relative to the AH-64D's flight path or position.

Target Update Rate

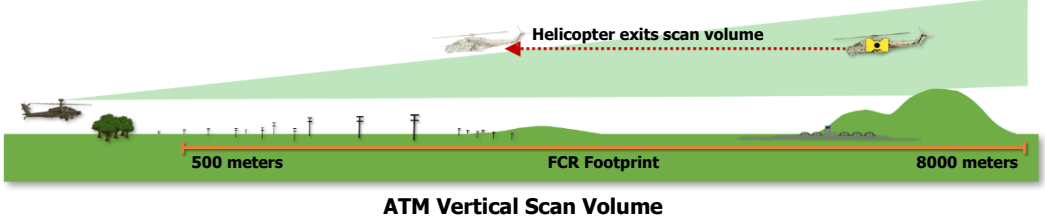
Although a Wide scan size allows an FCR-equipped AH-64D to monitor the local airspace in a 360° search pattern (excluding the tail blanking area under certain conditions), it is not ideal for target engagements. When engaging an air target while using the FCR as the selected sight, a smaller scan size is more ideal due to the increased rate at which the target's position and velocity is updated within the FCR scan volume.

The target update rate for each FCR scan size is listed below, which may vary for scan sizes other than Wide, depending on whether the target is in the center of the scan volume or near the edge.

- Wide scan size (360°) – 6 seconds.
- Medium scan size (180°) – 3 to 6 seconds.
- Narrow scan size (90°) – 1.5 to 3 seconds.
- Zoom scan size (45°) – 0.75 to 1.5 seconds.

Vertical Dimensions of Scan Volume

The default elevation setting when the FCR is set to ATM is +3°, which will align the lower limit of the FCR vertical scan volume with the altitude of the aircraft; or more precisely, the altitude of the FCR radome itself.



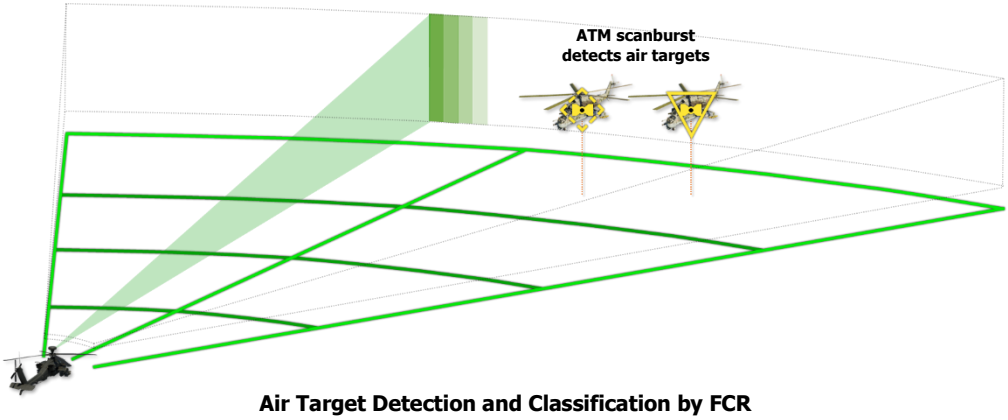
ATM Vertical Scan Volume

If an aircraft is detected by the FCR that is approaching at a constant altitude, the aircrew can expect the aircraft to exit the FCR scan volume as the range decreases. At closer ranges to an air target, the elevation of the FCR will likely need to be adjusted more frequently to account for the differences in altitude and relative position.

FCR Target Handovers (ATM)

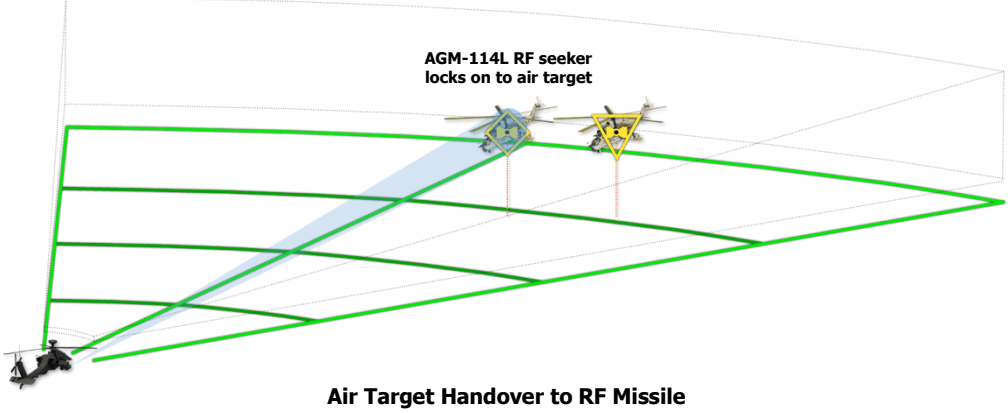
When engaging air targets with AGM-114L radar-guided missiles, the FCR does not provide direct guidance to the missiles themselves prior to, or after, the missiles are launched. Rather, the FCR provides the missile with a target handover sent to the missile via the launcher umbilical, which includes the target's position and whether it is moving or stationary (in the case of a hovering helicopter). The missile's onboard active radar seeker acquires the target using this information, either before launch while still on the launcher rail (LOBL mode), or after launch while already in flight (LOAL mode). (See RF LOBL/LOAL Selection Logic for more information.)

When committing to an engagement of an air target using the FCR as the selected sight, it is ideal to perform a single scanburst along the azimuth of intended target of engagement with the scan size set to Narrow or Zoom. This will gather an updated position of the air target just prior to actioning a weapon system.



Air Target Detection and Classification by FCR

When a Next-To-Shoot (NTS) target has been designated by the FCR and missiles are actioned in the same crewstation that is employing the FCR as the selected sight, the next-to-launch AGM-114L missile receives a target handover of the NTS target. Any time the FCR designates a new NTS target, a different NTS target is selected by the crewmember, or the missiles are de-actioned and subsequently actioned again, a new target handover is sent to the next-to-launch AGM-114L missile with the most recent target information.



Air Target Handover to RF Missile

Unless engaging a stationary, hovering helicopter that is beyond a range 2.5 kilometers, the AGM-114L will enter LOBL mode after receiving the target handover from the FCR and attempt to acquire the air target. Due to the greater velocity and maneuverability of aircraft compared to ground vehicles, the likelihood of a successful engagement is much greater if the AGM-114L is launched after the missile seeker has acquired the air target.

FCR Priority Schemes (ATM)

Three Priority Schemes may be selected on the FCR Utility sub-page which affects how targets are prioritized by the FCR in GTM, RMAP, or ATM. These Priority Schemes reflect different tactical situations that may be encountered by the AH-64D team and allow FCR-equipped aircraft within the team to react to changes on the battlefield in real-time.

- **Default Scheme A.** Stationary helicopters will be prioritized over moving helicopters or fixed-wing aircraft.
- **Default Scheme B.** Stationary helicopters will be prioritized over moving helicopters or fixed-wing aircraft.
- **Default Scheme C.** Moving helicopters and fixed-wing aircraft will be prioritized over stationary helicopters.

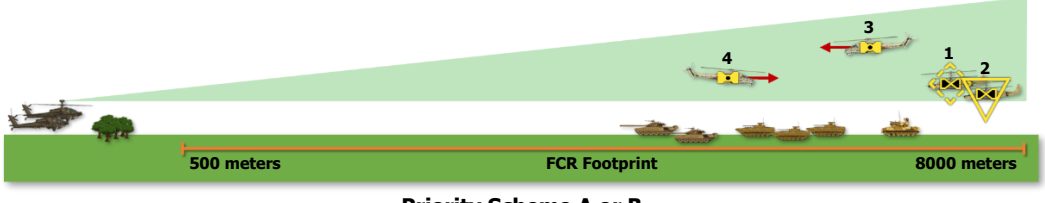
NOTE: Although fixed-wing aircraft are included in the target prioritization logic, the AH-64D is not equipped with munitions that are ideal for engaging high-speed aircraft.

Two tactical scenarios are described below to illustrate the potential applicability of each Priority Scheme when employing the FCR in Air Targeting Mode. However, these scenarios are generalized and do not encompass the entirety of how the Priority Schemes may be applied to a given tactical situation.

For information regarding Priority Schemes when employing the FCR in GTM or RMAP, see the Ground Targeting Mode section within this chapter.

Scenario 1. Performing an attack against an enemy armor force that is supported by armed helicopters, in which an FCR-equipped AH-64D is tasked to provide protection for the AH-64D team against enemy helicopters that favor hovering attack techniques.

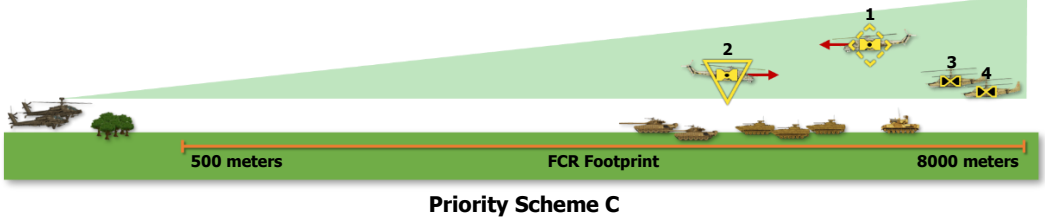
In a scenario in which enemy helicopters are expected to employ hovering attacks from stationary battle positions and bounding when repositioning between battle positions, target priorities will be focused on helicopters that are stationary over the battlefield. If enemy helicopters are detected to be stationary in a hover, these aircraft are prioritized for targeting over aircraft that are moving across the battlefield.



Priority Scheme A or B

Scenario 2. Performing an attack against an enemy armor force that is supported by armed helicopters, in which an FCR-equipped AH-64D is tasked to provide protection for the AH-64D team against enemy helicopters that favor high-speed attack techniques.

In a scenario in which enemy helicopters are expected to employ high-speed moving, pop-up, or diving attacks, target priorities will be focused on helicopters that are moving over the battlefield. If enemy aircraft are detected inbound with a positive closure rate toward the ownship, these aircraft are prioritized for targeting over aircraft that are flying away from the ownship or are in a stationary hover.

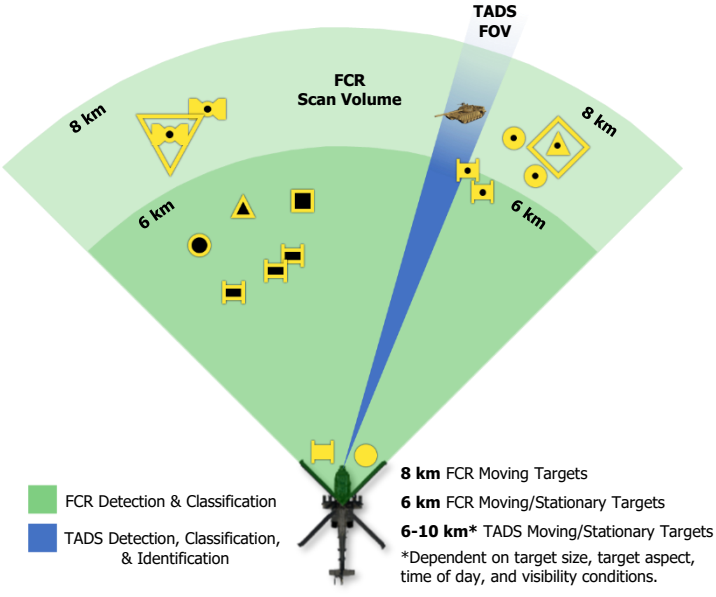


Priority Scheme C

FCR ACQUISITION AND RANGING

The FCR cannot recognize specific vehicle types or equipment on the battlefield, nor identify whether targets are friend or foe; however, the wide area search capability of the FCR allows the crew to efficiently direct the optical sensors of the TADS for such purposes. Alternatively, during periods of limited visibility, the FCR C-Scope function can directly aid the CPG in acquiring targets within the TADS field-of-view by performing a narrow scanburst along the same line-of-sight and overlaying virtual target symbols within the TADS sensor video.

The key advantage in using the FCR for initial detection and classification of targets is its ability to scan 50 square kilometers of the battlefield within seconds, while simultaneously performing an initial classification of each target of military interest that is detected within the FCR scan volume. Performing the same task while using optical sensors would require a significantly longer period of time and would be further constrained by the narrow aperture of the optical sensors themselves, the relative size and aspect angle of each target, the time of day, and visibility conditions. Enemy forces that pose a direct threat to the aircraft, but are unknowingly outside the optical sensor's field-of-view, may go unnoticed until the aircraft is under attack.



Detection, Classification, & Identification of Targets

Generally speaking, FCR scan sizes are best utilized in the following manner.

- Initial detection and classification of targets within the battlespace: Wide/Medium scan size.
- Target acquisition and weapons engagement: Narrow/Zoom scan size.

As with most tactical situations, many variables may determine the ideal FCR mode and scan patterns. Factors such as terrain, anticipated enemy positions or movement on the battlefield, proximity of friendly forces, and the maneuvering of the AH-64D team itself will play significant roles in determining the ideal FCR scan size, whether Priority Fire Zones or No Fire Zones should be activated, and which FCR Priority Scheme should be employed.

Additional details regarding the employment of the FCR for target acquisition are listed below.

- Although the maximum detection range of the FCR is 8 kilometers, the FCR alone will only process and display stationary ground target symbols within a range of 6 kilometers.
- The FCR page is used for controlling and employing the Fire Control Radar as a sight. As such, it is limited to displaying the 16 high priority targets as the crewmember's "shoot list", which will remain frozen at the completion of the scanburst for ease of designation, engagement, and post-engagement BDA.
- Target point T50 may be placed at the location of an FCR target and simultaneously set as the crewmember's acquisition source by selecting CAQ (VAB R5) on the TSD page and cursor-selecting an FCR target symbol on the TSD itself. This may be used to acquire a low priority target that is not displayed on the FCR page.

Acquisition Sources

The use of acquisition sources can reduce the time necessary to bring the FCR towards the intended FCR scan area. This is particularly useful when leveraging the FCR's area detection and classification capabilities to rapidly highlight potential target positions or increase situational awareness. When target locations are already detected using another sensor onboard the aircraft (to include visual detection by either crewmember), setting that sensor as the acquisition source and enabling the SLAVE function increases the efficiency of target acquisition using an FCR scanburst; especially when using narrow scan sizes.

Acquisition sources also reduce the amount of verbal communications and coordination of sensors that must occur between the crewmembers, which increases combat efficiency. In contrast to target handovers to either crewmembers' HMD or the CPG's TADS, which require less specificity due to their line-of-sight in the vertical plane, target handovers to the FCR are more reliant on correct target descriptions and range estimations since a single FCR scan may generate multiple targets along a given azimuth.

Examples of efficient target handovers to the FCR utilizing acquisition sources are listed below.

"Gunner, target, Pilot helmet sight. Tracked armor moving at 4 kilometers."

"Pilot, target, TADS. Enemy helicopter inbound, on the horizon."

In either case, the crewmember using the FCR as their sight simply selects the announced source of target information as the acquisition source (and in the case of the CPG, enables SLAVE), slewing the FCR centerline directly to the location of the intended target(s).

Acquisition sources listed below will command the FCR centerline to a specific azimuth relative to the aircraft nose, but will not restrict the FCR scan size nor will it prevent any other targets from being prioritized within the selected FCR scan volume.

- **PHS.** Pilot Helmet Sight; commands the FCR centerline to the azimuth of the Pilot's helmet. May be used to direct the FCR to the location designated by the Pilot's HMD LOS Reticle.
- **GHS.** Gunner Helmet Sight; commands the FCR centerline to the azimuth of the Copilot/Gunner's helmet. May be used to direct the FCR to the location designated by the CPG's HMD LOS Reticle.
- **SKR.** Seeker; commands the FCR centerline to the azimuth of the next-to-shoot AGM-114 missile seeker. May be used to direct the FCR to the target location that is currently being tracked by the next-to-shoot AGM-114 missile.
- **FXD.** Fixed forward; commands the FCR centerline to align with the Armament Datum Line (ADL) at 0° in azimuth.
- **TADS.** Target Acquisition Designation Sight; commands the FCR centerline to the azimuth of the TADS turret. May be used to direct the FCR to the location designated by the TADS sensor.
- **W##, H##, C##, T##.** Waypoint, Hazard, Control Measure, or Target/Threat point; commands the FCR centerline to the coordinates of the selected point within the navigation database. May be used to direct the FCR to a pre-planned, stored, or transmitted location for reconnaissance, target acquisition, or weapons engagement; or re-acquisition if line-of-sight was lost.
- **TRN.** Terrain point; commands the FCR centerline to the coordinates of the selected terrain point within the navigation database. May be used to direct the FCR to a cursor-selected location on the TSD that is not associated with an existing Waypoint, Hazard, Control Measure, or Target/Threat point for reconnaissance, target acquisition, or weapons engagement.

Range Sources

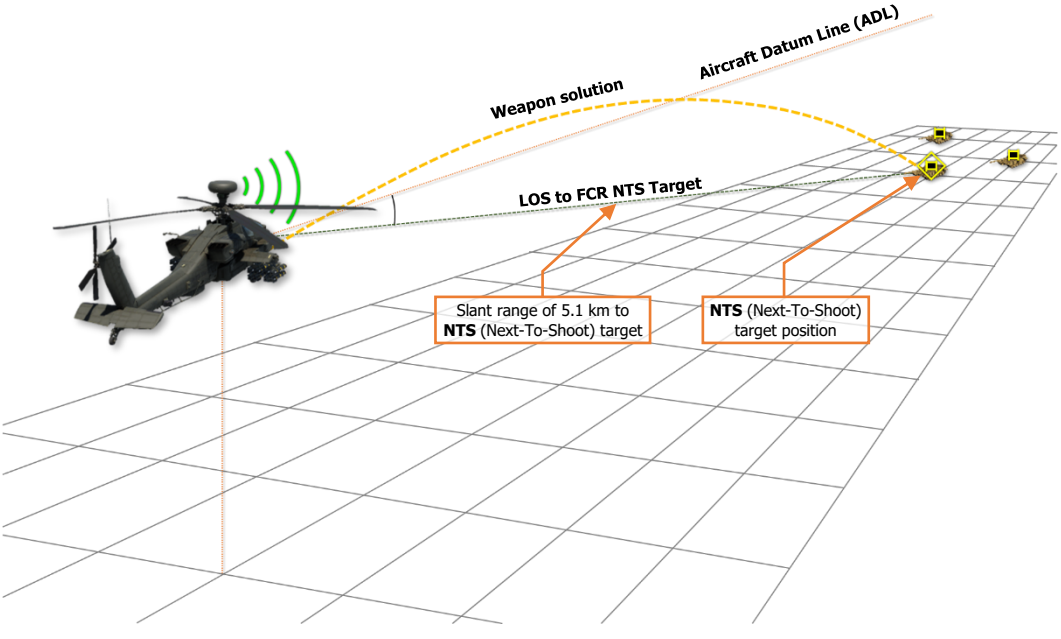
Among the three sights (HMD, TADS, and FCR) that may be employed by the AH-64D aircrew for targeting, the FCR is the most limited with regards to ranging options. When the FCR is being utilized as the selected sight, only one range source is available, which is a Radar range. However, it is one of the most accurate ranging sources available to the crew.

- **Radar range.** Radar range is automatically entered as the range source any time the crewmember selects FCR as the selected sight. When transmitting, the FCR precisely measures the slant range between the ownship and targets detected on (or above) the battlefield using reflected radar energy.

  If no NTS target has been designated, "R?.?" will be displayed within the Range Source field of the High Action Display (HAD). In addition, "LOS INVALID" will be displayed within the Weapon Inhibit field of the High Action Display any time a weapon is actioned and an NTS target has not been designated or has not been re-detected during a subsequent scan cycle.

Radar Range

Once a target location has been processed by the FCR, its position relative to the ownship is retained within the aircraft memory as a 3-dimensional geographic location. The Radar range displayed within the crewmember's High Action Display will always reflect the slant range to the current Next-To-Shoot (NTS) target as selected on the FCR page. As the aircraft moves or re-positions to a different location, the radar range is updated accordingly in real-time, in a similar manner to using a Navigation range to a point within the navigational database.



Radar Range

As this range source is dynamic, a Radar range may be used when calculating a targeting solution for any weapon system onboard the aircraft. However, targets that are displayed in partial-intensity on the FCR page represent stale FCR targeting data, and may not represent accurate battlefield target locations.

Sight LINK

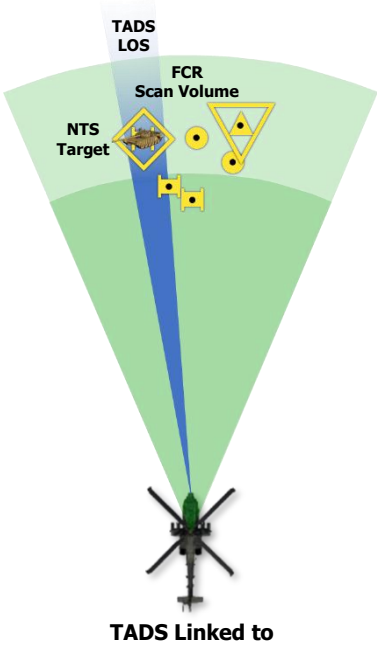
The FCR may be linked with the TADS to leverage the capabilities of both sights simultaneously against target locations acquired by one or the other. If either crewmember's selected sight is FCR, the TADS may be linked to the FCR; or if the CPG's selected sight is TADS, the FCR may be linked to the TADS.

NOTE: Although the TADS may be manually controlled by the CPG while it is linked to the FCR, the TADS is not the CPG's selected sight under these conditions. As such, the LRFD cannot be fired and the CPG will be unable to engage targets using the TADS unless it is subsequently selected as the CPG's sight.

Likewise, although some functions of the FCR may be employed by the CPG while it is linked to the TADS, the FCR is not the CPG's selected sight under these conditions. As such, the CPG will be unable to engage targets using the FCR unless it is subsequently selected as the CPG's sight.

Linking TADS to FCR

If either crewmember's selected sight is FCR and an FCR target has been designated as Next-To-Shoot (NTS), pressing the Sight Select switch on the Collective Mission Grip or TEDAC Right Handgrip to the LINK position within the same crewstation will link the TADS line-of-sight (LOS) to the geographical location of the FCR NTS target. "P-FCRL" or "C-FCRL" will be displayed in the Sight Select Status field of the High Action Display of the crewmember that has enabled LINK.



TADS Linked to FCR NTS Target

If the Pilot's selected sight is FCR, the CPG's selected sight is TADS, and the Pilot links the TADS to the FCR, the CPG's sight will automatically be set to HMD and any actioned weapon in the CPG crewstation will be de-actioned.

If any of the following criteria are met, the TADS cannot be linked to the FCR and the LINK switch position will be ignored.

- An NTS target has not been designated by the FCR.
- The crewmember's selected sight is HMD.
- The crewmember's acquisition source is set to TADS.
- Either crewmember's NVS Mode switch is set to NORM or FIXED with TADS as the selected NVS sensor.

If the TADS is already linked to the FCR and a new scanburst is commanded, the TADS will remain linked but will return to the fixed forward position until a new NTS target is designated.

The following TADS controls on the TEDAC handgrips will remain operational in the CPG crewstation while the TADS is linked to the FCR.

- Sensor Select switch.
- Field-Of-View Select switch.
- IAT/OFS switch.
- LMC button.
- FLIR Polarity button.
- SLAVE button.

If any of the following criteria are met within the crewstation that selected LINK, LINK will be disabled and the TADS will return to the fixed forward position.

- The crewmember re-selects LINK while the TADS is already linked to the FCR NTS target.
- The crewmember selects HMD as the sight.
- The crewmember selects a different acquisition source.

Alternatively, the CPG may press the Sight Select switch to the TADS position to disable LINK and take control of the TADS as the selected sight to independently track, lase, and engage targets as necessary.

Linking TADS for Combat Identification (CID)/Battle Damage Assessment (BDA) of an FCR Target

When potential targets are detected on the battlefield, only the aircrew is capable of identifying the detected military units and equipment and whether they are friend or foe, a process known as Combat Identification, or CID. In addition, only the aircrew can determine whether an enemy vehicle is operational or destroyed, a process known as Battle Damage Assessment, or BDA. Since the FCR is not capable of recognizing a target (T-72 or M1A2), determining its coalition affiliation (friend or foe), or whether a target is destroyed, linking the TADS to the FCR allows the Copilot/Gunner (CPG) to perform CID and BDA with regard to FCR-detected targets.

When the TADS is linked to the FCR, the TADS will default to a Medium FOV (field-of-view) if the selected sensor is FLIR, or Wide FOV if the selected sensor is DTV. If the aircraft and/or target are moving, this helps ensure the CPG is able to visually acquire the target within the TADS video, and subsequently stabilize the TADS on target, before the target exits the selected sensor's FOV. The CPG may then select Narrow or Zoom FOV as necessary for the purposes of performing CID or BDA of the FCR NTS target.

When employing an RF missile against an FCR target while the TADS is linked to the FCR, if the next-to-launch RF missile has entered LOBL mode and has successfully locked on to a target ("RF MSL TRACK" displayed in the High Action Display), the TADS will slave to the line-of-sight of the corresponding missile's seeker rather than the FCR NTS target. This allows the CPG to confirm the missile has locked on to the intended target prior to launch.

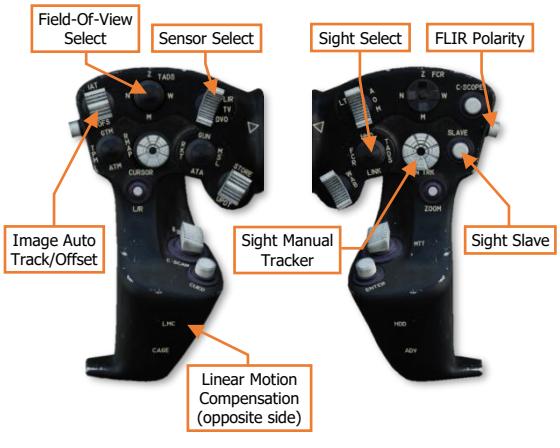
Slewing TADS while Linked to the FCR

If necessary, the CPG may manually slew the TADS while it is still linked to the FCR, allowing the crew to acquire and identify additional targets in vicinity of the FCR NTS target, or to hand off an FCR target to the TADS for engagement. This also allows the crew to perform immediate Battle Damage Assessment (BDA) on a target after firing an RF missile against the FCR NTS target, which would otherwise shift the TADS LOS to the next FCR target at the moment the missile was commanded to launch, which would automatically sequence the NTS designation.

When linked to the FCR NTS target, the TADS laser rangefinder/designator (LRFD) will be inhibited from firing and the Laser Spot Track (LST) and Image Auto-Track (IAT) functions will be overridden and disabled. However, the TADS will still attempt to maintain any tracks that remain within its optical field-of-view while linked to the FCR.

After the TADS LOS has been linked to the FCR NTS target, the CPG may press the SLAVE button on the TEDAC Right Handgrip, which will de-slave the TADS and enable the Sight Manual Tracker, allowing the CPG to manually slew the TADS as normal.

To manually slew the TADS while linked to the FCR NTS target, perform the following:



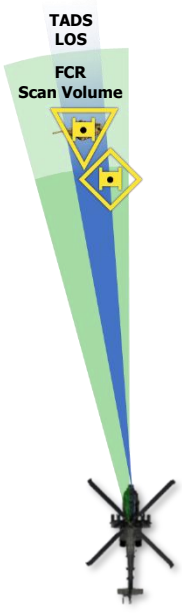
1. Sight Slave (SLAVE) button – Press.
2. Sight Manual Tracker (MAN TRK) – Slew and employ TADS as desired.
   - Sensor Select switch – Select FLIR or DTV as desired.
   - Field-Of-View Select switch – Select as desired.
   - FLIR Polarity button – Press as desired.
   - Manual tracking - Engage Linear Motion Compensation (LMC) as necessary.
   - Automatic tracking - Engage Image Auto Track (IAT).
3. Sight Slave (SLAVE) button – Press to slave the TADS back to FCR NTS target.

   or

3. Sight Select switch – Select LINK to slave the TADS back to the FCR NTS target.

Linking FCR to TADS

If the CPG's selected sight is TADS, pressing the Sight Select switch on Collective Mission Grip or TEDAC Right Handgrip to the LINK position will link the FCR centerline to the azimuth of the TADS line-of-sight (LOS). "TADSL" will be displayed in the Sight Select Status field of the High Action Display in the CPG crewstation.



FCR Linked to TADS LOS

If the CPG's selected sight is TADS, the Pilot's selected sight is FCR, and the CPG links the FCR to the TADS, the Pilot's sight will automatically be set to HMD, and any actioned weapon in the Pilot crewstation will be de-actioned.

If any of the following criteria are met, the FCR cannot be linked to the TADS and the LINK switch position will be ignored.

- The CPG's selected sight is HMD.
- The CPG's acquisition source is set to FCR.
- Either crewmember's NVS Mode switch is set to NORM or FIXED with TADS as the selected NVS sensor.

The following FCR controls will become operational on the CPG's Collective Mission Grip and TEDAC handgrips while the FCR is linked to the TADS.

- Mode Select switch.
- Scan Select switch.
- Scan Size Select switch.
- ZOOM button.

If any of the following criteria are met within the CPG crewstation after selecting LINK, LINK will be disabled and the FCR will return to the fixed forward position.

- The CPG re-selects LINK while the FCR is already linked to the TADS LOS.
- The CPG selects HMD as the sight.
- The CPG selects a different acquisition source.

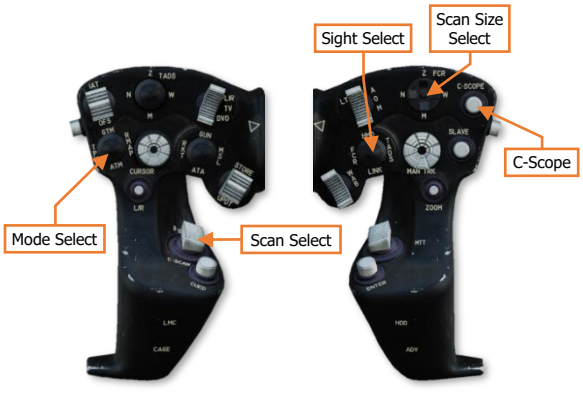
Alternatively, either crewmember may press the Sight Select switch to the FCR position to disable LINK and take control of the FCR as the selected sight to independently perform scans or engage targets as necessary.

Performing FCR scans while Linked to the TADS

If necessary, the CPG may perform FCR scans while it is still linked to the TADS, allowing the crew to detect and acquire additional targets along the azimuth of the TADS line-of-sight, or to hand off a target acquired within the TADS field-of-view to the FCR for engagement. However, such procedures are most effective when C-Scope has been enabled to allow the CPG to correlate the FCR target symbols with those seen within the TADS sensor video.

To perform an FCR scanburst while linked to the TADS LOS, perform the following:

1. Mode Select switch – Select GTM, RMAP, or ATM as appropriate.
2. Scan Size Select switch – Select Narrow (N) or Zoom (Z) as appropriate.
3. Scan Select switch – Select S-SCAN.



FCR HAND CONTROLS

Either crewmember may employ the Fire Control Radar for targeting and engagement of enemy targets.

Cyclic & Collective Controls

The Pilot and Copilot/Gunner Collective Mission Grips include identical controls for FCR employment.

TEDAC Controls

FCR controls are replicated on the Collective Mission Grip and TEDAC handgrips in the CPG crewstation. This allows the CPG to employ the FCR for targeting and engagement without interfering with the flight controls, and seamlessly transitioning between using the FCR and TADS.

DATALINK (DL)

US Army photo
by Eve Baker

DATALINK COMMUNICATIONS

The AH-64D utilizes a secure, modem-based datalink (SMDL) to send and receive targeting data, tactical reports, text messages, and mission files amongst other AH-64Ds within the team. The modem traffic is relayed as discreet microbursts of data across the helicopters' radios, which allows multiple datalink networks to be tuned simultaneously; one network across each radio.

As envisioned for use on the modern battlefield, AH-64D teams are employed as tactical maneuver units in a combined arms scenario alongside friendly infantry, armor, and artillery echelons. In such scenarios, communications are not only critical to the success of the mission but are also multi-tiered to coordinate with the various other air and ground forces operating in the same area of operations. This can impose significant command and control challenges on unit commanders when coordinating the movements and actions of large formations of attack helicopters; the challenges of which are exacerbated when performed by aircrews that are simultaneously operating at extremely low altitudes, especially at night.

These challenges in command and control can be mitigated by employing semi-automated and direct exchanges of data between AH-64D team members to reduce voice traffic and increase the efficiency of distributing tactical information. Several tactical report formats are available to AH-64D aircrews in exchanging targeting data, fires distribution, battle damage assessments, position updates, and status of onboard fuel and munitions. In addition, individual points or entire mission files may be transmitted across the datalink to synchronize information displayed on the TSD of each AH-64D as battlefield conditions evolve or as changes in mission occur in real-time.

Datalink messages may be transmitted between AH-64D Team members and Primary members within a datalink network. Up to 16 aircraft may be present within a network, with 15 network members in each aircraft's network list and the 16th aircraft being the ownship.

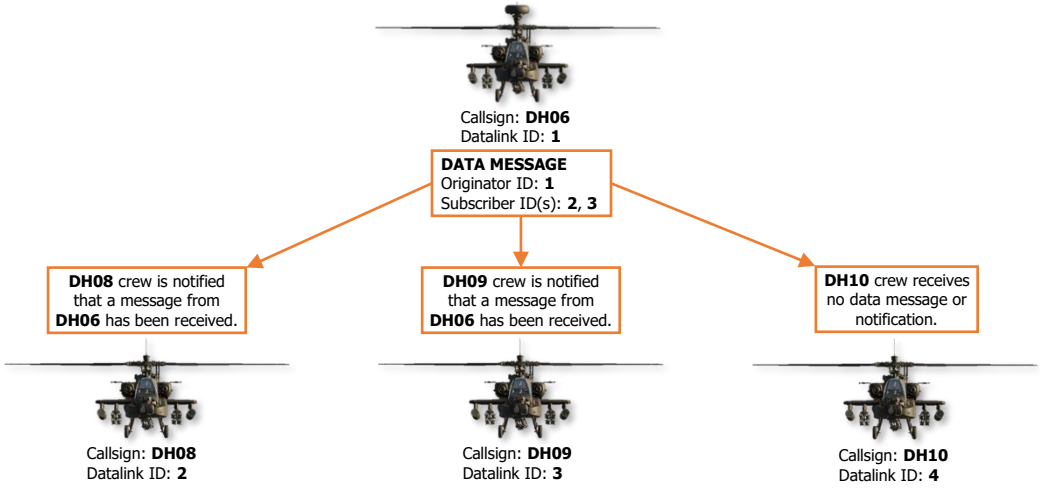
Team members. Team members receive text messages and mission files. These messages coordinate team actions and movements and distribute mission updates across the entire team of AH-64Ds on a datalink network.

Primary members. Primary members receive tactical reports, targeting data, fires distribution, and individual TSD points. These messages coordinate tactical actions of individual companies and platoons of AH-64Ds.

Secure Modem Datalink (SMDL) Network

A datalink network consists of multiple AH-64D network members transmitting and receiving data messages between each aircraft by assigning unique identification numbers within each data message, one for the message originator and one for the message subscriber.

When a data message is transmitted across the radio frequency that all network members are tuned, the modems onboard each aircraft receive the data message and compare the message's subscriber ID(s) with those that are assigned to their aircraft. If the subscriber ID within the message matches their ownship ID number, the modem stores the message within the modem buffer and notifies the crew via advisories on the EUFD. The originator ID within the message is correlated with the matching ID number of a network member and the corresponding callsign of the sender is displayed to the crew receiving the message. If the subscriber ID within the message does not match their ownship ID number, the modem rejects the message without crewmember interaction.



Datalink network between members of "Darkhorse" company

Each network may consist of 16 network members, containing 15 subscribers in addition to the ownship. Any of the 15 subscribers may be set as a Team member, a Primary member, or both; however, a maximum of 7 subscribers within each network may be designated as a Primary member. The designation of a subscriber as Team or Primary determines the type of data messages the member may receive from the ownship.

Team Messages (COM page)

Command and control, and mission updates.

- **TEXT** Text messages
- **CURRENT MISSION** Mission files residing in the aircraft memory
- **MISSION 1** Mission 1 files residing on the DTC
- **MISSION 2** Mission 2 files residing on the DTC (Data Transfer Cartridge)

Primary Messages (TSD and FCR pages)

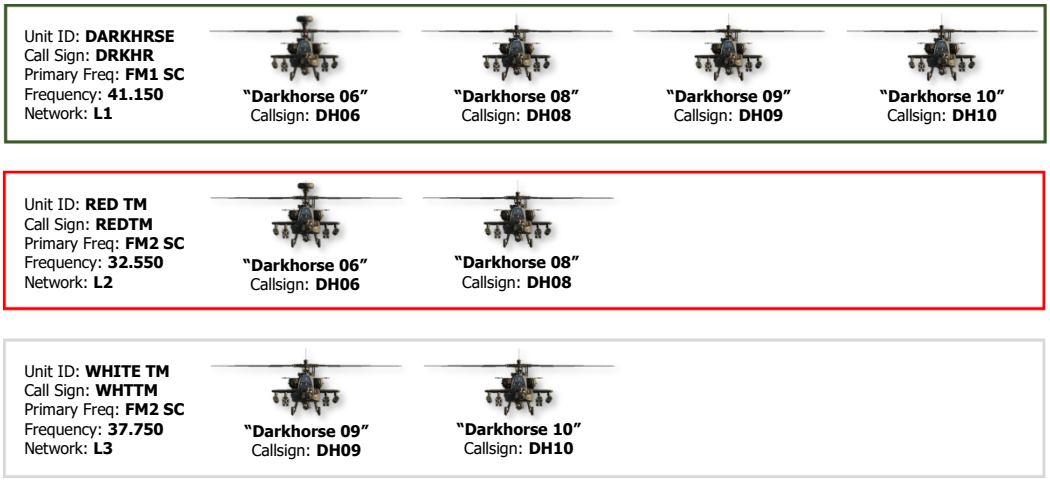
Targeting, fire control, and status reports.

- **BDA** Battle Damage Assessment reports
- **TGT** FCR Target reports
- **PP** Present Position reports
- **FARM** Fuel/Ammo/Rockets/Missiles reports
- **PFZ/NFZ** Priority Fire Zones/No Fire Zones
- **POINT** Individual TSD Point transmissions
- **RFHO** FCR RF Target Handover

The designation of network subscribers as Team or Primary members are uniquely defined by each individual network member, and only affect outgoing data messages from the ownship. For example, the aircrew in DH06 may designate each of the remaining three aircraft as Team members within their cockpit for sending text messages to the entire flight platoon, but each of the other three aircrews may have designated DH06 as the sole Team member within each of their respective cockpits for sending text messages back to the flight leader.

Each Preset on the COM page may be configured with independent network and modem settings, to include unique frequencies, network subscribers, and Team and Primary designations. If a preset has been configured for network protocols, the network associated with that preset will be designated by a letter indicating the type of protocol, and a number corresponding with the preset number. Only presets 1 through 8 may be configured with DATALINK protocol on the MODEM sub-page, which is indicated by an "L" on the COM page and EUFD.

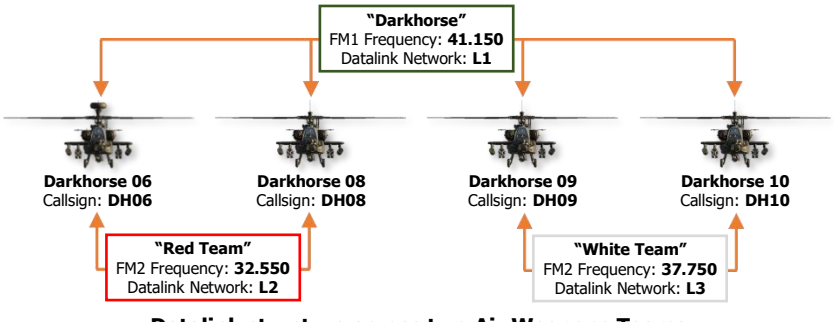
In the example below, Presets 1, 2, and 3 have been configured for DATALINK protocol, and the networks associated with each preset have been configured with unique lists of network subscribers on the NET sub-page. Preset 1 includes each aircraft within the entire flight platoon, while Presets 2 and 3 only include subscribers from each individual Air Weapons Team (AWT) within the flight platoon; Red Team and White Team.



Network configurations for Presets 1, 2, and 3

Since each preset can include a unique network configuration, and a different preset may be tuned to each radio, it is possible to simultaneously tune different datalink networks for each echelon within the entire flight platoon, with datalink messages being transmitted across the appropriate frequency for the echelon to which it pertains.

In the example below, each aircrew can communicate and exchange datalink messages with the entire flight platoon using a common radio frequency and datalink network on the FM1 radio. However, Red Team and White Team are using their FM2 radios to communicate and exchange datalink messages within their respective AWT's; with each AWT utilizing a separate radio frequency and datalink network.



Datalink structure across two Air Weapons Teams (AWT) within a single flight platoon

Datalink Controls

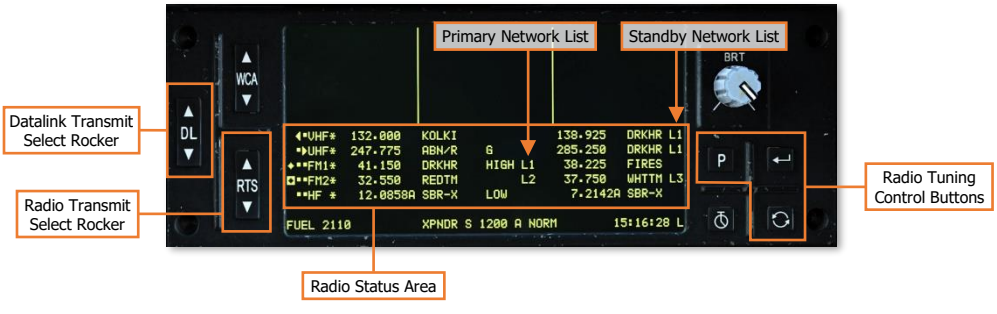
The AH-64D's datalink modem utilizes the same radio equipment that is used for voice communications to relay data between other aircraft within the AH-64D team. As such, datalink networks are tuned in the same manner as tuning a radio to a communications preset. However, unlike voice transmissions, the datalink can only function when a radio has been tuned to a preset, which allows the modem to send and receive datalink messages across the network associated with that preset. If a radio is manually tuned to a frequency, datalink messages cannot be transmitted or received across that radio, even if tuned to the same frequency of an existing datalink network.

(See the Radio Communications chapter for more information regarding the tuning of presets.)

EUFD Controls

The Enhanced Up-Front Display (EUFD) provides the aircrew with a consolidated location for viewing the current configuration and datalink settings of each radio. The modem can receive datalink messages from the VHF, UHF, FM1, and FM2 radios simultaneously, but each crewmember may only transmit datalink messages across a single radio at any given time.

The radio through which each crewmember transmits datalink messages is independent from the radio the crewmember has selected for voice transmissions. The Datalink Transmit Select rocker is used to select a radio for datalink transmissions while the Radio Transmit Select rocker is used to select a radio for voice transmissions. In the example below, the current crewstation is configured to transmit voice over the VHF radio and datalink over the FM2 radio. The opposite crewstation is configured to transmit voice over the UHF radio and datalink over the FM1 radio.



The Primary Network List displays which radios are configured to transmit and receive datalink messages, and to which datalink network the radio has been tuned. In the example above, the modem is monitoring the FM1 radio for datalink messages from the network associated with Preset 1 and monitoring the FM2 radio for datalink messages from the network associated with Preset 2.

The Standby Network List displays which datalink networks are associated with the radio presets residing in the standby slots for each radio. When considering the standby slots of each radio, the number of networks that may be readily accessible at any given time is as follows:

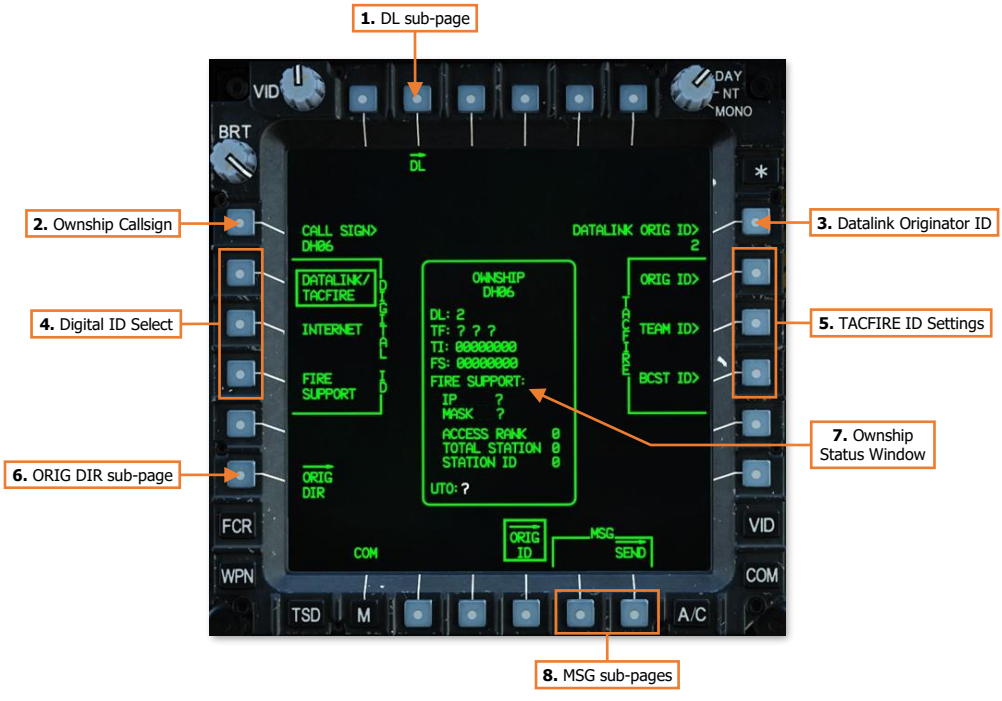
- 8 datalink networks (two for each radio) may be loaded into the VHF, UHF, FM1, and FM2 radios.
- 4 datalink networks (one for each radio) may be tuned and monitored for data communications.
- 2 datalink networks (one for each crewmember) may be selected to transmit data communications, independently of the radios selected by each crewmember for transmitting voice communications.

If generator power is lost, crewmembers may still use the radios and the EUFD interface for voice communications while operating on battery power, but datalink communications will not be possible.

(See Enhanced Up-Front Display (EUFD) for more information.)

COM Originator Identification (ORIG ID) Sub-Page

The ORIG ID sub-page allows crewmembers to review or modify the ownship's identification settings for sending and receiving traffic across the datalink network(s). The ownship's ID settings may be individually edited from this page, or they may be replaced all at once using pre-planned network member data accessed through the Originator Directory (ORIG DIR) sub-page.



1. **DL sub-page.** Displays the Datalink sub-page.
2. **Ownship Callsign.** Activates the KU for inputting the originator callsign for the ownship. A minimum of 3 and a maximum of 5 alphanumeric characters may be entered.

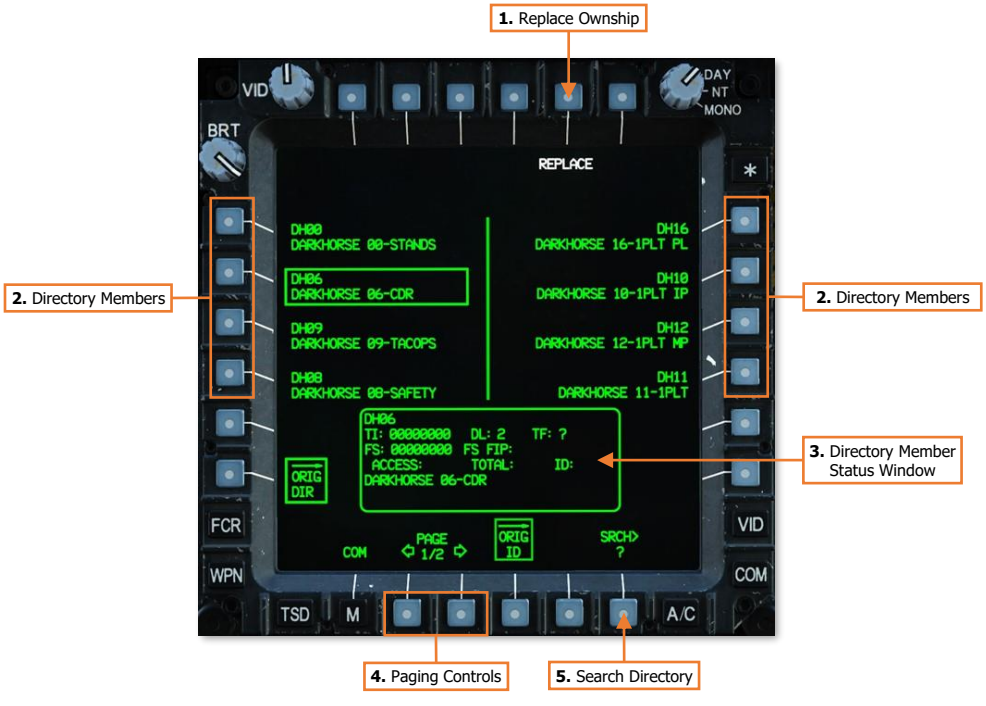
   NOTE: The originator callsign is for reference only and will not affect the function of the datalink networks.
3. **Datalink Originator ID.** Activates the KU for inputting the originator identification (ID) number which identifies the ownship on the datalink network. The alphanumeric character ranges that are valid for entry are 0-39 (with no leading zeros), A-Z, 1A-1Z, 2A-2Z, and 3A-3I; for a total of 127 unique network ID numbers.

   NOTE: Each network member, to include the ownship, must have a unique ID number. If two or more members on the same datalink network are assigned the same identification number, erroneous behavior may be observed when using the datalink, or when using functions within the cockpit that are associated with the datalink.
4. **Digital ID Select.** Selects a page format for configuring digital ID settings for each type of protocol.
   - **DATALINK/TACFIRE.** Displays digital ID settings for DATALINK or TACFIRE protocols.
   - **INTERNET.** Not implemented.
   - **FIRE SUPPORT.** Not implemented.

5. **TACFIRE ID Settings.** Not implemented.
6. **ORIG ID sub-page.** Displays the Originator Directory sub-page.
7. **Ownship Status Window.** Displays the current digital ID settings of the ownship.
8. **MSG sub-pages.** Displays Message sub-pages for sending or receiving digital messages.
   - **MSG – REC.** Displays the Message Receive sub-page. If no messages are present on the receive list, this sub-page option will not be displayed.
   - **MSG – SEND.** Displays the Message Send sub-page.

COM Originator Directory (ORIG DIR) Sub-Page

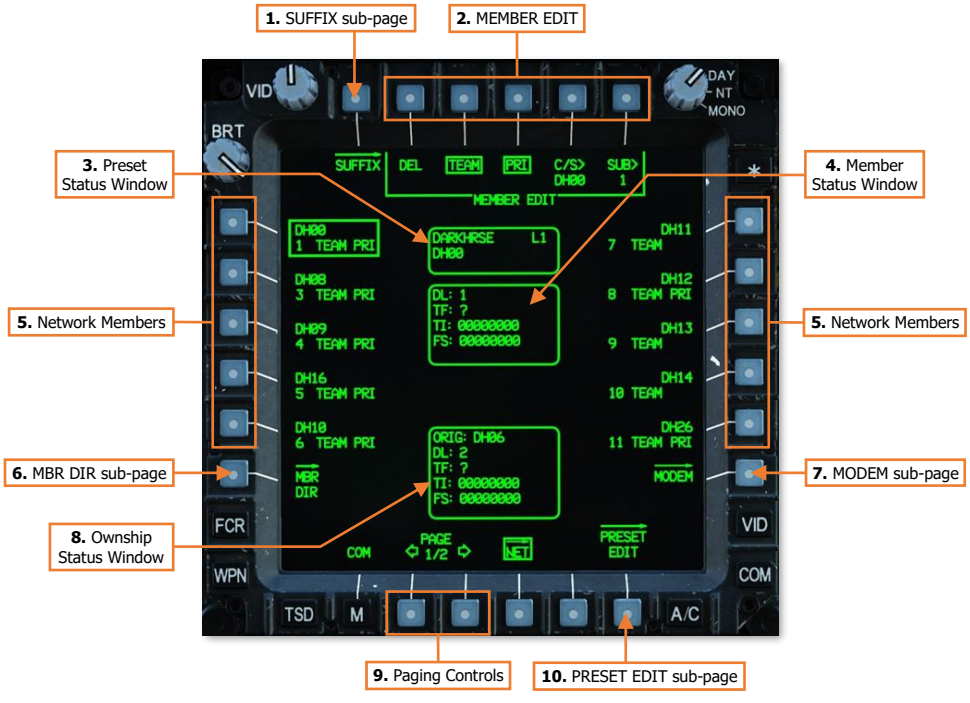
The ORIG DIR sub-page allows crewmembers to set their ownship identification settings to a pre-planned network member entry. This directory facilitates efficient and rapid configuration of the ownship's originator ID to correspond to a pre-planned network identification.



1. **Replace Ownship.** Replaces the ownship's digital ID settings with those of the directory member that has been selected for review.
2. **Directory Members.** Selects a directory member for review within the Directory Member status window.
3. **Directory Member Status Window.** Displays the callsign and digital ID settings of the selected directory member.
4. **Paging Controls.** Cycles forward and back through multiple pages of the directory.
5. **Search Directory.** Activates the KU for inputting alphanumeric characters to search for a specific member within the directory. Displayed members will be filtered accordingly based on the results.

COM Network (NET) Sub-Page

The NET sub-page allows crewmembers to review or modify the callsign and identification settings of each member within the datalink network of the selected preset. The callsign and subscriber ID settings for each network member may be manually edited from this page, or they may be replaced altogether using pre-planned network member data accessed through the Member Directory (MBR DIR) sub-page.



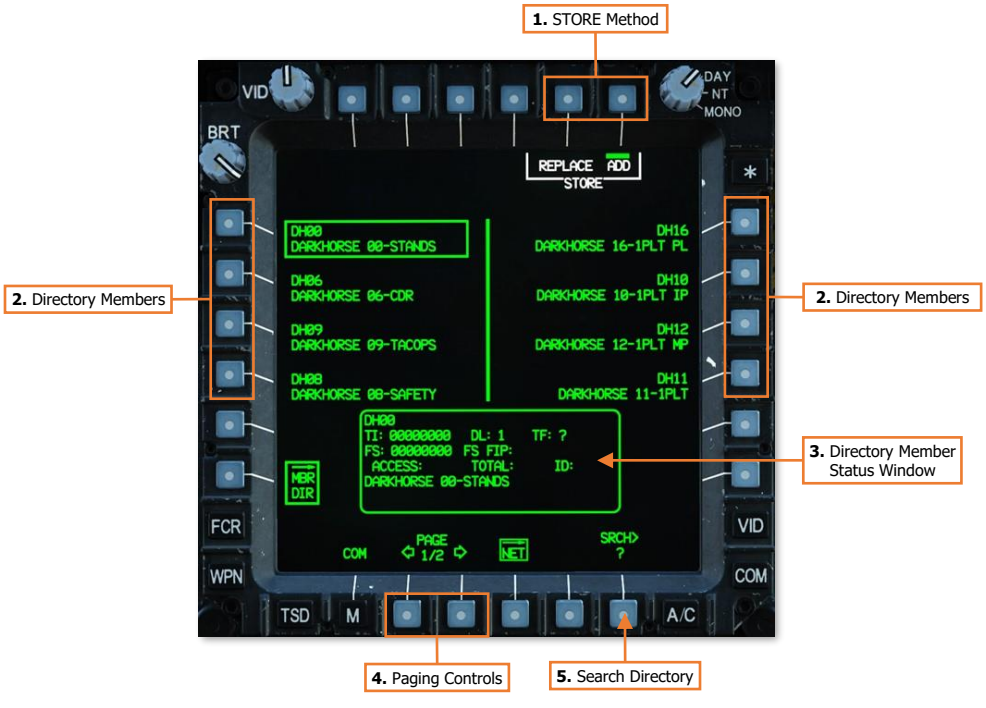
1. **SUFFIX sub-page.** Not implemented.
2. **MEMBER EDIT.** Displays options for editing the digital ID settings of the selected network member.
   - **MEMBER EDIT – DEL.** Deletes the network member from the preset.
   - **MEMBER EDIT – TEAM.** Designates the network member as a Team member. Any of the 15 members within a network may be designated as a Team member.
   - **MEMBER EDIT – PRI.** Designates the network member as a Primary member. No more than 7 members within a network may be designated as a Primary member.
   - **MEMBER EDIT – C/S.** Activates the KU for inputting the network callsign of the member. A minimum of 3 and a maximum of 5 alphanumeric characters may be entered.
   - **MEMBER EDIT – SUB.** Activates the KU for inputting the subscriber identification (ID) number, which identifies the member on the datalink network. The alphanumeric character ranges that are valid for entry are 0-39 (with no leading zeros), A-Z, 1A-1Z, 2A-2Z, and 3A-3I; for a total of 127 unique network ID numbers.

     NOTE: Each network member, to include the ownship, must have a unique ID number. If two or more members on the same datalink network are assigned the same identification number, erroneous behavior may be observed when using the datalink, or when using functions within the cockpit that are associated with the datalink.

3. **Preset Status Window.** Displays the unit ID and modem protocol of the preset network, along with the callsign of the selected network member.
4. **Member Status Window.** Displays the digital ID settings of the selected network member.
5. **Network Members.** Selects a network member for review within the Member Status Window.
6. **MBR DIR sub-page.** Displays the Member Directory sub-page.
7. **MODEM sub-page.** Displays the Modem sub-page.
8. **Ownship Status Window.** Displays the digital ID settings of the ownship.
9. **Paging Controls.** Cycles forward and back through multiple pages of the network member list.
10. **PRESET EDIT sub-page.** Displays the Preset Edit sub-page.

COM Member Directory (MBR DIR) Sub-Page

The MBR DIR sub-page allows crewmembers to add new members to the network or replace existing member entries in the network member list. This directory facilitates efficient and rapid configuration of the network member list using pre-planned network identification data.

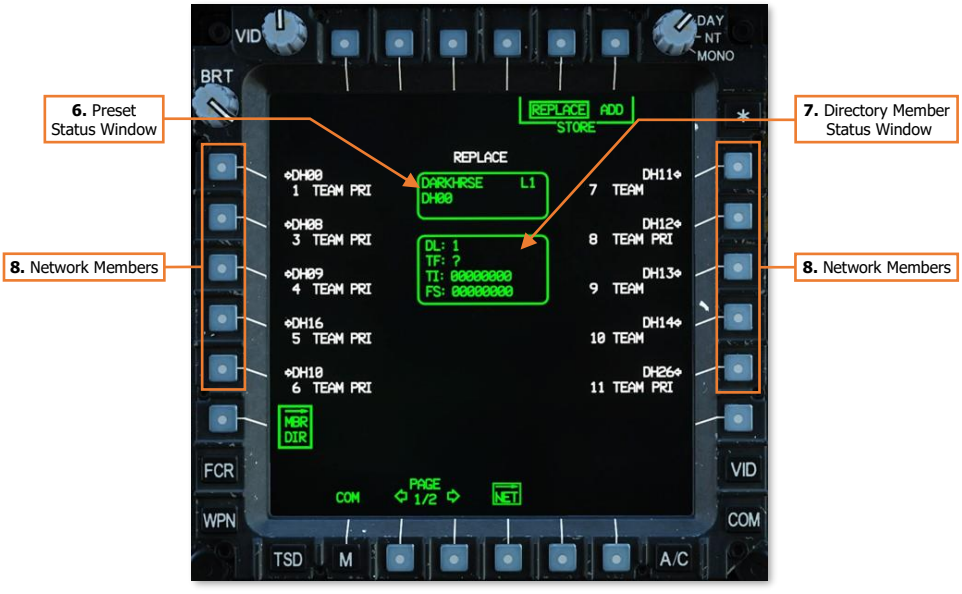


1. **STORE Method.** Inserts the selected directory member into the selected datalink network.
   - **STORE – REPLACE.** Displays the REPLACE format of the Member Directory sub-page.
   - **STORE – ADD.** Adds the selected directory member into the first network entry is that is available. If the datalink network already contains 15 network members, this option will be disabled and "barriered" unless an existing network member is deleted from the selected datalink network.

2. **Directory Members.** Selects a directory member for review within the Directory Member status window.
3. **Directory Member Status Window.** Displays the digital ID settings of the selected directory member.
4. **Paging Controls.** Cycles forward and back through multiple pages of the directory.
5. **Search Directory.** Activates the KU for inputting alphanumeric characters to search for a specific member within the directory. Displayed members will be filtered accordingly based on the results.

Member Directory – Replace Format

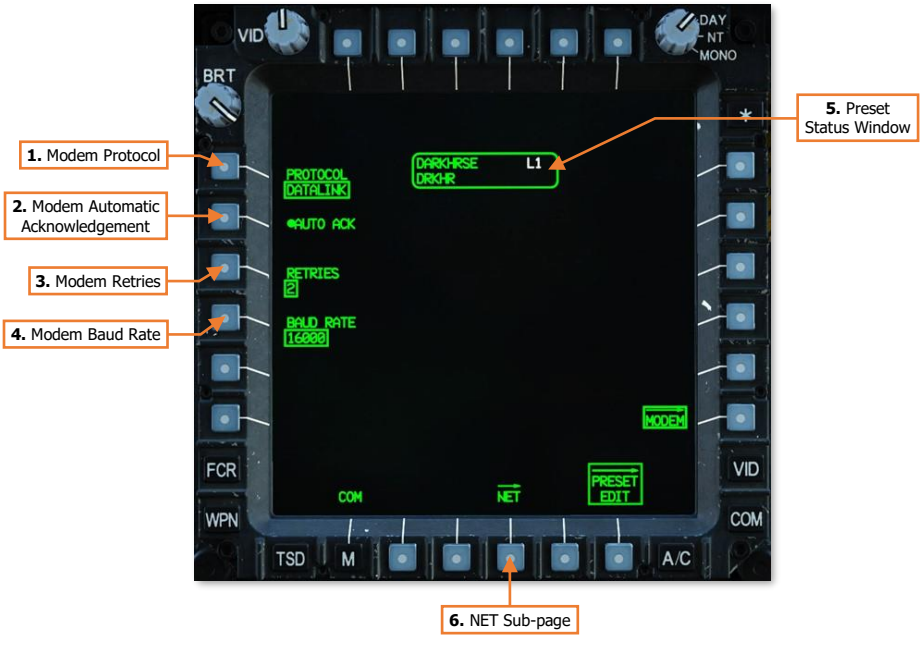
That Replace format of the Member Directory sub-page allows crewmembers to select an existing network member within the current datalink network to replace with the selected directory member.



6. **Preset Status Window.** Displays the unit ID and modem protocol of the preset network, along with the callsign of the selected directory member that will replace a selected network member.
7. **Directory Member Status Window.** Displays the digital ID settings of the selected directory member that will replace a selected network member.
8. **Network Members.** Selects an existing network member for replacement by the directory member displayed within the Preset Status Window, using the information displayed within the Directory Member Status Window.

COM Modem (MODEM) Sub-Page

The MODEM sub-page allows crewmembers to configure the settings the modem will utilize when sending or receiving data through any radios tuned to the selected preset.



1. **Modem Protocol.** Selects the type of protocol the modem will utilize for the selected preset.
   - **DATALINK.** DATALINK-protocol digital messages may be sent using any radio tuned to the selected preset. The modem will monitor any radios tuned to the selected preset for incoming digital messages compatible with AH-64D-only DATALINK protocols.
   - **TACFIRE.** Not implemented.
   - **INTERNET.** Not implemented.
   - **FIRE SUPPORT.** Not implemented.
   - **NONE.** Radios tuned to the selected preset cannot send digital messages. The modem will not monitor any radios tuned to the selected preset.
2. **Modem Automatic Acknowledgement.** Enables/disables automatic acknowledgements by the modem. If a digital message is received, the modem will transmit a discreet acknowledgement to the originator ID of the sender that the digital message has been received by the ownship.

   NOTE: When a request for data is transmitted to a network subscriber, an "acknowledgement" from the subscriber's modem only confirms the request for data was received. An acknowledgement does not contain the requested data, which is transmitted within a "reply".
3. **Modem Retries.** Selects the number of subsequent attempts the modem should transmit digital messages if an acknowledgement of reception is not received from any intended message recipients.

   If an acknowledgement is not received from all intended recipients following the number of selected retries, a "XMIT NAK" (No acknowledgement to transmission) advisory message will be displayed on the EUFD,

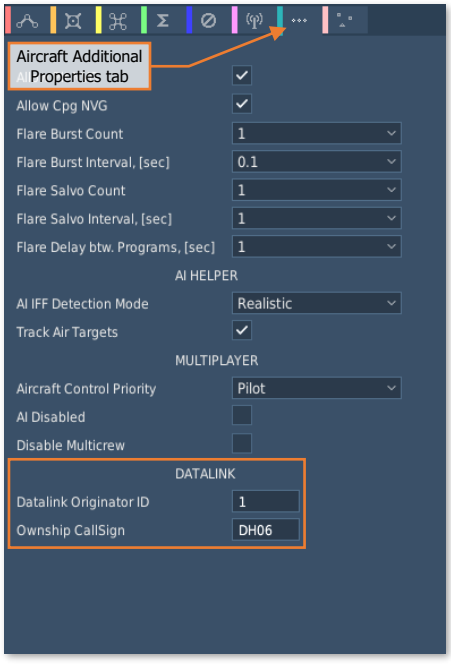
indicating which radio through which the modem failed to receive all required acknowledgements. This advisory will be removed if the modem successfully receives acknowledgements from all intended recipients from a subsequent digital message transmission.

- **0.** The modem will not make additional attempts to transmit a digital message.
- **1.** The modem will make one additional attempt to transmit a digital message to any subscribers that did not return an acknowledgement.
- **2.** The modem will make two additional attempts to transmit a digital message to any subscribers that did not return an acknowledgement.

4. **Modem Baud Rate.** Not implemented.
5. **Preset Status Window.** Displays the unit ID, callsign, and modem protocol of the selected preset network.
6. **NET sub-page.** Displays the Network sub-page.

Datalink Mission Editor Options

Mission creators may configure the datalink settings for each aircraft within the Mission Editor. These settings are located on the Aircraft Additional Properties and Datalinks tabs.



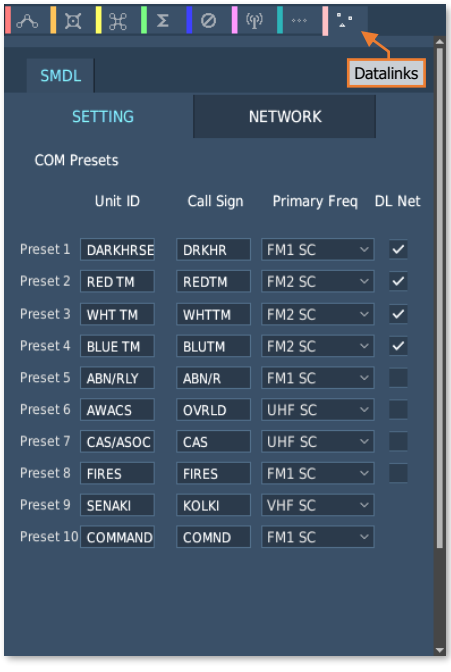
Aircraft Additional Properties. Allows the mission creator to configure any remaining properties that are unique to the aircraft type.

- **Datalink Originator ID.** The originator ID will be how the datalink modems of other AH-64Ds within the mission will recognize the aircraft when sending or receiving datalink messages. The alphanumeric character ranges that are valid for entry are 0-39 (with no leading zeros), A-Z, 1A-1Z, 2A-2Z, and 3A-3I; for a total of 127 unique network ID numbers.

  NOTE: Each network member, to include the ownship, must have a unique ID number. If two or more members on the same datalink network are assigned the same identification number, erroneous behavior may be observed when using the datalink, or when using functions within the cockpit that are associated with the datalink.

- **Ownship Call Sign.** This data field will determine how the aircraft is annotated within the cockpit of other AH-64Ds within the mission when sending or receiving datalink messages. A minimum of 3 and a maximum of 5 alphanumeric characters may be entered.

(See ORIG ID sub-page for more information.)



Datalinks – SETTING tab. Allows the mission creator to configure the details of each preset on the COM page.

- **Unit ID.** This data field determines how the preset is displayed on the COM page and on the EUFD Preset list. Up to 8 alphanumeric characters may be entered.

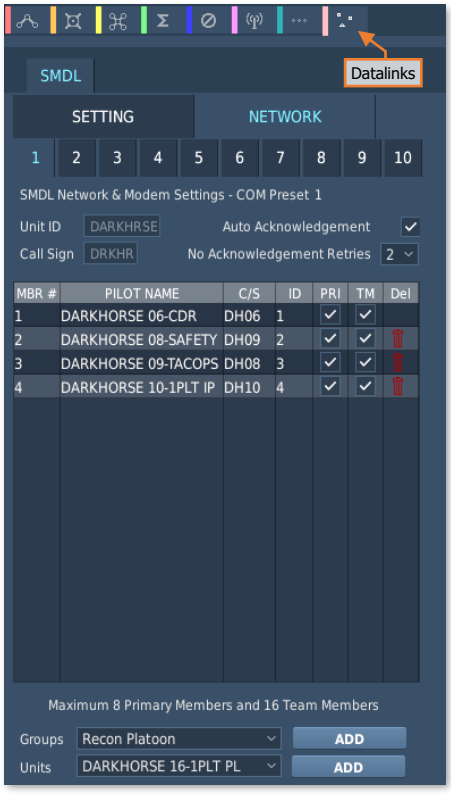
- **Call Sign.** This data field determines how the preset is displayed on the EUFD when assigned to a radio. Up to 5 alphanumeric characters may be entered.

- **Primary Freq.** Displays options for designating a primary frequency and radio for the preset. The corresponding entries on the COM Preset format will be displayed in white to highlight the intended radio and net with which the preset is intended to be utilized during the mission. The primary designation does not affect the function of any radio equipment or how the preset is assigned to a specific radio.

- **DL Net.** When checked, DATALINK protocols will be enabled on the MODEM sub-page for the preset.

(See PRESET EDIT sub-page in the Radio Communications chapter for more information.)

Datalinks – NETWORK tab. Allows the mission creator to configure the network and modem settings for each preset on the COM page.



- **Preset Buttons (1-10).** Selects the corresponding preset with which to edit the network and modem settings in the table below.
- **Auto Acknowledgement.** When checked, automatic acknowledgements will be transmitted by the modem when a digital message is received across the datalink network associated with this preset.
- **No Acknowledgement Retries.** Selects the number of subsequent attempts the modem should transmit digital messages if an acknowledgement of reception is not received across the datalink network associated with this preset.
- **MBR #.** Displays the index of each network member associated with this preset. A maximum of 16 members may be present within each network. The ownship will always occupy the first entry; entries 2-16 will correspond with network subscribers.
- **PILOT NAME.** Displays the name of each network member, which corresponds to how their entries will be annotated within the ORIG DIR and MBR DIR sub-pages.
- **C/S.** Displays the Call Sign of each network member.
- **ID.** Displays the subscriber ID of each network member.
- **PRI.** When checked, the member will be designated as a Primary member within the datalink network associated with this preset. A maximum of 8 Primary members may be present within each network, with the ownship always included as the first entry.
- **TM.** When checked, the member will be designated as a Team member within the datalink network associated with this preset. A maximum of 16 Team members may be present within each network, with the ownship always included as the first entry.
- **Del.** When the red "trash can" icon within this column is selected, the member will be removed from the datalink network associated with this preset. The ownship cannot be deleted from the network.
- **Groups Selection/ADD Button.** Displays options for selecting other AH-64D BLK.II Helicopter Groups within the mission. Only AH-64D BLK.II Helicopter Groups that are of the same coalition and not already present within the displayed network will be available for selection.

  When the ADD button is pressed, all AH-64Ds within that Helicopter Group will be added to the member list of the displayed network.
- **Units Selection/ADD Button.** Displays options for selecting individual AH-64D BLK.II helicopters within the mission. Only AH-64D BLK.II helicopters that are of the same coalition and not already present within the displayed network will be available for selection.

  When the ADD button is pressed, the AH-64D will be added to the member list of the displayed network.

(See NET and MODEM sub-pages for more information.)

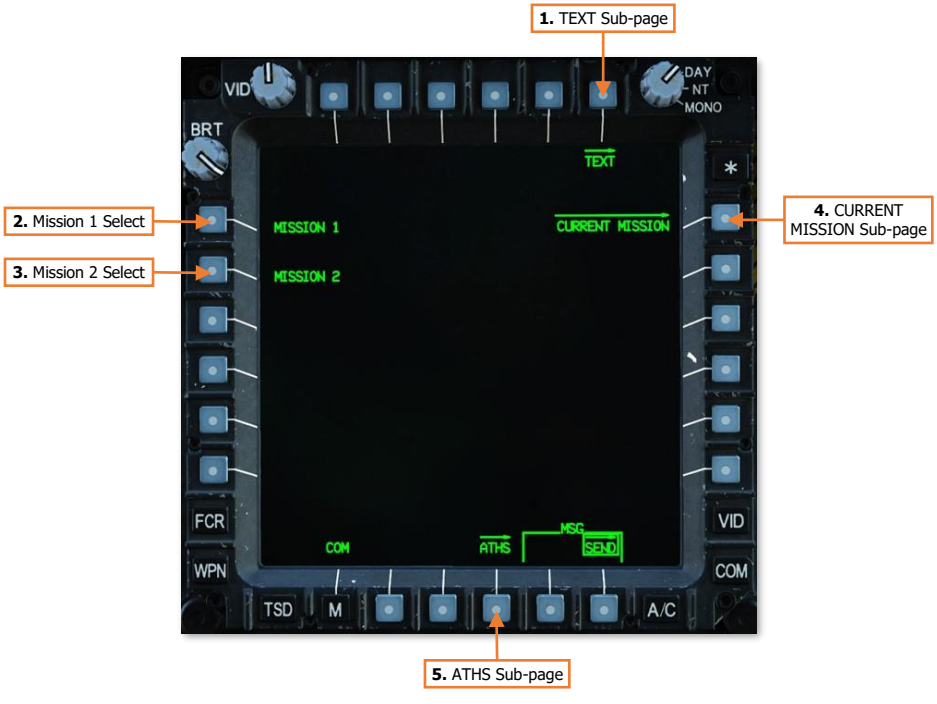
TEAM MESSAGES

Team messages are used to relay and distribute command and control information, mission updates, or reconnaissance information among networks of AH-64Ds. These message types include individual text messages and entire mission files. Any time a text message or mission file is transmitted across a datalink network, all subscribers designated as a Team member within that network will receive them.

Although Team messages themselves cannot be selectively sent to individual aircraft within a datalink network, the networks themselves may be configured to facilitate this. Team member designations within a network may be altered from the NET sub-page, or separate datalink networks may be configured with unique Team member designations.

COM Message Send (MSG SEND) Sub-Page

The Message Send sub-page presents several options for sending text messages or mission files.



1. **TEXT sub-page.** Displays the Text sub-page.
2. **MISSION 1.** Not implemented.
3. **MISSION 2.** Not implemented.
4. **CURRENT MISSION sub-page.** Displays the Current Mission sub-page.
5. **ATHS sub-page.** Not implemented.

Sending Text Messages

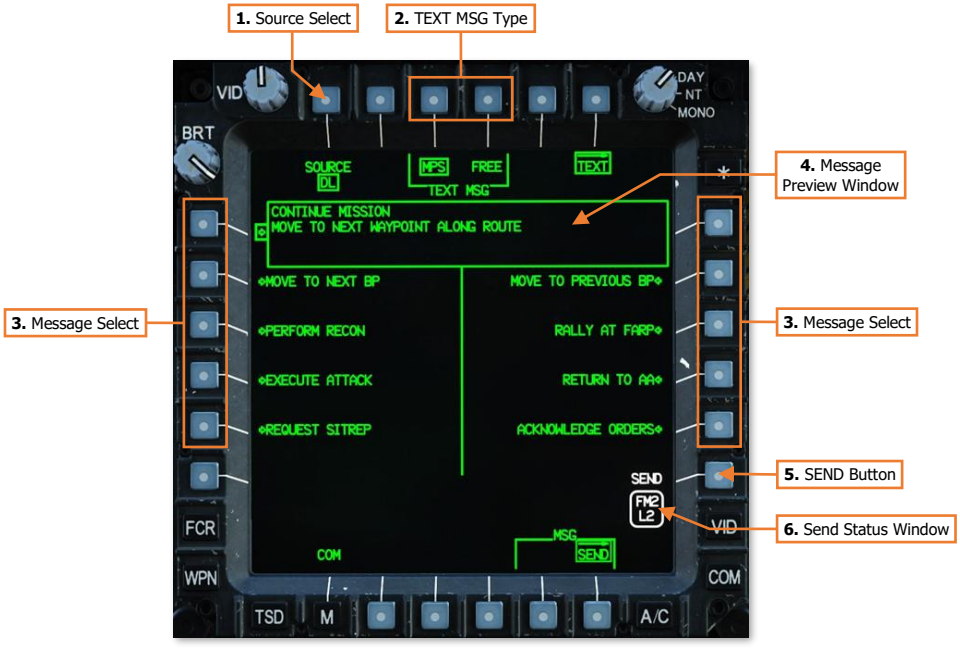
Text messages may contain up to 4 lines of text, with each line consisting of no more than 44 alphanumeric characters (or spaces), for a maximum of 176 characters.

COM MSG-SEND Text (TEXT) Sub-Page

The TEXT sub-page allows aircrews to select a pre-composed text message for transmission across the datalink network, or manually compose a text message themselves using the Keyboard Unit (KU).

Text Message - MPS Format

Ten text messages may be composed using Mission Planning Systems prior to the mission. These text messages allow aircrews to rapidly send critical or time-sensitive messages between aircraft without needing to manually input each message prior to transmission.



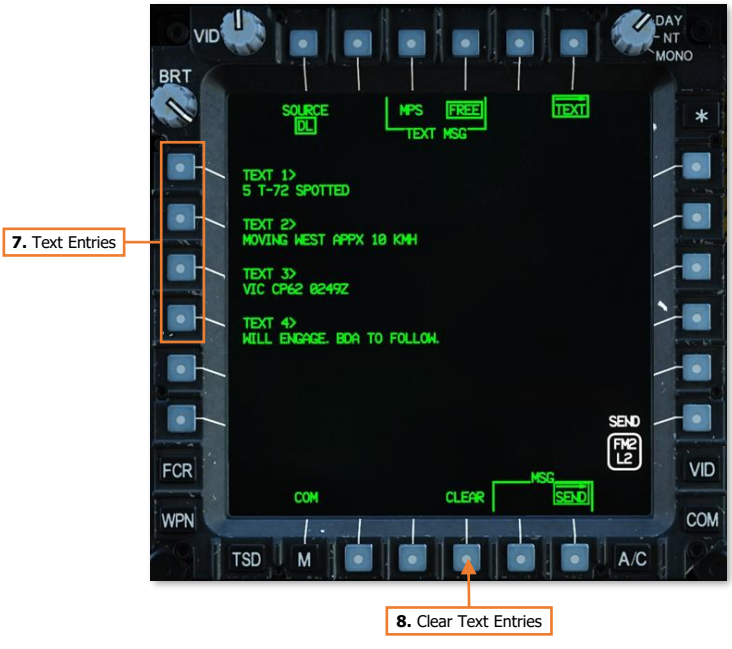
1. **Source Select.** Not implemented.
2. **TEXT MSG Type.** Selects a page format for sending pre-composed or manually entered text messages.
   - **TEXT MSG – MPS.** Displays up to 10 text messages that have been composed prior to the mission.
   - **TEXT MSG – FREE.** Displays options for manually composing a text message using the KU.
3. **Message Select.** Selects an MPS Text message for preview.
4. **Message Preview Window.** Displays the text message that will be transmitted if the SEND button is pressed.
5. **SEND Button.** The SEND button is displayed when a MPS Text message is selected for preview, or at least one character has been entered into one line of a Free Text message, and the Datalink Transmit Select Indicator is set to a radio that has been configured for transmitting digital messages.

When the SEND button is pressed, the text message will be sent to all network subscribers that are designated as Team members.

6. **Send Status Window.** Displays the radio and datalink network over which the text message will be transmitted.

Text Message - Free Format

Free text messages may be composed in the cockpit using the Keyboard Unit (KU). This allows aircrews to send text messages regarding unplanned events, contingencies, or reconnaissance information.



7. **Text Entries.** Activates the KU for inputting a line of text. Each line of text may contain a maximum of 44 characters.

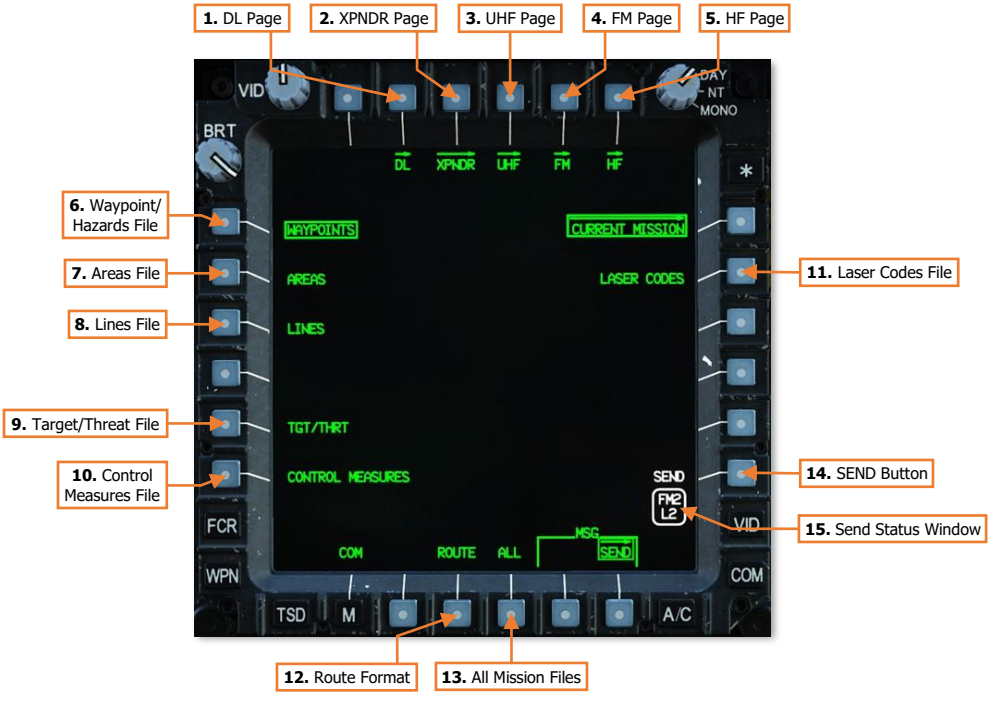
8. **Clear Text Entries.** Deletes all characters from each line of text.

Sending Mission Files

Mission files may be sent from the aircraft database across the datalink network, which will overwrite the corresponding mission file when stored in the receiving aircraft. Each mission file may be individually selected for transmission, or the entire mission database may be selected for transmission.

COM MSG-SEND Current Mission (CURRENT MISSION) Sub-Page

The CURRENT MISSION sub-page transmits mission files from the aircraft memory across the datalink network. When stored, the mission files onboard the receiving aircraft will be replaced with the received mission file. This allows commanders or team leaders to synchronize information displayed on the TSD of each AH-64D as changes in mission occur in real-time. This may also be used to update the TSD database of subsequent teams entering the battlespace from those already on-station performing reconnaissance or conducting a "battle handover".



1. **DL Page.** Displays the Datalink page.
2. **XPNDR Page.** Displays the Transponder page.
3. **UHF Page.** Displays the UHF Radio page.
4. **FM Page.** Displays the FM Radio page.
5. **HF Page.** Displays the HF Radio page.
6. **Waypoint/Hazards File.** Selects the Waypoint/Hazards file (W01-W50) for transmission.
7. **Areas File.** Selects the Areas file for transmission. (N/I)
8. **Lines File.** Selects the Lines file for transmission. (N/I)

9. **Target/Threat File.** Selects the Target/Threat file (T01-T50) for transmission.
10. **Control Measures File.** Selects the Control Measures file (C51-C99) for transmission.
11. **Laser Codes File.** Selects the Laser Codes file (Codes A-R) for transmission.
12. **Route Format.** Displays the Route format.
13. **All Mission Files.** Selects all mission files residing within the aircraft memory for transmission. Each mission file will be transmitted in rapid succession to each Team member.
14. **SEND Button.** The SEND button is displayed when a mission file is selected and the Datalink Transmit Select Indicator is set to a radio that has been configured for transmitting digital messages.

    When the SEND button is pressed, the selected mission file(s) will be sent to all network subscribers that are designated as Team members.
15. **Send Status Window.** Displays the radio and datalink network over which the mission file will be transmitted.

Route Format

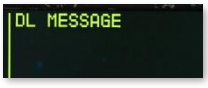
The Route format allows each route to be individually selected for transmission, or the entire Route file may be transmitted.

NOTE: If a route contains any points with different coordinates (or are simply not present) within the receiving aircraft, the route sequence will appear differently within the receiving aircraft when stored. The corresponding points within each route should be transmitted to, and stored within, the receiving aircraft before the routes themselves are transmitted and stored.

16. **Route Select.** Selects an individual route from within the Routes file for transmission.
17. **Routes File.** Selects the Routes file (Routes 1-10) for transmission.

Receiving Text Messages & Mission Files

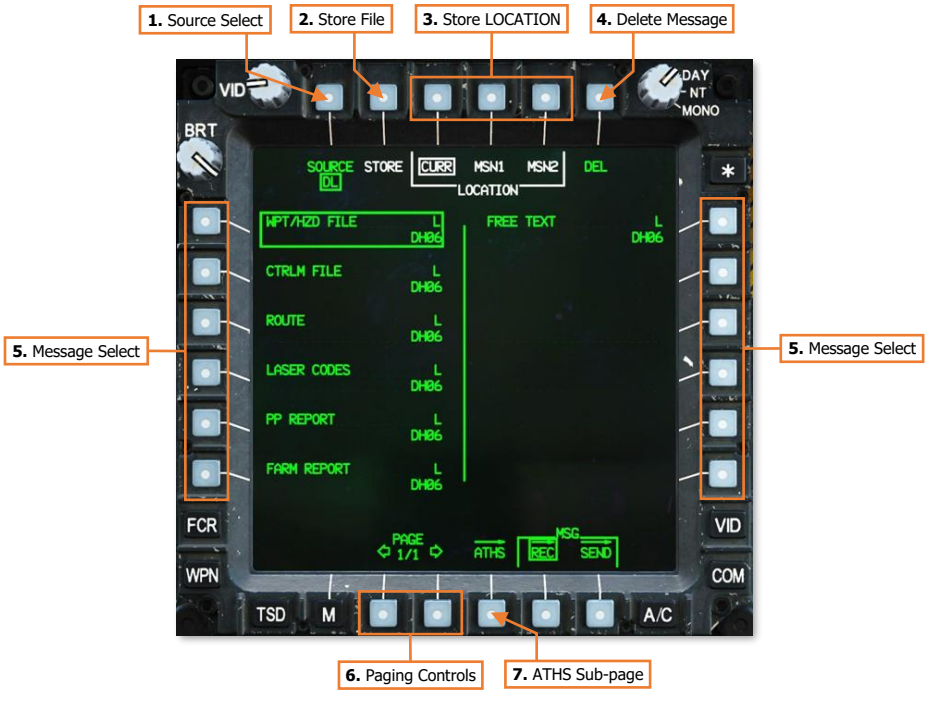
Either crewmember may review, store, or delete any received text message, mission file, or other datalink message. However, deleting or storing a datalink message will perform the action for both crewstations.



When a text message or mission file has been received through the datalink, the EUFD will display a "DL MESSAGE" advisory, prompting the aircrew to access the MSG REC sub-page to review (or store) the received datalink message.

COM Message Receive (MSG REC) Sub-Page

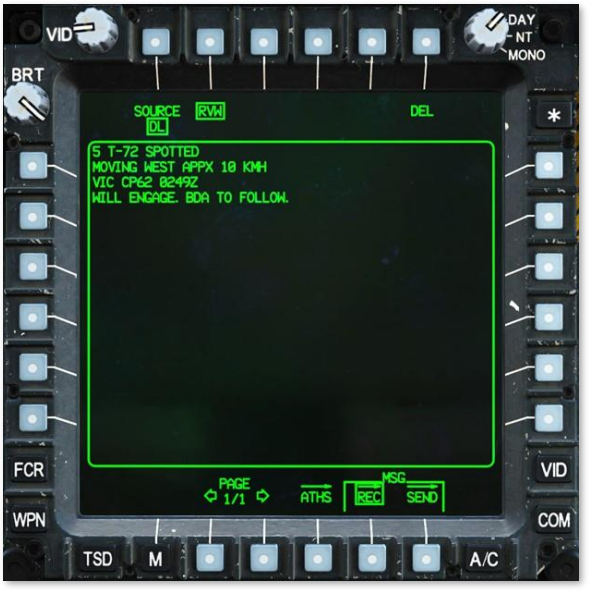
The MSG REC sub-page allows aircrews to view a list containing all datalink messages that have been received.



1. **Source Select.** Not implemented.
2. **Store File.** Stores the selected mission file, TSD point, tactical report, or PF/NF zones.
3. **Store LOCATION.** Selects a location for storing the selected mission file, TSD point, or PF/NF zones. This option is not available when a tactical report is selected from the message list. (N/I)
   - **LOCATION – CURR.** Stores the selected data within the database residing in the aircraft memory.
   - **LOCATION – MSN1.** Stores the selected data within the MISSION 1 database residing on the DTC.
   - **LOCATION – MSN2.** Stores the selected data within the MISSION 2 database residing on the DTC.
4. **Delete Message.** Deletes the selected message.
5. **Message Select.** Selects a received message for review, storing, or deletion.
6. **Paging Controls.** Cycles forward and back through multiple pages of the message list.

7. **ATHS sub-page.** Not implemented.

8. **Review Message.** Displays the Review format when a text message is selected from the message list. This option will be displayed in white if the selected text message has not been reviewed by either crewmember. Once the text message has been reviewed, the option will be displayed in green.



TSD POINTS

Any point residing within the TSD database may be transmitted across the datalink network. However, unlike mission files which are transmitted to all Team members within the datalink network, TSD points may only be transmitted to selected Primary members. This facilitates target handovers between individual aircraft by sending Target points, it allows team leaders to develop hasty control measures during the mission, and permits a more limited transfer of TSD points to specific aircraft in lieu of sending an entire file to all Team members.

Transmitting a Point

Points may be transmitted while the POINT sub-page is displayed in XMIT format. By default, no Primary members are selected to receive a point transmission; each Primary member must be selected as a method of confirming which subscribers should receive the selected point.

POINT Transmit (XMIT) format

Pressing the XMIT button (VAB L6) displays the POINT sub-page in Transmit format. Pressing the XMIT button a second time returns the POINT sub-page to the original format.

1. **Review Point.** Activates the KU for inputting a point file for transmission. Alternatively, a point may be selected for review directly from the TSD by using the MPD cursor.

2. **Primary Member Select.** Displays a list of Primary members within the selected datalink network that may be selected to receive the selected point. Each entry within the list is generated from the Callsigns of Primary members as displayed on the NET sub-page, truncated to the last three alphanumeric characters. For example, "DH08" is displayed as "H08" within the Primary member list on the TSD page.

   If the Datalink Transmit Select Indicator is moved to a different datalink network on the EUFD, the Primary member list will update to reflect the Primary members within the selected datalink network. If the Datalink

Transmit Select Indicator is moved to a radio that has not been tuned to a preset with a datalink network, or that network contains no Primary members, no callsigns will be displayed within the Primary member list.

3. **SEND Button.** The SEND button is displayed when a point is selected, the Datalink Transmit Select Indicator is set to a radio that has been configured for transmitting digital messages, and at least one Primary member has been selected to receive it.

4. **Send Status Window.** Displays the radio and datalink network over which the point will be transmitted.

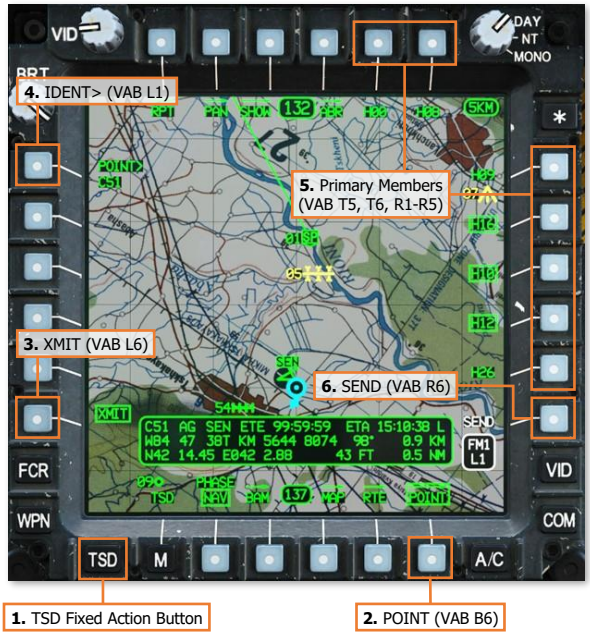
Transmitting a Point

To transmit a point, ensure the EUFD Datalink Transmit Select Indicator is set to the datalink network over which the transmission is intended, and then perform the following:

1. TSD Fixed Action Button – Press.
2. POINT (VAB B6) – Select.
3. XMIT (VAB L6) – Select.
4. POINT> (VAB L1) – Select and input the point index of the point to be transmitted into the KU (e.g., "W11", "H05", "C51", "T04", etc).

   or

4. MPD Cursor Controller/Enter – Select the point to be transmitted on TSD.



5. Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.
6. SEND (VAB R6) – Press.

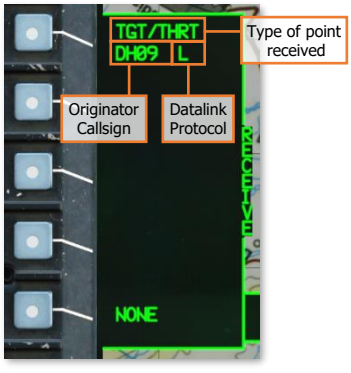
Once SEND (VAB R6) is pressed, the SEND text label will be displayed in inverse video as the transmission is performed to each Primary member that is selected to receive the point. When the transmission is complete, the SEND text label will revert to normal video.

If an acknowledgement of receipt is not received from any Primary member selected to receive the point, a "XMIT NAK" advisory will be displayed on the EUFD.

Receiving a Point

When a point has been received through the datalink, the EUFD will display an advisory indicating the type of point received. The "TGT/THRT" advisory will also be accompanied by an audio ring tone, prompting the aircrew to access the MSG REC sub-page or the TSD Receive List to store the received Target/Threat point.

Any time a datalink message intended for Primary members is received, the aircrew within the receiving aircraft may store the contents of the message by selecting the COM page and then the MSG REC sub-page, or they may store it directly from the TSD. A white REC option will be displayed at VAB L2, which will open the TSD Receive list.



1. TSD Fixed Action Button

The Receive list will display the four most recent datalink messages that have not already been stored (excluding text messages and mission files). Each entry will include the type of data that has been sent within the message, the originator callsign that sent the message, and the modem protocol through which it was received.

In the example on this page, a TGT/THRT point was received from "DH09" through the DATALINK protocol, indicated by an "L".

To store a point within the database, perform the following:

1. TSD Fixed Action Button – Press.
2. REC (VAB R2) – Select to display the Receive list.
3. Datalink message (VAB L2-L5) – Select.

   or

3. NONE (VAB L6) – Select to close the Receive list without storing a message.

TACTICAL REPORTS

Tactical reports may be transmitted between AH-64Ds across the datalink network. These reports streamline and digitize the distribution of tactical information between AH-64Ds during the mission, which facilitates a more efficient use of the radios for voice communications.

Crewmembers may send reports to any AH-64D Primary member(s) within the selected datalink network, or they may send a request for a report, also known as a "query". In addition, crewmembers may configure the modem to automatically send reports in response to queries without aircrew interaction; or they may disable this function, which will require a manual reply to such report queries.

Battle Damage Assessment Report. BDA reports allow crewmembers to send missile engagement data to their flight leaders, which can then forward that data across other datalink networks to AH-64D commanders.

Target Report. Target reports allow FCR-equipped AH-64Ds to distribute FCR-generated targeting or reconnaissance data to other AH-64Ds across the datalink network, which can be used to maintain situational awareness of the battlespace or aid in target acquisition within their own aircraft.

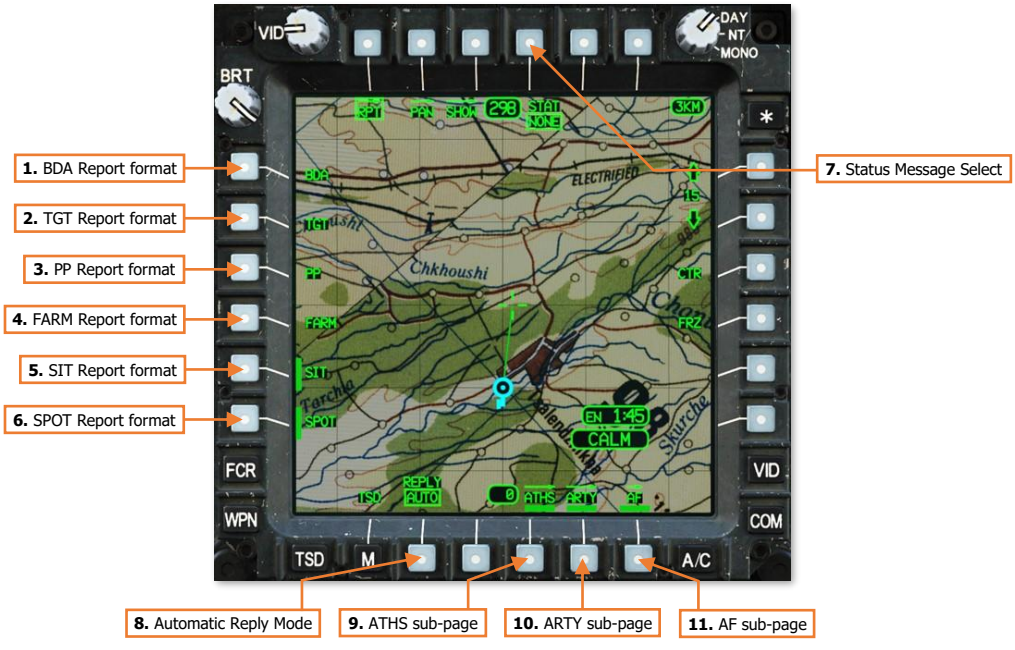
Present Position Report. Present Position reports update the positions of other AH-64Ds on the datalink network and displays their positions as friendly helicopter symbols on the TSD. These reports may be used to monitor the movements of each team of AH-64Ds, allowing flight leaders and commanders to synchronize tactical movements and actions.

Fuel/Ammunition/Rockets/Missiles Report. Also known as FARM, these reports send the current state of fuel, munitions, and expendable countermeasures remaining onboard, allowing flight leaders and commanders to monitor the remaining time-on-station, ordnance, and defensive capabilities of the AH-64Ds at any point during the mission.

All reports may be transmitted, requested, received, or reviewed through the TSD; or stored from the COM MSG REC sub-page.

TSD Report (RPT) Sub-page

Sending or requesting tactical reports is performed through the RPT sub-page on the TSD. This sub-page allows crewmembers to send Battle Damage Assessment (BDA) reports, FCR Target (TGT) reports, Present Position (PP) reports, or report the status of their onboard fuel, munitions, and expendable countermeasures using FARM reports. This page also allows crewmembers to disable the modem's automatic replies to queries.



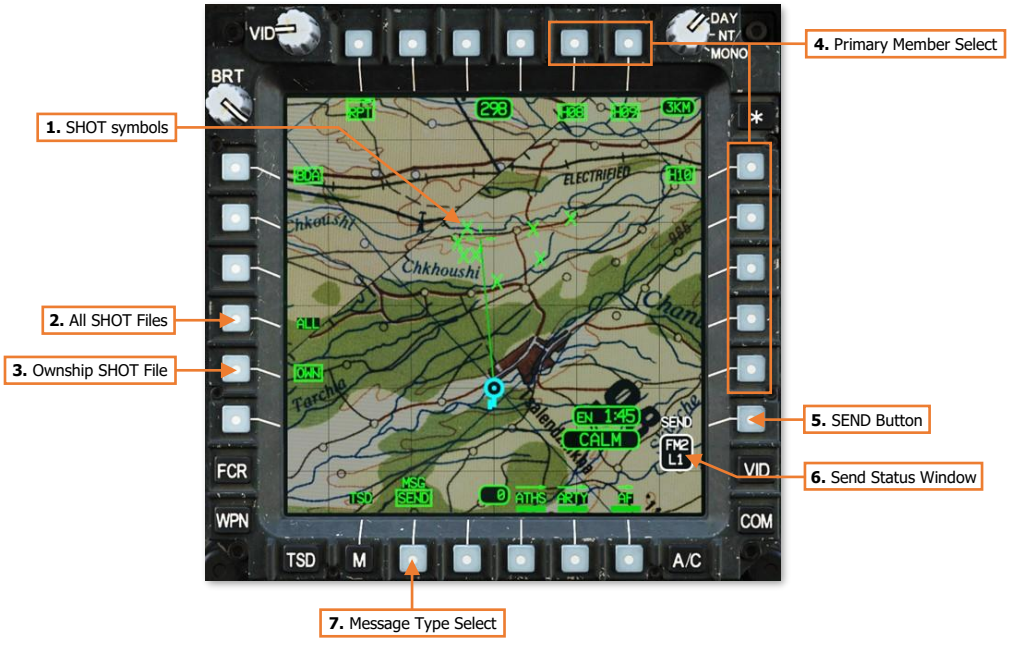
1. **BDA Report format.** Displays the Battle Damage Assessment Report format.
2. **TGT Report format.** Displays the FCR Target Report format.
3. **PP Report format.** Displays the Present Position Report format.
4. **FARM Report format.** Displays the Fuel/Ammunition/Rockets/Missiles Report format.
5. **SIT Report format.** Not implemented.
6. **SPOT Report format.** Not implemented.
7. **Status Message Select.** Not implemented.
8. **Automatic Reply Mode.** Enables/disables the automatic reply function of the datalink modem.
   - **AUTO.** The modem will automatically transmit reports in response to queries.
   - **OFF.** The aircrew will be notified of incoming queries and will be responsible for sending reports as necessary.
9. **ATHS sub-page.** Not implemented.
10. **ARTY sub-page.** Not implemented.
11. **AF sub-page.** Not implemented.

Selected Report (BDA, TGT, PP, FARM) format

Pressing the BDA (VAB L1), TGT (VAB L2), PP (VAB L3), or FARM (VAB L4) buttons displays the RPT sub-page in the selected report format. Pressing the corresponding report button a second time returns the RPT sub-page to the original format.

Battle Damage Assessment (BDA) Report

BDA reports transmit the SHOT file stored within the onboard database, which stores the details of each missile engagement performed by the ownship. The BDA report can also forward SHOT files that have already been received from other AH-64Ds via the datalink. SHOT files may be reviewed on the TSD SHOT sub-page.



1. **SHOT Symbols.** Missile engagement locations are stored to the ownship SHOT file and displayed on the TSD and FCR pages as green X symbols. Missile engagement locations received via the datalink are displayed as partial-intensity green X symbols on the TSD and FCR pages.

2. **All SHOT Files (ALL).** All SHOT file entries will be transmitted within the BDA report, which includes SHOT files stored by the ownship and SHOT files received through the datalink from other AH-64Ds.

3. **Ownship SHOT File (OWN).** Ownship SHOT file entries will be transmitted within the BDA report. This is the default selection.

4. **Primary Member Select.** Displays a list of Primary members within the selected datalink network that may be selected to receive the report. Each entry within the list is generated from the Callsigns of Primary members as displayed on the NET sub-page, truncated to the last three alphanumeric characters. For example, "DH08" is displayed as "H08" within the Primary member list on the TSD page.

   If the Datalink Transmit Select Indicator is moved to a different datalink network on the EUFD, the Primary member list will update to reflect the Primary members within the selected datalink network. If the Datalink Transmit Select Indicator is moved to a radio that has not been tuned to a preset with a datalink network, or that network contains no Primary members, no callsigns will be displayed within the Primary member list.

When BDA is the selected report type, no members are selected by default. However, if TGT, PP, or FARM are the selected report type, all members are selected by default.

5. **SEND Button.** The SEND button is displayed when a report is selected, the Datalink Transmit Select Indicator is set to a radio that has been configured for transmitting digital messages, and at least one Primary member has been selected to receive it.

6. **Send Status Window.** Displays the radio and datalink network over which the report will be transmitted.

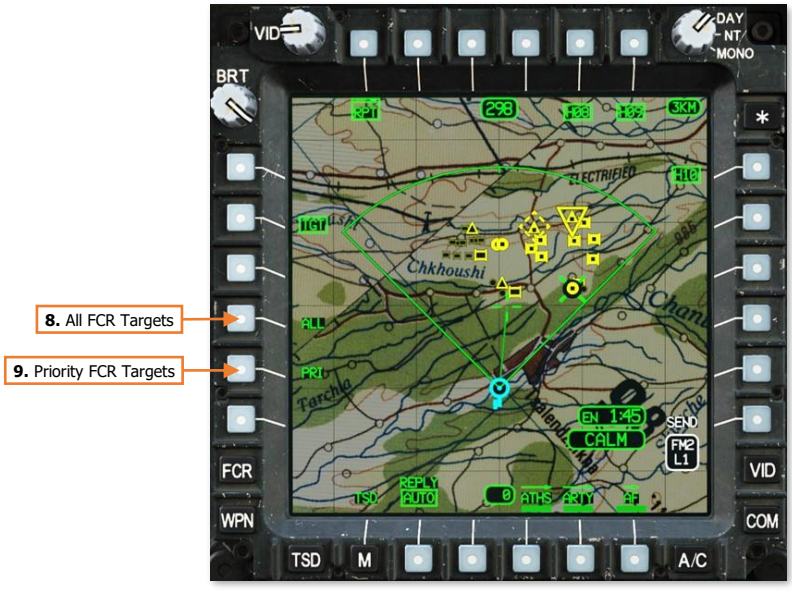
7. **Message Type Select.** Toggles the type of message that will be sent to the selected Primary members. This option is not displayed when the RPT sub-page is displayed in TGT format; FCR Target reports may be sent, but they cannot be requested.

   - **SEND.** A report will be sent to each Primary member that has been selected.
   - **RQST.** A query will be sent to each Primary member that has been selected.

Target (TGT) Report

TGT reports distribute FCR target data to other AH-64Ds. TGT reports may contain individually-selected FCR targets, high-priority FCR targets, or all FCR targets which includes high- and low-priority targets.

(See the Fire Control Radar chapter for more information.)



8. **All FCR Targets (ALL).** All FCR targets will be transmitted within the TGT report, which includes the 16 high-priority targets and all low-priority targets.

9. **Priority FCR Targets (PRI).** The 16 high-priority FCR targets will be transmitted within the TGT report.

The MPD cursor may be used to individually select FCR targets for transmission within the TGT report. If any FCR target is cursor-selected on the TSD while the TGT report format is displayed, that FCR target will be included within the FCR target report. Cursor-selecting any FCR target in this manner will de-select the ALL and PRI options, since a custom TGT report has been started using cursor-selected targets. Subsequently selecting ALL or PRI will erase the custom TGT report.

NOTE: There are no indications as to which FCR targets have been cursor-selected for a custom TGT report.

Present Position (PP) Report

PP reports transmit the ownship's present position to other AH-64Ds, which will be displayed as Datalink Subscriber control measure symbols on the TSD within the receiving aircraft. Each unique present position report is stored as C93 through C99 within the TSD database, allowing a maximum of 7 present position points to be displayed at any given time. If a PP report is received from a subscriber ID that corresponds with an existing point within C93-C99, the coordinate data of the point is updated with the most recent position received. If each point within C93-C99 is already occupied by present position data, each PP report that is subsequently received from a unique subscriber ID will overwrite the data stored in C93, then C94, etc. in a cyclic manner.

NOTE: Present Position reports are only transmitted on demand. These points are static in nature and are not automatically updated as each AH-64D within the datalink network moves across the battlefield.

10. Present Position Points. Displays the positions of other AH-64Ds within the datalink network. The last three alphanumeric characters within the corresponding subscriber's callsign are entered as the point's Free Text, which allows the crewmembers to identify the positions of other AH-64Ds on the TSD.

Fuel/Ammo/Rockets/Missiles (FARM) Report

FARM reports transmit the fuel state, munitions inventory, and the quantity of expendable countermeasures remaining onboard the aircraft. The FARM report also includes the present position and MSL altitude (above mean sea level) of the originating aircraft, and the time at which the data was transmitted. FARM reports may be reviewed on the TSD FARM sub-page.

Sending Tactical Reports

To send a report, ensure the EUFD Datalink Transmit Select Indicator is set to the datalink network over which the transmission is intended, and then perform the following:

1. TSD Fixed Action Button – Press.

2. RPT (VAB T1) – Select.

3. Report Type (VAB L1-L4) – Select the desired report format.

4. MSG (VAB B2) – Set to SEND.

5. Report Options (VAB L4/L5) – Select as necessary prior to transmitting a BDA or TGT report.

or

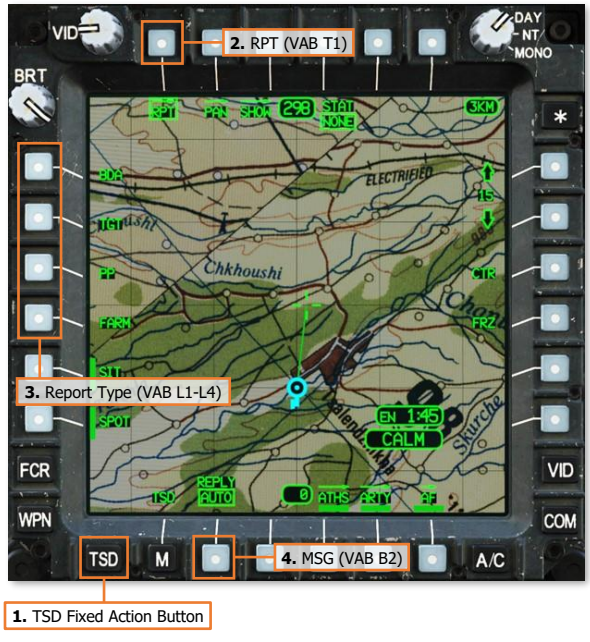
5. MPD Cursor Controller/Enter – Select individual FCR targets to be transmitted within the TGT report.

6. Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.

7. SEND (VAB R6) – Press.

Once SEND (VAB R6) is pressed, the SEND text label will be displayed in inverse video as the transmission is performed to each Primary member that is selected to receive the report. When the transmission is complete, the SEND text label will revert to normal video.

If an acknowledgement of receipt is not received from any Primary member selected to receive the report, a "XMIT NAK" advisory will be displayed on the EUFD.



Requesting Tactical Reports

To request a report, ensure the EUFD Datalink Transmit Select Indicator is set to the datalink network over which the transmission is intended, and then perform the following:

1. TSD Fixed Action Button – Press.
2. RPT (VAB T1) – Select.
3. Report Type (VAB L1, L3, or L4) – Select the desired report format.

   NOTE: FCR TGT Reports cannot be requested.
4. MSG (VAB B2) – Set to RQST.
5. Primary Members (VAB T5, T6, R1-R5) – Select.
6. SEND (VAB R6) – Press.

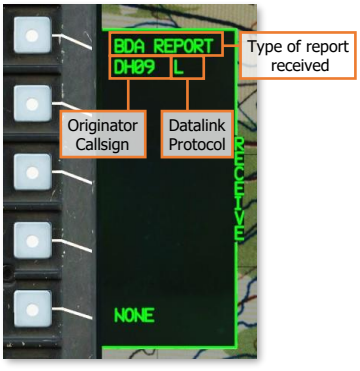
Once SEND (VAB R6) is pressed, the SEND text label will be displayed in inverse video as the transmission is performed to each Primary member that is selected to receive the query. When the transmission is complete, the SEND text label will revert to normal video.

If an acknowledgement of receipt is not received from any Primary member selected to receive the query, a "XMIT NAK" advisory will be displayed on the EUFD.

Receiving Tactical Reports

When a tactical report has been received through the datalink, the EUFD will display an advisory indicating the type of report received. "BDA REPORT" and "FCR TGT REPORT" advisories will be accompanied by an audio ring tone, prompting the aircrew to access the MSG REC sub-page or the TSD Receive List to store the received report.

Any time a datalink message intended for Primary members is received, the aircrew within the receiving aircraft may store the contents of the message by selecting the COM page and then the MSG REC sub-page, or they may store it directly from the TSD. A white REC option will be displayed at VAB L2, which will open the TSD Receive list.



The Receive list will display the four most recent datalink messages that have not already been stored (excluding text messages and mission files). Each entry will include the type of data that has been sent within the message, the originator callsign that sent the message, and the modem protocol through which it was received.

In the example on this page, a BDA report was received from "DH09" through the DATALINK protocol, indicated by an "L".

To store a tactical report within the database, perform the following:

1. TSD Fixed Action Button – Press.
2. REC (VAB R2) – Select to display the Receive list.
3. Datalink message (VAB L2-L5) – Select.

   or

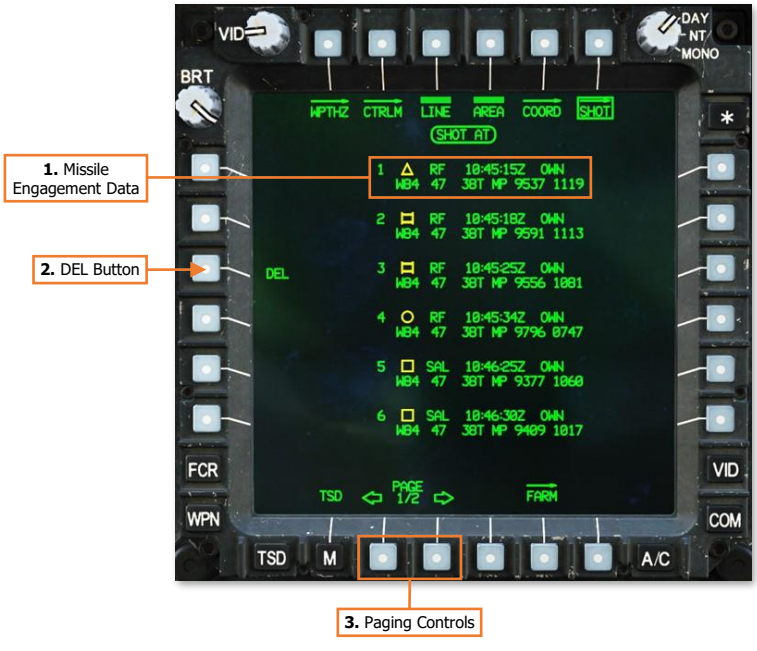
3. NONE (VAB L6) – Select to close the Receive list without storing a message.

Reviewing Tactical Reports

After receiving BDA and FARM reports, the information contained within the reports is extracted and stored within the aircraft database. The information from these reports may be reviewed from the TSD COORD sub-page.

TSD Shot (SHOT) Sub-page

The SHOT sub-page displays engagement data for every missile fired from the ownship and any BDA reports received through the datalink.



1. **Missile Engagement Data.** Every AGM-114 missile that is fired will generate a unique missile engagement index within the ownship SHOT file.

   - **Shot Index.** The index for each ownship missile engagement is numbered 1 through 16. Any SHOT files that are extracted from BDA reports received via the datalink will be stored in indexes 17-128, allowing a total of 16 missile engagements from 7 other AH-64Ds within the network.

     If the number of missile engagements from the ownship exceeds 16, which may occur after rearming at a Forward Arming and Refueling Point (FARP), the 17th missile engagement that is recorded will overwrite the data in index 1, the 18th missile engagement will overwrite the data in index 2, and so on in a cyclic manner.

     If the number of imported missile engagements extracted from BDA reports exceeds 112, missile engagement data will begin overwriting the data in index 17, then 18, and so on in a cyclic manner.

   - **Target Classification.** If an RF missile engagement is conducted against an FCR-detected target, the corresponding FCR target symbol will be displayed next to the Shot index. If an RF missile engagement is conducted using the TADS to generate target data, an "Unknown" (square) target symbol will be displayed. All SAL missile engagements will be displayed with an "Unknown" (square) target symbol.

- **Missile Type.** "RF" will be displayed when an AGM-114L missile is employed, or "SAL" when an AGM-114K missile is employed.
- **Time of Engagement.** The missile engagement is recorded at the moment that launch is commanded.
- **Ownship (OWN)/Datalink (DL).** "OWN" will be displayed for missile engagements 1-16. "DL" will be displayed for missile engagements 17-128 that have been received over the datalink network.
- **Location of Engagement.** The MGRS coordinates of the target, to include the Earth Datum and Datum Code, are displayed based on the location of the target handover data when employing an RF missile, or the line-of-sight and range source of the selected sight at the moment of launch when employing a SAL missile.

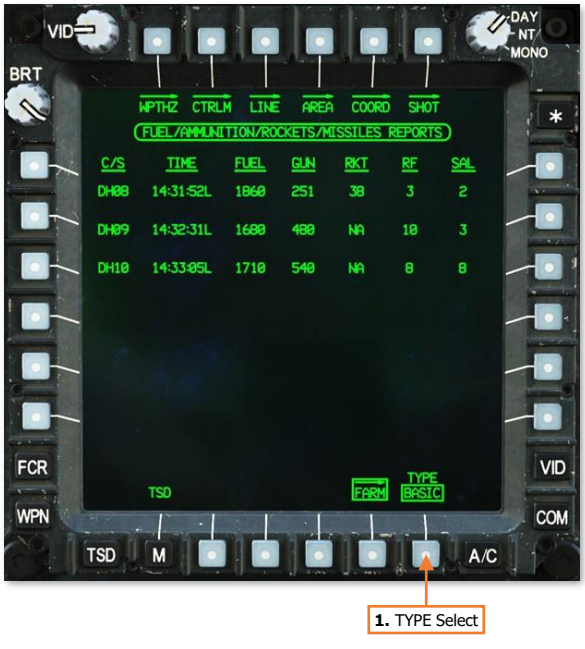
2. **DEL button.** Pressing the DEL button (VAB L3) replaces the DEL button with a two-button Grouped button confirmation option. Pressing the NO button (VAB L3) will abort the deletion process. Pressing the YES button (VAB L2) will delete all missile engagement data received over the datalink network.

   Ownship (OWN) missile engagement data cannot be deleted.

3. **Paging Controls.** Cycles forward and back through multiple pages of the SHOT file.

TSD Fuel/Ammunition/Rockets/Missiles (FARM) Sub-page

The FARM sub-page displays onboard fuel, munitions, countermeasures, and present position coordinate data of other AH-64Ds received through the datalink.



1. **TYPE Select.** Selects the type of FARM report data that is displayed.

   - **BASIC.** The Basic FARM report format displays the datalink subscriber's callsign, the time the report was received, the total fuel onboard (lbs.), remaining rounds of 30mm ammunition, remaining rockets onboard (of any type), and the remaining missiles onboard, separated between RF and SAL variants.

- **MSL.** The Missile (MSL) FARM report format displays the datalink subscriber's callsign, the time the report was received, and the remaining missiles onboard, separated between RF, SAL1, SAL2, and Other missile variants. Only RF (AGM-114L) and SAL2 (AGM-114K) are simulated within DCS: AH-64D.

- **EXPEN.** The Expendables (EXPEN) FARM report format displays the datalink subscriber's callsign, the time the report was received, and the remaining expendable countermeasures onboard, separated between Flare, Chaff, and Other. Only flares and chaff are simulated within DCS: AH-64D.

- **PP.** The Present Position (PP) FARM report format displays the datalink subscriber's callsign, the time the report was received, the subscriber's present position in both MGRS and Latitude/Longitude coordinate formats, and the subscriber's altitude in feet above mean sea level (MSL).

BATTLE AREA MANAGEMENT

As attack helicopters, AH-64Ds are capable of engaging large numbers of enemy targets within a short time span. When massing fires against enemy forces, proper distribution of fire should be used to ensure as many targets are engaged as possible while maximizing the use of all munitions that are available within the team, all while avoiding potential fratricide and collateral damage of non-military infrastructure. This is especially crucial when employing "fire-and-forget" weapons such as the radar-guided AGM-114L missile.

Fire zones facilitate this distribution of firepower across the battlefield by assigning specific geographic zones for engagement by individual AH-64Ds (Priority Fire Zones; PFZ) and other geographic zones that should *not* be engaged (No Fire Zones; NFZ). Priority Fire Zones and No Fire Zones may be transmitted between selected Primary members across the datalink network, which allows flight leaders and commanders to digitize the distribution of fires during the mission. These fire zones may be created, deleted, transmitted, or received through the TSD. In addition, received fire zones may also be stored from the MSG REC sub-page, which is accessed from the COM page.

When drawing Priority Fire Zones or No Fire Zones, 4-sided zones may be created by either crewmember using several methods, ranging from simple rectangles to irregular-shaped quadrilaterals. Once drawn, PFZ's may then be assigned to any Primary member(s) within the selected datalink network.

Fire zones may also be individually activated or deactivated, which will affect how any FCR-equipped AH-64Ds prioritize ground targets that are detected within those zones. (See the Fire Control Radar chapter for more information.)

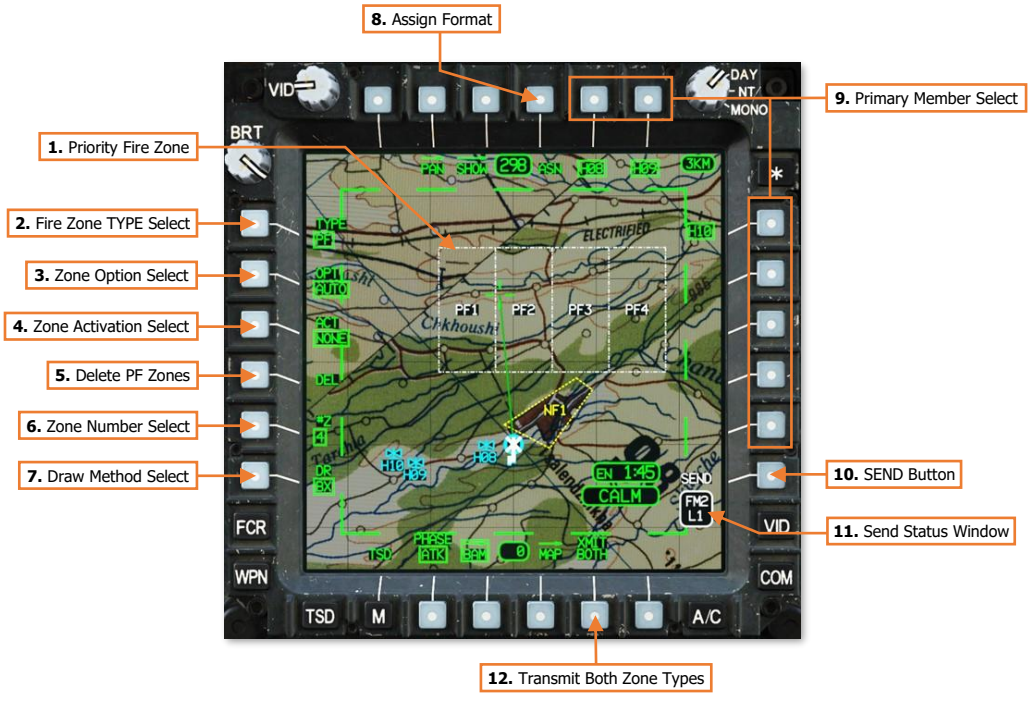
- All FCR targets detected within an activated PFZ will out-prioritize any FCR targets that are outside the PFZ.
- All FCR targets detected within an activated NFZ will not be prioritized by the FCR, even if those targets are also within an overlapping PFZ that is also activated. However, it should be noted that activating an NFZ will not prevent any targets within the zone from being engaged; it will only affect the FCR's target prioritization process.

TSD Battle Area Management (BAM) Sub-page

All functions regarding Priority Fire and No Fire Zones are performed through the BAM sub-page on the TSD. This sub-page allows crewmembers to create or delete fire zones, activate/deactivate fire zones, assign PFZ's to specific Primary members, or transmit fire zones to Primary members within the selected datalink network.

Priority Fire (PF) format

The BAM sub-page is displayed in PF format when the fire zone type (VAB L1) is set to PF. This format displays options and controls for creating, deleting, assigning, or activating Priority Fire Zones.



1. **Priority Fire Zone.** Displays a geographic area in which weapons fire from the assigned Primary member should be concentrated at the appropriate time in battle. Up to 8 PFZ's may be present on the TSD at any given time, with each zone identified with a number 1 through 8.

2. **Fire Zone TYPE Select.** Toggles the BAM page between PF and NF formats.

3. **Zone Option Select (OPT).** Selects the method of sub-dividing geographic areas between each Priority Fire Zone.

   - **AUTO.** The geographic area to encompass all PFZ boundaries is selected using the MPD cursor, which is automatically subdivided into individual PFZ's based on the number of zones selected using VAB L5.
   - **MAN.** Each individual PFZ is manually drawn using the MPD cursor, the total number of which is selected using VAB L5.
   - **TRP.** Four equally sized PFZ's are placed on the TSD by the MPD cursor in a Target Reference Point quadrant pattern, with the height and width of each PFZ based on the KM value selected using VAB L5. The MPD cursor will be displayed in TRP format when positioned within the TSD footprint.

4. **Zone Activation Select (ACT).** Displays the PFZ activation menu, which allows the crewmember to activate any PFZ from the displayed list. When a PFZ has been activated, the border lines of the zone will marquee in a continuous pattern. Only one PFZ may be active at any given time.

   NOTE: Activating a PFZ will remove all zone text labels within the boundaries of the zone.

5. **Delete PF Zones (DEL).** Deletes all Priority Fire Zones.

6. **Zone Number Select (#Z).** Displays the zone number selection menu, which allows the crewmember to choose the number of PFZ's that are drawn when OPT is set to AUTO or MAN.

   When entering the BAM sub-page, this selection will default to the number of Primary members that are present within the datalink network selected by the Datalink Transmit Select Indicator, plus one additional zone for the ownship (e.g., if there are three Primary members within the selected datalink network, the zone number selection will default to "4").

   If the Datalink Transmit Select Indicator is set to a radio that is not tuned to a datalink network, or the selected datalink network has no subscribers designated as Primary members, the zone number selection will default to 1.

7. **Draw Method Select (DR).** Selects the method of drawing Priority Fire Zones using the MPD cursor.

   - **Box (BX).** A rectangular-shaped zone will be drawn based on the alignment of the TSD. The first Cursor-Enter command using the MPD cursor will establish the first corner, and the second Cursor-Enter command will establish the opposing corner.

   - **Line (LN).** A custom quadrilateral-shaped zone may be drawn independent of the alignment of the TSD. Each Cursor-Enter command using the MPD cursor establishes the next corner of the zone in sequence.

8. **Assign format (ASN).** Displays the Priority Fire Assign format.

9. **Primary Member Select.** Displays a list of Primary members within the selected datalink network that may be selected to receive the PF Zone file. Each entry within the list is generated from the Callsigns of Primary members as displayed on the NET sub-page, truncated to the last three alphanumeric characters. For example, "DH08" is displayed as "H08" within the Primary member list on the TSD page.

   If the Datalink Transmit Select Indicator is moved to a different datalink network on the EUFD, the Primary member list will update to reflect the Primary members within the selected datalink network. If the Datalink Transmit Select Indicator is moved to a radio that has not been tuned to a preset with a datalink network, or that network contains no Primary members, no callsigns will be displayed within the Primary member list.

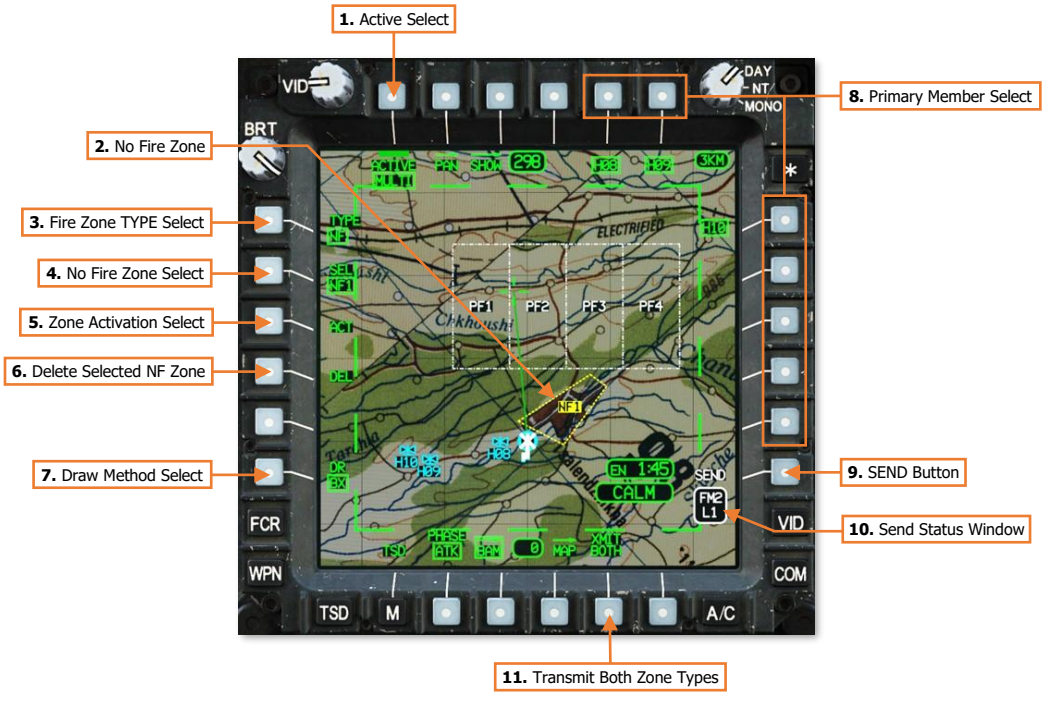
10. **SEND Button.** The SEND button is displayed on the PF format when at least one PFZ is present on the TSD, the Datalink Transmit Select Indicator is set to a radio that has been configured for transmitting digital messages, and at least one Primary member has been selected to receive it.

11. **Send Status Window.** Displays the radio and datalink network over which the zone(s) will be transmitted.

12. **Transmit Both Zone Types (XMIT BOTH).** The XMIT BOTH button is displayed on the BAM sub-page when at least one PFZ and one NFZ is present on the TSD. When selected, pressing the SEND button will simultaneously transmit the PF Zone and NF Zone files to the selected Primary member(s).

No Fire (NF) format

The BAM sub-page is displayed in NF format when the fire zone type (VAB L1) is set to NF. This format displays options and controls for creating, deleting, or activating No Fire Zones.



1. **Active Select.** No function.
2. **No Fire Zone.** Displays a geographic area in which weapons fire is prohibited during the battle. Up to 8 NFZ's may be present on the TSD at any given time, with each zone identified with a number 1 through 8.
3. **Fire Zone TYPE Select.** Toggles the BAM page between PF and NF formats.
4. **No Fire Zone Select (SEL).** Displays the NFZ selection menu, which allows the crewmember to select individual No Fire Zones for drawing, deleting, or activating/de-activating the selected zone. Any number of NFZ's may be active at any given time.
5. **Zone Activation Select (ACT).** Activates/Deactivates the NFZ selected using VAB L2. When a NFZ has been activated, the border lines of the zone will marquee in a continuous pattern.
6. **Delete Selected NF Zone (DEL).** Deletes the NFZ selected using VAB L2.
7. **Draw Method Select (DR).** Selects the method of drawing No Fire Zones using the MPD cursor.
   - **Box (BX).** A rectangular-shaped zone will be drawn based on the alignment of the TSD. The first Cursor-Enter command using the MPD cursor will establish the first corner, and the second Cursor-Enter command will establish the opposing corner.
   - **Line (LN).** A custom quadrilateral-shaped zone may be drawn independent of the alignment of the TSD. Each Cursor-Enter command using the MPD cursor establishes the next corner of the zone in sequence.

8. **Primary Member Select.** Displays a list of Primary members within the selected datalink network that may be selected to receive the NF Zone file. Each entry within the list is generated from the Callsigns of Primary members as displayed on the NET sub-page, truncated to the last three alphanumeric characters. For example, "DH08" is displayed as "H08" within the Primary member list on the TSD page.

   If the Datalink Transmit Select Indicator is moved to a different datalink network on the EUFD, the Primary member list will update to reflect the Primary members within the selected datalink network. If the Datalink Transmit Select Indicator is moved to a radio that has not been tuned to a preset with a datalink network, or that network contains no Primary members, no callsigns will be displayed within the Primary member list.

9. **SEND Button.** The SEND button is displayed on the NF format when at least one NFZ is present on the TSD, the Datalink Transmit Select Indicator is set to a radio that has been configured for transmitting digital messages, and at least one Primary member has been selected to receive it.

10. **Send Status Window.** Displays the radio and datalink network over which the zone(s) will be transmitted.

11. **Transmit Both Zone Types (XMIT BOTH).** The XMIT BOTH button is displayed on the BAM sub-page when at least one PFZ and one NFZ is present on the TSD. When selected, pressing the SEND button will simultaneously transmit the PF Zone and NF Zone files to the selected Primary member(s).

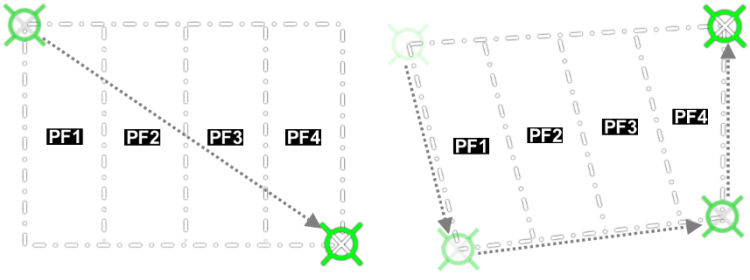
Drawing Fire Zones

Fire zones may be placed on the TSD by either crewmember using several options and draw methods that are selected from the BAM sub-page. The creation of Priority Fire Zones may be Automatic, Manual, or placed around a central TRP, but each No Fire Zone must be individually selected and drawn. However, PFZ's and NFZ's may both be drawn using either the Box (BX) or Line (LN) methods.

When using the Line method to draw PFZ's or NFZ's, a line will not be accepted if placed in such a way that it crosses an existing line of the same zone. For example, an hourglass-shaped zone cannot be created.

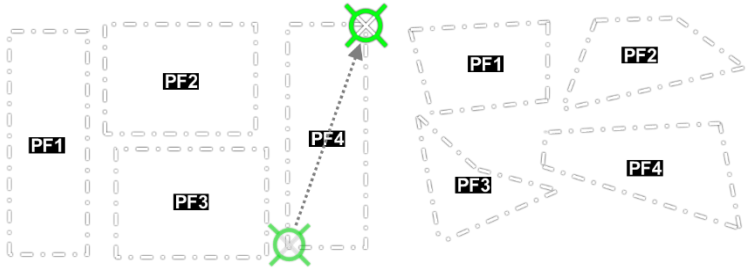
AUTO PFZ Option. The geographic area to encompass all PFZ boundaries is selected using the MPD cursor, which is automatically subdivided into individual PFZ's based on the number of zones selected using VAB L5.

If the Box method is used to draw the PFZ's, the MPD cursor designates the two opposing corners of the PFZ area. If the Line method is used to draw the PFZ's, the MPD cursor designates each corner in sequence, with the total area sub-divided based on the vector of the first line drawn.



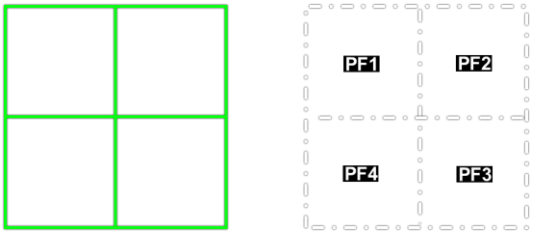
MAN PFZ Option. Each individual PFZ is manually drawn using the MPD cursor, the total number of which is selected using VAB L5.

If the Box method is used to draw the PFZ's, the MPD cursor designates the two opposing corners of each PFZ. If the Line method is used to draw the PFZ's, the MPD cursor designates each corner in sequence. The next zone is then drawn in the same manner until all zones are drawn.



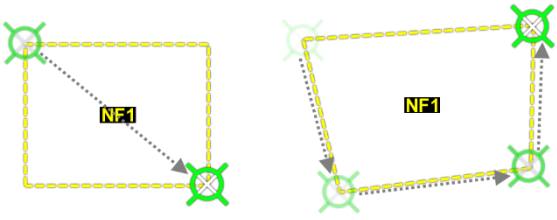
TRP PFZ Option. Four equally sized PFZ's are placed on the TSD by the MPD cursor in a Target Reference Point quadrant pattern, with the height and width of each PFZ based on the KM value selected using VAB L5.

The MPD cursor will be displayed in TRP format when positioned within the TSD footprint. The size of the MPD cursor's TRP outline will be dynamically sized based on the selected TRP size and the current TSD scale. The MPD cursor designates the center of the TRP, after which four equally sized square PFZ's are created.



Selected NFZ. Each individual NFZ is selected and manually drawn using the MPD cursor.

If the Box method is used to draw the NFZ, the MPD cursor designates the two opposing corners of the selected NFZ. If the Line method is used to draw the NFZ, the MPD cursor designates each corner in sequence.



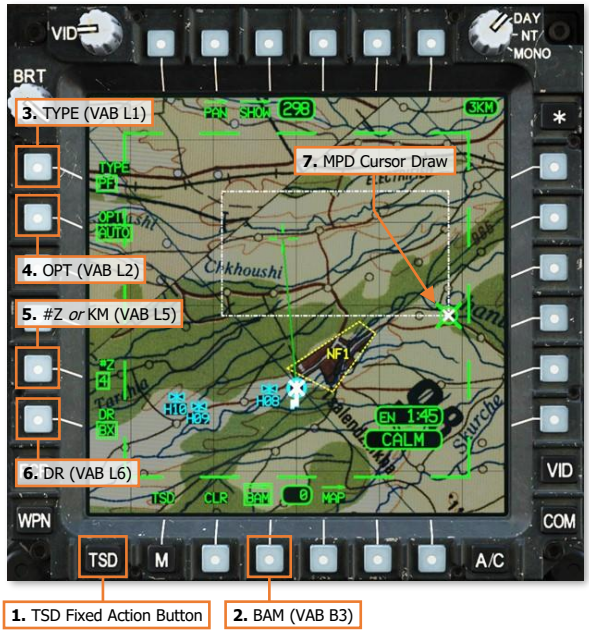
Drawing Priority Fire Zones

To draw a Priority Fire Zone on the TSD, perform the following:

1. TSD Fixed Action Button – Press.
2. BAM (VAB B3) – Select.
3. TYPE (VAB L1) – Set to PF.
4. OPT (VAB L2) – Select AUTO, MAN, or TRP as desired.
5. #Z (VAB L5) – Select desired number of zones if OPT is set to AUTO or MAN.

   or

5. KM (VAB L5) – Select zone size (in kilometers) if OPT is set to TRP.
6. DR (VAB L6) – Select BX or LN as desired.
7. MPD Cursor Controller/Enter – Draw each zone in sequence as necessary.



If a zone is being drawn while the OPT is set to MAN or AUTO, and the crewmember wishes to undo any previous cursor actions for the zone being drawn, CLR (VAB B2) may be pressed to remove each previous cursor action in sequence.

Once the zone(s) are drawn, ASN (VAB T4), ACT (VAB L3), and DEL (VAB L4) will be displayed, allowing the crewmember to assign or activate PFZ's, or delete all PFZ's from the TSD.

Drawing No Fire Zones

To draw a No Fire Zone on the TSD, perform the following:

1. TSD Fixed Action Button – Press.
2. BAM (VAB B3) – Select.
3. TYPE (VAB L1) – Set to NF.
4. SEL (VAB L2) – Select.
5. Zone Select (VAB T1, T2, L1-L6) – Select an empty (white) zone as desired.

   NOTE: Drawn NF Zones will be displayed in green. NF Zones that have not been drawn will be displayed in white.
6. DR (VAB L6) – Select BX or LN as desired.
7. MPD Cursor Controller/Enter – Draw the zone as necessary.

If a zone is being drawn and the crewmember wishes to undo any previous cursor actions, CLR (VAB B2) may be pressed to remove each previous cursor action in sequence.

8. ACT (VAB L3) – Select to accept and activate the NFZ.

   or

8. ACCEPT (VAB L4) – Select to accept but *not* activate the NFZ.

Once the zone is accepted by pressing ACT or ACCEPT, DEL (VAB L4) will be displayed, allowing the crewmember to delete the selected NFZ from the TSD.

Assigning Priority Fire Zones

Each Priority Fire Zone may have up to two Primary members within the selected datalink network assigned; however, each Primary member may only be assigned to one zone. Once a Primary member is assigned to a PFZ, the corresponding callsign will be removed from the Assign Primary Member options at VAB T5, T6, and R1-R5 when any other PFZ is selected. Likewise, once the ownship is assigned to a PFZ, OWN will be removed from VAB B6 when any other PFZ is selected. If the ownship or a Primary member is to be assigned to a different zone, the PFZ to which they are already assigned must be selected and their callsign subsequently de-selected to remove the assignment from that zone. This will return their callsign, or the ownship, to the list of Primary members that may then be assigned to any PFZ.

When the PF Zone file is transmitted to the corresponding Primary members across the datalink, an aircrew's assigned PFZ will be annotated with "OWN" within their respective cockpit.

Priority Fire Assign (ASN) format

The BAM sub-page is displayed in ASN format when the Fire Zone TYPE (VAB L1) is set to PF and ASN (VAB T4) is selected. This format displays options for assigning Priority Fire Zones to Primary members or the ownship.

1. **Priority Fire Zone Select.** Selects the corresponding PFZ for assigning the ownship and/or a Primary Member. The text label for the currently selected PFZ will be displayed in inverse video. When an assignment has been made, the next PFZ will be automatically selected in sequence.
2. **Assign Primary Member.** Displays a list of Primary members within the selected datalink network that may be assigned to the currently selected PFZ.
3. **Assign Ownship (OWN).** Assigns the ownship to the currently selected PFZ.

Sending Fire Zones

Sending fire zones across the datalink is performed through the BAM sub-page of the TSD. Crewmembers may send Priority Fire Zones, No Fire Zones, or all fire zones to any Primary member(s) within the selected datalink network. When transmitting the PF Zone file, all PFZ's will be transmitted from the ownship to the selected Primary members, which will overwrite all PFZ data on the receiving aircraft's TSD. Likewise, when transmitting the NF Zone file, all NFZ's will be transmitted from the ownship to the selected Primary members, which will overwrite all NFZ data on the receiving aircraft's TSD.

When the PF or NF Zone data is overwritten in the receiving aircraft, all PFZ's and/or NFZ's will be synced to the state of the BAM sub-page in the transmitting aircraft at the time the PF Zone or NF Zone files were transmitted, to include the shape and location of each zone, whether each zone is active or inactive, and the assignments to each PFZ. This data overwrite ensures that the fires distribution plan is updated across the entire AH-64D team and that each aircraft shares the same fire zone state.

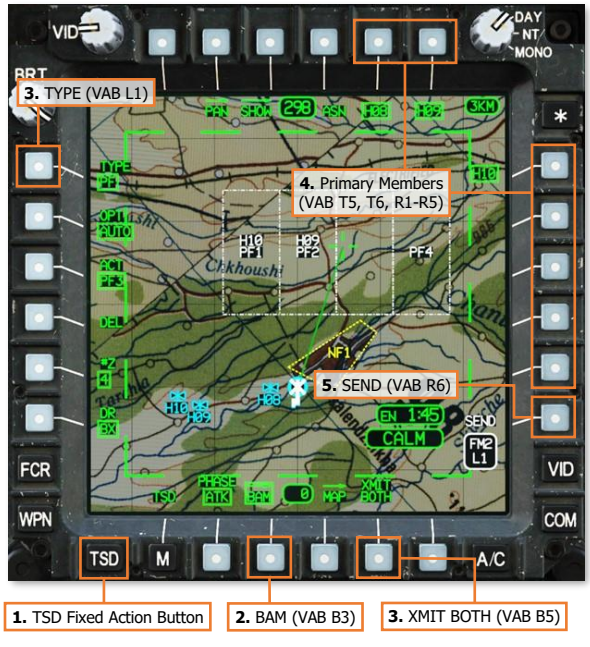
To transmit fire zones, ensure the EUFD Datalink Transmit Select Indicator is set to the datalink network over which the transmission is intended, and then perform the following:

1. TSD Fixed Action Button – Press.
2. BAM (VAB B3) – Select.
3. TYPE (VAB L1) – Set to PF or NF, if intending to send only one type of zones.

   or

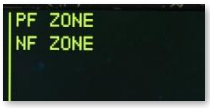
3. XMIT BOTH (VAB B5) – Select, if intending to send both types of zones.
4. Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.
5. SEND (VAB R6) – Press.

Once SEND (VAB R6) is pressed, the SEND text label will be displayed in inverse video as the transmission is performed to each Primary member that is selected to receive the zones(s). When the transmission is complete, the SEND text label will revert to normal video.



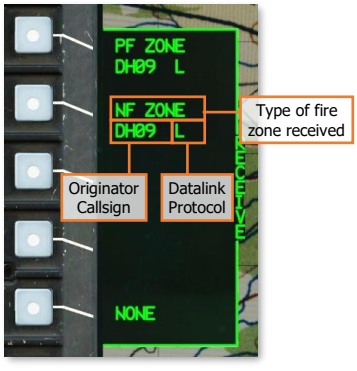
If an acknowledgement of receipt is not received from any Primary member selected to receive the zone(s), a "XMIT NAK" advisory will be displayed on the EUFD.

Receiving Fire Zones



When fire zones have been received through the datalink, the EUFD will display an advisory indicating the type of zone(s) received. These advisories will be accompanied by an audio ring tone, prompting the aircrew to access the MSG REC sub-page or the TSD Receive List to store the received fire zones.

Any time a datalink message intended for Primary members is received, the aircrew within the receiving aircraft may store the contents of the message by selecting the COM page and then the MSG REC sub-page, or they may store it directly from the TSD. A white REC option will be displayed at VAB L2, which will open the TSD Receive list.



The Receive list will display the four most recent datalink messages that have not already been stored (excluding text messages and mission files). Each entry will include the type of data that has been sent within the message, the originator callsign that sent the message, and the modem protocol through which it was received.

In the example on this page, PF and NF Zones were received from "DH09" through the DATALINK protocol, indicated by an "L".

To store fire zones within the database, perform the following:

1. TSD Fixed Action Button – Press.
2. REC (VAB R2) – Select to display the Receive list.
3. Datalink message (VAB L2-L5) – Select.

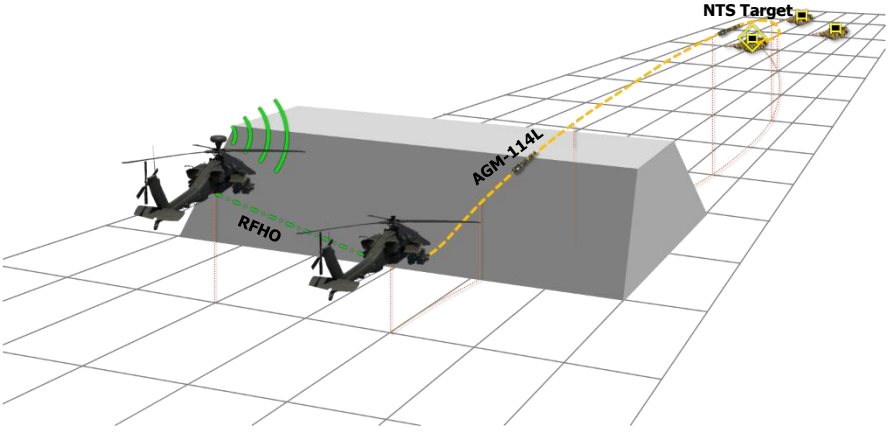
   or

3. NONE (VAB L6) – Select to close the Receive list without storing a message.

RADAR TARGET HANDOVERS

Radar-generated targets detected by FCR-equipped AH-64Ds may be transmitted to other AH-64Ds across the datalink network. Unlike FCR TGT Report datalink messages, which only provide situational awareness or aid in target acquisition using the receiving aircraft's own sensors, RF Handover (RFHO) datalink messages may be used for direct targeting by AGM-114L radar-guided missiles without the receiving aircraft acquiring the target.

RFHO datalink messages may be sent to any AH-64D Primary member(s) within the selected datalink network, allowing the receiving aircraft to engage the FCR target with RF missiles, rockets, or 30mm gunfire, regardless of whether the receiving aircraft is equipped with an FCR themselves. However, if received by an AH-64D that is equipped with an FCR, the RFHO data will replace any target data generated by the receiving aircraft's own FCR.



RF Handover (RFHO) Engagement

FCR page RF Handover (RFHO) Selection Menu

Sending an FCR target handover is performed from the RFHO selection menu on the FCR page. This selection menu is accessed by pressing the RFHO (VAB R4) button and allows crewmembers to send the Next-To-Shoot (NTS) target to a Primary member within the selected datalink network. The RFHO button is displayed on the FCR page when the FCR is the crewmember's selected sight, an NTS target has been designated, and the Datalink Transmit Select Indicator on the EUFD is set to a radio that has been tuned to a preset with at least one Primary member within the corresponding datalink network. (See the Fire Control Radar chapter for more information.)

1. **Next-To-Shoot (NTS) Select.** Advances the NTS and ANTS target designations through the 16 high priority targets in a descending order before cycling back to the first target on the list.

   Each time an RFHO is transmitted, the NTS and ANTS designations will automatically sequence to the next targets on the High Priority Target List, allowing rapid engagement of the high priority targets by RF missiles fired from the ownship and/or other AH-64Ds receiving RFHO messages.

2. **Next-To-Shoot (NTS) Target.** The NTS target symbol indicates the designated target location to which all sighting functions of the FCR are performed, or which target will be transmitted via an RFHO.

3. **Primary Member Select.** Displays a list of Primary members within the selected datalink network that may be selected to receive the RFHO. Each entry within the list is generated from the Callsigns of Primary members as displayed on the NET sub-page, truncated to the last three alphanumeric characters. For example, "DH08" is displayed as "H08" within the Primary member list on the FCR page.

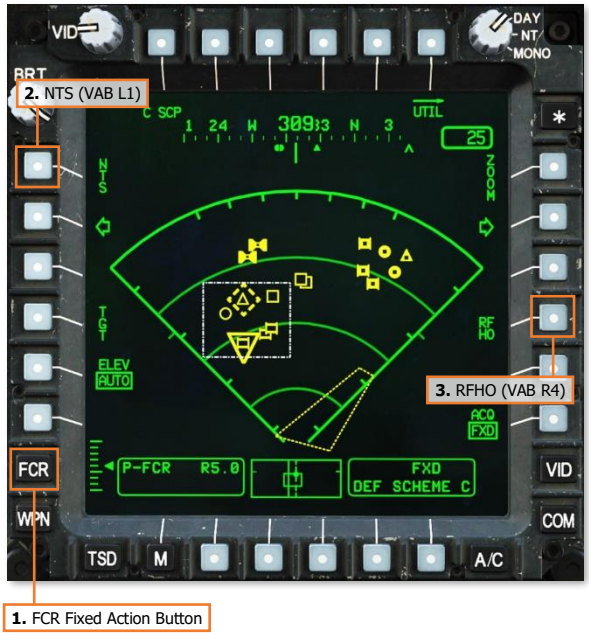
   If the Datalink Transmit Select Indicator is moved to a radio that has not been tuned to a preset with a datalink network, the Primary member list will be closed and the RFHO (VAB R4) option will be removed from the FCR page.

4. **SEND Button.** The SEND button is displayed when a Primary member has been selected to receive the current NTS target as an RFHO.

5. **Send Status Window.** Displays the radio and datalink network over which the report will be transmitted.

Sending an RF Handover

To send an RFHO, ensure the EUFD Datalink Transmit Select Indicator is set to the datalink network over which the transmission is intended, and then perform the following:



1. Sight Select switch – FCR, if FCR is not the selected sight. (Collective Mission Grip or TEDAC Right Handgrip)

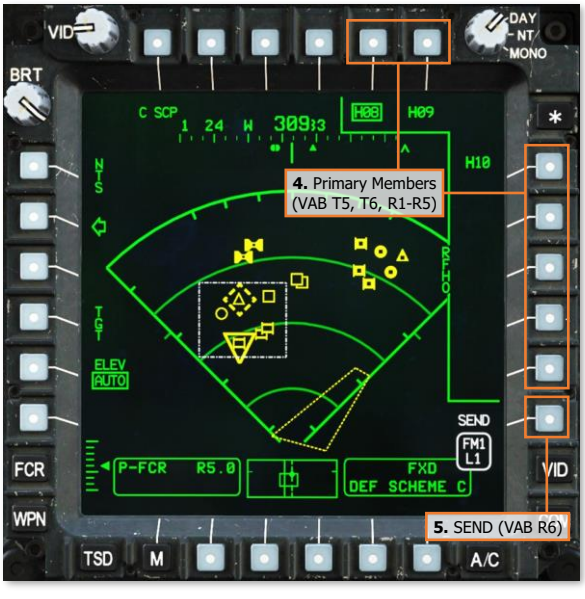
   or

1. FCR Fixed Action Button – Press, if FCR is the selected sight.
2. NTS (VAB T1) – Select to advance NTS designation to desired FCR target for RF Handover.

   or

2. MPD Cursor Controller/Enter – Designate desired FCR target as NTS for RF Handover.

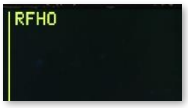
3. RFHO (VAB R4) – Select.
4. Primary Member (VAB T5, T6, R1-R5) – Select as desired.
5. SEND (VAB R6) – Press.



Once SEND (VAB R6) is pressed, the SEND text label will be displayed in inverse video as the transmission is performed to the Primary member that is selected to receive the RFHO. When the transmission is complete, the SEND text label will revert to normal video.

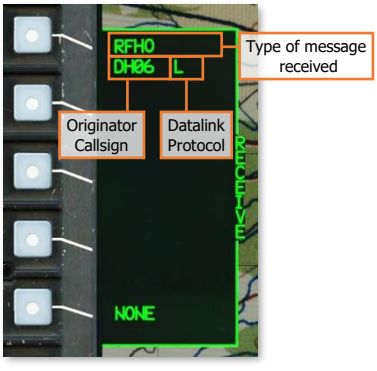
If an acknowledgement of receipt is not received from any Primary member selected to receive the RFHO, a "XMIT NAK" advisory will be displayed on the EUFD.

Receiving an RF Handover



When an RFHO has been received through the datalink, the EUFD will display an "RFHO" advisory accompanied by an audio ring tone, prompting the aircrew to access the MSG REC sub-page or the TSD Receive List to store the RFHO message. (See the Weapon Employment chapter for more information regarding engagement of an RFHO target)

Any time a datalink message intended for Primary members is received, the aircrew within the receiving aircraft may store the contents of the message by selecting the COM page and then the MSG REC sub-page, or they may store it directly from the TSD. A white REC option will be displayed at VAB L2, which will open the TSD Receive list.



The Receive list will display the four most recent datalink messages that have not already been stored (excluding text messages and mission files). Each entry will include the type of data that has been sent within the message, the originator callsign that sent the message, and the modem protocol through which it was received.

In the example on this page, an RFHO message was received from "DH06" through the DATALINK protocol, indicated by an "L".

To store an RFHO within the database, perform the following:

1. TSD Fixed Action Button – Press.
2. REC (VAB R2) – Select to display the Receive list.
3. Datalink message (VAB L2-L5) – Select.

   or

3. NONE (VAB L6) – Select to close the Receive list without storing a message.

WEAPONS EMPLOYMENT

US Army photo
by SSG Preston Malizia

It is recommended that the Tactical Employment chapter is reviewed prior to reading this chapter. This will familiarize the reader with the roles that sights and acquisition sources play when employing weapons in a tactical scenario.

Additionally, the Helmet-Mounted Display (HMD), Target Acquisition Designation Sight (TADS), and Fire Control Radar (FCR) chapters should be reviewed prior to reading through the weapon procedures within this chapter which rely on the corresponding sights and their associated range sources.

When describing cockpit controls or specific tasks performed in each crewstation, the following symbols will be used to denote each crewstation or cockpit control effects between the crewstations.

PLT Denotes a task that is performed by the Pilot.

CPG Denotes a task that is performed by the Copilot/Gunner.

PLT / CPG Denotes a task that may be performed by either crewmember.

PLT & CPG Denotes a task that is performed by both crewmembers.

© Denotes a cockpit control, option, or setting that is "common" between crewstations. A change performed in one crewstation will affect both crewstations. Any item that does not have this symbol is "independent" between crewstations.

"Pilot" Denotes the crewmember occupying the aft crewstation.

"pilot" Denotes the crewmember manipulating the aircraft flight controls in the conduct of performing a specific flight maneuver.

WEAPONS EMPLOYMENT

Each weapon system of the AH-64D is fully integrated into the fire control system and automatically managed by the Weapon Processors (WP). This integration increases the aircrew's combat effectiveness by allowing each crewmember to focus on the targeting of enemy positions using their selected sight. The WP's generate weapon solutions and command the positions of the gun turret and wing pylons in accordance with the selected weapon(s), the calculated weapon aiming solution(s), and the specific weapon settings within each cockpit.

When a crewmember intends to employ a weapon system, the weapon is selected, or "actioned", using the cyclic- or TEDAC-mounted Weapon Action Switch (WAS); also known as "WASing" (pronounced "Wahz-ing"). When the crewmember selects the same weapon that is already actioned, the weapon is "de-actioned"; also known as "de-WASing".

Neither crewstation has priority control of any weapon system over the other, allowing either crewmember to action a weapon at any time, taking control away from the opposite crewmember using a "last actioned" logic. As an exception to this logic, both crewmembers may action the rocket system in a Cooperative (COOP) mode.

The AH-64D's three weapon systems are the AGM-114 missiles, 2.75-inch unguided rockets, and 30mm gun.

- **Hellfire Modular Missile System (HMMS)**. The AGM-114 missile is a highly accurate anti-armor munition, capable of engaging point targets at long range across a wide variety of battlefield conditions. The Hellfire is the primary weapon system of the AH-64D.
- **Aerial Rocket Sub-system (ARS).** The 2.75-inch unguided rockets are an aerial rocket bombardment system designed for engaging or suppressing area targets at close or long range and is effective against groups of vehicles or personnel in the open.
- **Area Weapon System (AWS).** The 30mm gun is designed for engaging or suppressing targets at close range and is effective against lightly armored vehicles, unarmored vehicles, and personnel.

Both crewmembers may employ separate weapon systems independently and simultaneously, however only one weapon system may be physically fired at any given time. If a weapon system is in the process of firing or is already committed to launching a munition, the other weapon system will be inhibited from firing for two seconds to prevent interference with the other. (See Weapon Inhibits on the following page for more information.)

Weapon Inhibits

If a condition exists that would prevent the safe employment of a weapon system (such as another weapon system already firing), or a condition that could negatively impact a weapon's effectiveness under the current conditions, the Weapons Processors will present a "Weapon Inhibit" message to the crewmember(s) to which the message pertains. Weapon inhibits are grouped into two categories: Performance Inhibits and Safety Inhibits.

Performance Inhibits

Performance inhibits alert the crewmember(s) that the actioned weapon system cannot perform effectively under the current flight or sighting conditions. The actioned weapon system will be inhibited from firing if the crewmember pulls the weapon trigger to the first detent; but these inhibits may be overridden by pulling the trigger to the second detent.

Safety Inhibits

Safety inhibits alert the crewmember(s) that employment of the actioned weapon system under the current flight or sighting conditions would present a potential safety hazard to the aircraft and aircrew, or friendly forces in the vicinity. These inhibits cannot be overridden using the second detent of the weapons trigger.

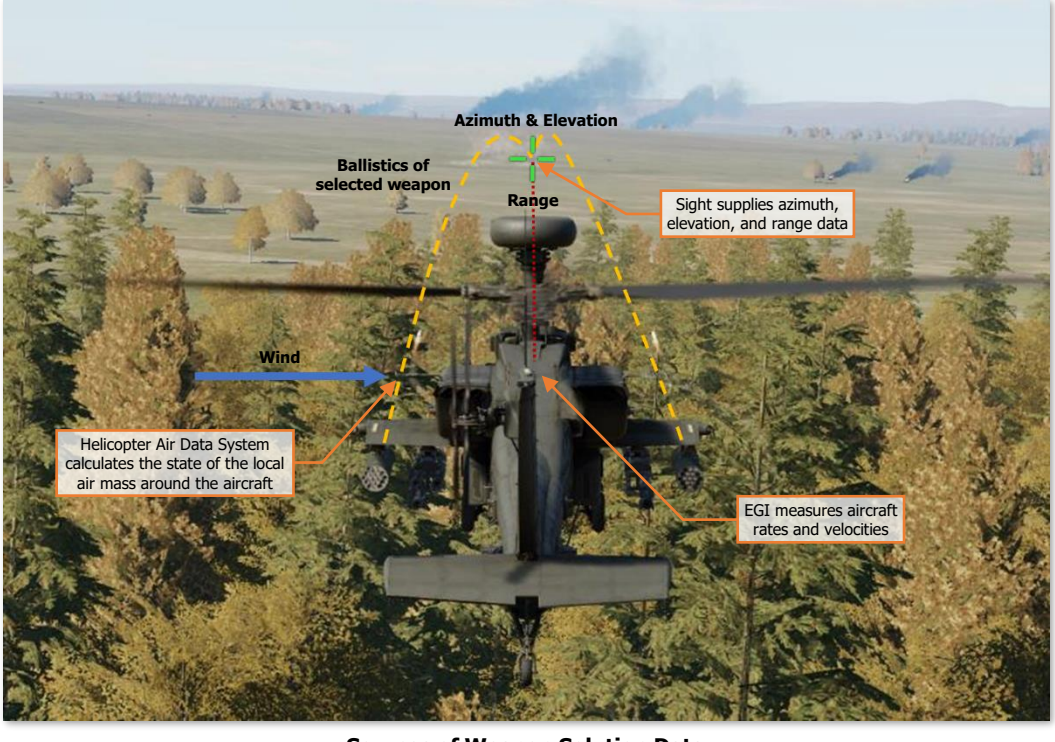
Performance and safety inhibits that are specific to the Area Weapon System, Aerial Rocket Sub-system, or Hellfire Modular Missile System are described in their relevant sections.

Weapon Aiming Solution

The fire control system of the AH-64D is highly automated and only requires the crewmembers to perform accurate sighting against the intended target. Factors such as aircraft speed, altitude above the target, range to target, winds, or the ballistics of the weapon itself are automatically calculated to produce a weapon aiming solution.

The EGI supplies the Weapon Processors with aircraft inertial data such as attitude, linear velocities, and angular rates. The Airspeed And Direction Sensor (AADS) probes mounted to the engine nacelles sense airspeed magnitude, direction, and free airstream temperature, which is used by the High Integrated Air Data Computer (HIADC) to compute air mass related data such as relative winds and local air density. The crewmember's selected sight is used to determine the targets relative position from the aircraft in azimuth, elevation, and range.

The Weapon Processors use the supplied data along with crewmember's selected weapon and cockpit settings to calculate where the actioned weapon must be aimed in order to place rounds on target. This aiming solution determines the commanded position of the gun turret, the commanded pylon angle of the rocket launchers, and the vertical and lateral position of the rocket steering cursor within the crewmember(s) sight symbology.



Sources of Weapon Solution Data

Crewmember actions that typically increase the accuracy of the weapon aiming solution are ensuring the selected sight is stabilized on the intended target and ensuring precise ranging data is supplied throughout the engagement. In addition, the Pilot should strive to maintain a stable attitude as much as possible to assist the Copilot/Gunner in targeting and to provide a stable weapon platform when munitions are being fired or launched.

Pylon Articulation

Hydraulically-driven articulation mechanisms are integrated into each of the four wing pylons of the AH-64 which facilitates the swivel of the weapon mounts in the vertical axis. The articulation of each pylon is independently controlled by the AH-64D's Weapons Processors, based on the state of the aircraft (in flight or on the ground), the selected weapon system of either crewmember, the current weapon inventory onboard the pylon, and the calculated ballistic solution of the weapon itself, if applicable. The operation of the wing pylons is fully automatic and does not require management by the crewmembers.

As any helicopter's longitudinal airspeed is a function of its pitch attitude, the articulation of the wing pylons allows the missile and rocket launchers to be "decoupled" from the pitch attitude of the helicopter. This mostly eliminates the requirement to adjust the pitch attitude of the helicopter to align the weapon system with the calculated weapon solution in the vertical axis. This in turn facilitates the employment of these weapons across a wide range of airspeeds, while performing acceleration/deceleration maneuvers, or from a stationary hover.

Pylon Articulation

However, the articulation range of each pylon is limited to +4° to -15°, relative to the aircraft datum line (ADL). In the event the calculated weapon solution is beyond the articulation range of the pylon at the current aircraft attitude, a corresponding weapon inhibit message will be presented to the crewmember within their sight symbology. Under such circumstances, it may be necessary to adjust the pitch attitude of the aircraft to bring the weapon solution within the articulation range of the applicable weapon system.

This should be expected when employing unguided rockets against targets at long ranges, in which case it is unlikely the rocket launchers can elevate high enough without performing a positive pitch maneuver with the aircraft. (See Aerial Rocket Sub-system for more information.)

Weapon employment tips and recommendations

The following points are recommended practices for employing weapons from the DCS: AH-64D. These recommendations are not all-encompassing, nor do they reflect the best procedure for every situation, but will typically increase the chances of successful weapon engagements.

- The settings for each weapon system may be changed by manually selecting the corresponding weapon along the bottom row of options on the Weapon (WPN) page. This permits the weapons to be configured prior to being actioned by a crewmember. During start-up procedures, it is recommended that these settings be configured as appropriate based on the anticipated tactical situation instead of waiting until the weapons are actioned for employment; in some circumstances in which enemy contact has already occurred.
- The MANRNG> value on the WPN page defaults to 1,500 meters for the Pilot and 3,000 meters for the Copilot/Gunner (CPG). If the selected sight is set to HMD when the gun is actioned, the crewmember's range source will be automatically set to a Manual range value corresponding with the MANRNG> setting for the purposes of hasty engagements against close-range targets (or threats). Therefore, during start-up procedures, it is recommended that this value be set between 1000 and 1500 meters to ensure the range setting corresponds with a range that will be most practical for HMD gun engagements.
- Off-axis gun engagements are useful for hasty, close-range shots using the HMD; however, the gun will be most accurate when employed in a deliberate manner by placing the target off the nose and using TADS for targeting.
- If intending to use TADS Linear Motion Compensation (LMC), an approximate range measurement of the target area will assist the CPG in establishing an appropriate LMC slew rate prior to pulling the laser trigger to the 2nd detent for designation, which will minimize large "range jumps" when the laser is fired.
    - Switch to Automatic ranging by entering "A" as the MANRNG> value on the WPN page. This will automatically adjust the range value based on the radar altitude and TADS look-down angle.

      or
    - Use the 1st detent of the laser trigger to fire a brief ranging pulse to measure the range to the target area prior to enabling LMC.
- If intending to autonomously employ laser-guided missiles (self-designating), ensure the Priority missile channel is set to the same laser code as the TADS laser rangefinder/designator (LRFD).
    - The TADS LRFD laser code is set on the WPN Code sub-page.
    - The missile channels are set on the WPN Channel sub-page.
    - The Priority missile channel is selected on the WPN page when set to MSL format.
- If intending to autonomously employ laser-guided missiles in LOBL mode, ensure TRAJ (VAB R3) is set to "DIR" on the WPN page MSL format. This will slave the AGM-114K missile seeker to the TADS line-of-sight prior to the LRFD being fired, which will ensure the missile will detect the laser designation.
- If the TADS LRFD is not firing when the laser trigger is pulled (indicated by the X pattern displayed around the TADS LOS Reticle), verify the following within the CPG cockpit:
    - The selected sight is TADS.
    - The A/S button on the Armament Panel is set to ARM.
    - The LT switch on the TEDAC Right Handgrip is set to the center Off position. If the LST is set to Automatic or Manual mode, the LRFD is inhibited from firing.
    - LASER (VAB L6) is powered on the WPN Utility sub-page.
- When using a laser designator from a helicopter at low altitudes, precision is more critical when lasing at shallow angles across the terrain than compared to a fixed-wing aircraft that is lasing from high-altitudes with steep look-down angles. When using the TADS LRFD to measure range for the gun or rockets, being precise with the laser will result in a more precise weapon aiming solution. When designating for laser-

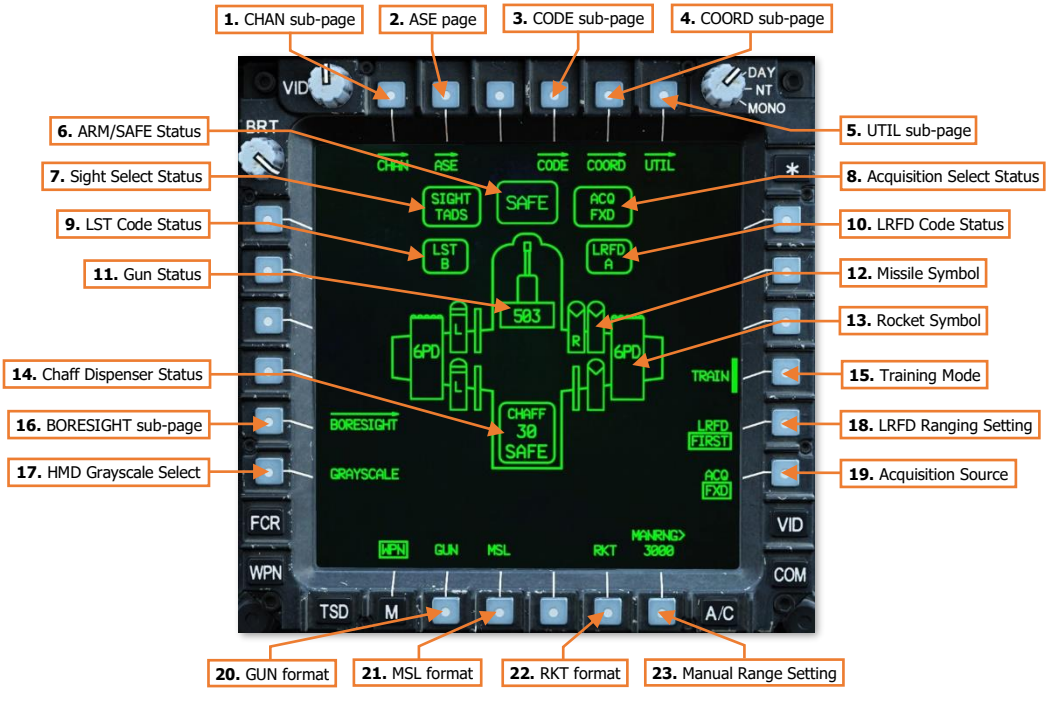
guided missiles, it is even more important to ensure the missile actually impacts the target; versus hitting the ground nearby or beyond it.

- GND STOW (VAB R5) may be enabled on the WPN Utility sub-page from either crewstation. This will fix the wing pylons to -5° relative to the Aircraft Datum Line (ADL), which will correspond with the Head Tracker within the HMD symbology.
    - This may be used as a "fixed" rocket mode, allowing the pilot to use the Head Tracker as an aiming reticle for the rockets. However, ballistic compensation for range will not be provided, so the Head Tracker will need to be elevated above the intended target to account for the trajectory drop of the rockets as the range to target increases.
    - When employing laser-guided missiles in a dive, GND STOW may be used to force the missile launchers to align with the Head Tracker. This allows the pilot to use the Head Tracker as an aiming reticle for the missiles. If the TADS is set as the Pilot's ACQ, maneuvering the aircraft so that the Head Tracker is pointed at the Cued LOS Reticle while the CPG is lasing will ensure the missiles can maneuver toward the laser designation after they leave the launcher rail.
- Performance inhibits may be overridden using the 2nd detent of the weapon trigger; but ensuring that no weapon inhibit messages are displayed prior to pulling the trigger increases the chances of the desired weapon effects. If tactically feasible, efforts should always be taken to improve the likelihood of a successful engagement by correcting the conditions that are resulting in the display of performance inhibits.
- The AH-64 aircrew consists of two crewmembers. Employing weapons accurately and effectively is just as much the responsibility of the Pilot as it is the Copilot/Gunner (CPG). A Pilot that flies haphazardly makes the CPG's job more difficult, and a CPG that doesn't coordinate with the Pilot prior to releasing munitions is needlessly complicating his or her own tasks.

Weapon (WPN) Page

The WPN page presents a top-down overview of the aircraft weapons load along with relevant sight, sensor, and countermeasure statuses. The WPN page will contextually change format to display additional weapon-specific settings any time a weapon is actioned within the crewstation or manually selected along the bottom row of Variable Action Buttons (VAB).

Other key settings that may be accessed from this page include changing the selected acquisition source (ACQ), selecting a manual or automatic range source, changing the laser codes assigned to the TADS Laser Rangefinder/Designator and Laser Spot Tracker, or boresighting the IHADSS.



1. **CHAN sub-page.** Displays the WPN Channel sub-page.
2. **ASE page.** Displays the Aircraft Survivability Equipment (ASE) page.
3. **CODE sub-page.** Displays the WPN Code sub-page.
4. **COORD sub-page.** Displays the WPN Coordinates sub-page. (See TSD Coordinate sub-page for more information.)
5. **UTIL sub-page.** Displays the WPN Utility sub-page.
6. **ARM/SAFE Status.** Displays the master armament state.

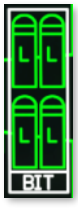
SAFE. No weapons are actioned. TADS LRFD is inhibited from firing.

ARM. No weapons are actioned. TADS LRFD may be fired.

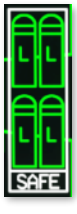
SAFE. Actioned weapon(s) and TADS LRFD are inhibited from firing.

ARM. Actioned weapon(s) and TADS LRFD may be fired.

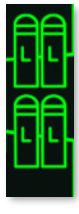
7. **Sight Select Status.** Indicates the sight currently selected within the crewstation.
   - **HMD.** Displayed when the crewmember's selected sight is HMD.
   - **TADS.** Displayed when the crewmember's selected sight is TADS (CPG only).
   - **FCR.** Displayed when the crewmember's selected sight is FCR.
8. **Acquisition Select Status.** Indicates the acquisition source currently selected within the crewstation.
   - **PHS.** When slave is enabled, the currently selected sight will slave to the azimuth and elevation of the Pilot's Helmet Sight.
   - **GHS.** When slave is enabled, the currently selected sight will slave to the azimuth and elevation of the Copilot/Gunner's Helmet Sight.
   - **SKR.** If the next-to-shoot AGM-114 is tracking a laser designation or target in LOBL mode when slave is enabled, the currently selected sight will slave to the azimuth and elevation of the missile seeker.
   - **FCR.** When slave is enabled, the currently selected sight will slave to the location of the Next-To-Shoot (NTS) target detected by the Fire Control Radar. This option is only displayed if the FCR mast-mounted assembly is installed and the FCR is powered.
   - **FXD.** When slave is enabled, the currently selected sight will slave to a fixed forward direction along the Armament Datum Line (ADL, 0° in azimuth/-4.9° in elevation).
   - **W##, H##, C##, T##.** When slave is enabled, the currently selected sight will slave to the location of the Waypoint, Hazard, Control Measure, or Target/Threat point set as the acquisition source within the crewstation, and the range source will switch to a Navigation range equal to the slant range between the aircraft and the selected point. ## indicates the specific point number to which the Waypoint, Hazard, Control Measure, or Target/Threat point has been stored.
   - **TRN.** When slave is enabled, the currently selected sight will slave to the location of the terrain location cursor-selected on the TSD within the crewstation, and the range source will switch to a Navigation range equal to the slant range between the aircraft and the Terrain point.
9. **LST Code Status.** Displays the laser code that the TADS Laser Spot Tracker will scan for when enabled. (See WPN Code sub-page for more information.)
10. **LRFD sub-page.** Displays the laser code that the TADS Laser Rangefinder/Designator will emit when fired. (See WPN Code sub-page for more information.)
11. **Gun Status/Symbol.** Displays the status of the Area Weapon System and the remaining quantity of ammunition onboard. If the gun system is powered off, the gun symbol will be removed from the page. (See Area Weapon System for more information.)
12. **Missile Symbol/Missile Launcher.** Displayed when a missile is loaded onto the corresponding missile launcher rail underneath the corresponding wing pylon, the type of missile that is loaded, and the missile's status. If the missile system is powered off, missile and launcher symbols will be removed from the page. (See Hellfire Modular Missile System for more information.)



BIT. A built-in-test is being performed to determine the status of any missiles that are detected onboard the launcher.



SAFE. The missile launcher is in a SAFE status. Missiles are inhibited from being launched.



ARM. The missile launcher is in an ARM status. Missile launch is permitted.

13. **Rocket Launcher Symbol.** Displayed when a rocket launcher is loaded underneath the corresponding wing pylon, along with the rocket warhead type that is selected within the crewstation. If the rocket system is powered off, any rocket launcher symbols will be removed from the page. (See Aerial Rocket Sub-system for more information.)

14. **Chaff Dispenser Status.** Displays the arming state of the chaff dispenser and the remaining quantity of individual chaff cartridges.

SAFE. 30 chaff cartridges remain on board. Chaff is inhibited from being dispensed.

ARM. 30 chaff cartridges remain on board. Chaff may be dispensed.

15. **Training Mode.** Not implemented.

16. **BORESIGHT sub-page.** Displays the WPN Boresight sub-page. (See IHADSS Boresight for more information.)

17. **HMD Grayscale Select.** Selects a grayscale pattern for display within the HDU. The grayscale pattern is used to set the appropriate brightness and contrast levels for the HDU video output.

18. **LRFD Ranging Setting.** Selects which laser return is utilized by the LRFD when fired using the 1st detent of the LRFD trigger on the TEDAC Right Handgrip. This setting is common between crewstations.

    - **FIRST.** The first laser return that is received by the LRFD is utilized for range.
    - **LAST.** The last laser return that is received by the LRFD is utilized for range.

19. **Acquisition Source (ACQ).** Displays the acquisition source selection menu. (See Acquisition Sources in the Tactical Employment chapter for more information.)

20. **GUN format.** Displays the WPN Gun format.

21. **MSL format.** Displays the WPN Missile format.

22. **RKT format.** Displays the WPN Rocket format.

23. **Manual Range Setting.** Activates the KU for inputting a manual or automatic range as the range source for that crewstation.

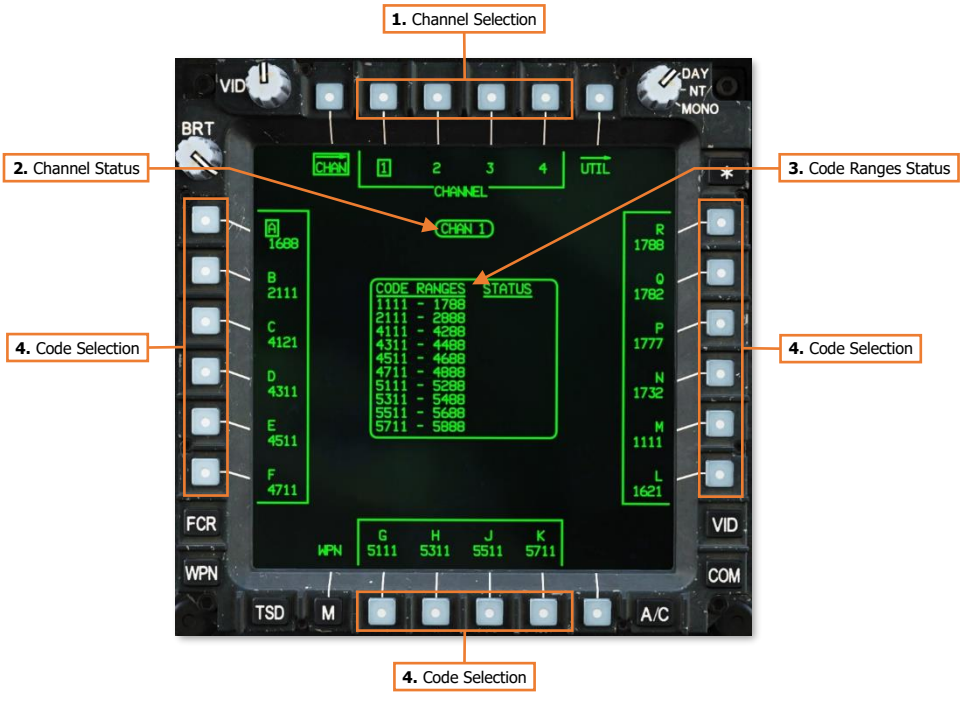
    - **Manual Range.** May be entered in 1-meter increments between 100 and 50,000 meters, and then pressing ENTER on the KU. If a range value is not entered prior to pressing ENTER on the KU, the manual range value already displayed on the WPN page will be entered as the range source.
    - **Automatic Range.** May be enabled by entering a value of "A", and then pressing ENTER on the KU.

    NOTE: Under the following conditions, manual and automatic range cannot be used as the range source within the corresponding crewstation. The Manual Range Setting will be disabled from receiving input and MANRNG> will be "barriered" on the WPN page.

    - The FCR is the selected sight within the crewstation.
    - Missiles are actioned within the crewstation with the TYPE (VAB R1) set to SAL and TRAJ (VAB R3) set to LO or HI.

WPN Channel (CHAN) Sub-page

The CHAN sub-page allows either crewmember to change the laser code assigned to each of the four missile channels. When the WPN page is displayed in MSL format and the missile TYPE is set to SAL, any of these four missile channels may be selected as either the Priority or Alternate channel.



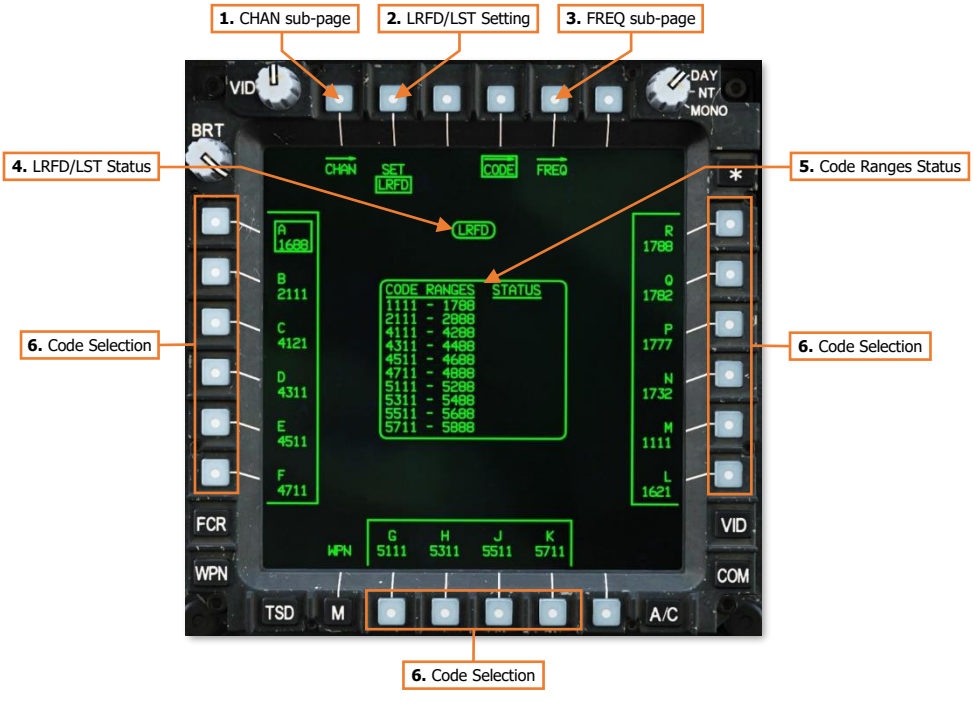
1. **Channel Selection.** Selects the missile channel for laser code assignment.
2. **Channel Status.** Displays the missile channel that is currently selected for laser code assignment.
3. **Code Ranges Status.** Displays the pulse repetition frequencies that may be entered into any of the 16 preset laser codes.
4. **Code Selection.** Assigns the corresponding laser code to the selected missile channel. The laser code currently assigned to the selected missile channel will be boxed.

   Laser codes are assigned using one of 16 presets labeled "A" through "R", excluding I and O to prevent confusion with one and zero respectively.

WPN Code (CODE) Sub-page

The CODE sub-page allows either crewmember to change the laser code assigned to the TADS Laser Rangefinder/Designator (LRFD) and Laser Spot Tracker (LST).

The FREQ sub-page may also be accessed from this sub-page, permitting either crewmember to modify the specific pulse repetition frequency (PRF) value used by each laser code.

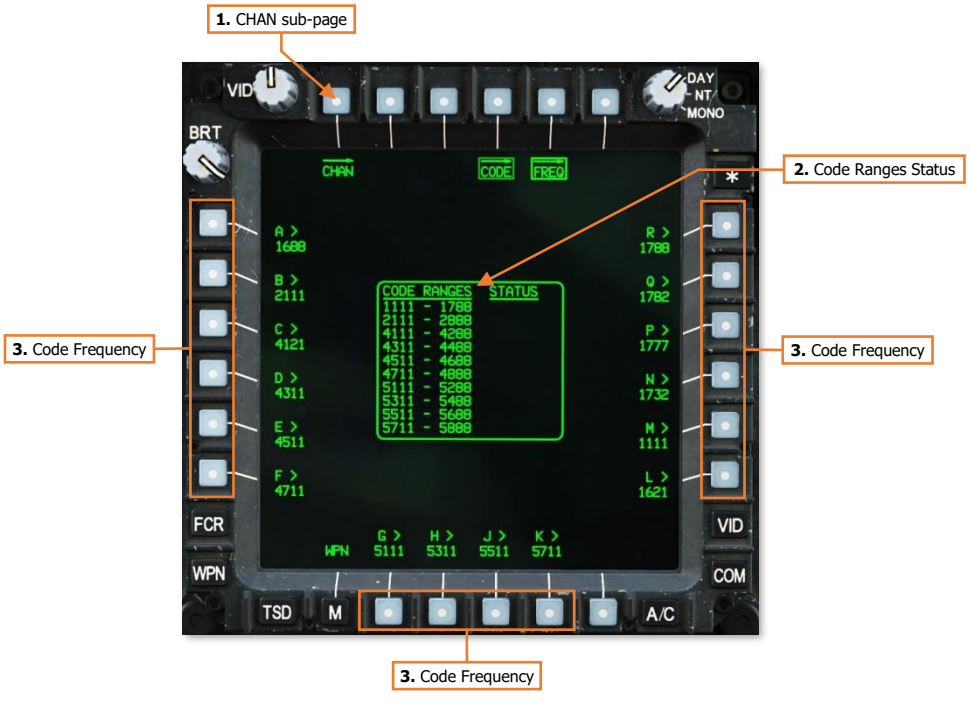


1. **CHAN sub-page.** Displays the WPN Channel sub-page.
2. **LRFD/LST Setting.** Toggles the selected TADS sensor (LRFD or LST) for laser code assignment.
3. **FREQ sub-page.** Displays the WPN Frequency sub-page.
4. **LRFD/LST Status.** Displays the TADS sensor (LRFD or LST) that is selected for laser code assignment.
   - **LRFD.** The TADS LRFD will emit the selected laser code when fired.
   - **LST.** The TADS LST will search for an offboard laser designation source that matches the selected laser code when set to Automatic or Manual mode. (See Laser Spot Track for more information.)
5. **Code Ranges Status.** Displays the pulse repetition frequencies that may be entered into any of the 16 preset laser codes.
6. **Code Selection.** Assigns the corresponding laser code to the selected TADS sensor (LRFD or LST). The laser code currently assigned to the selected TADS sensor will be boxed.

   Laser codes are assigned using one of 16 presets labeled "A" through "R", excluding I and O to prevent confusion with one and zero respectively.

WPN Frequency (FREQ) Sub-page

The FREQ sub-page allows either crewmember to modify the specific pulse repetition frequency (PRF) value used by each laser code using the Keyboard Unit (KU).



1. **CHAN sub-page.** Displays the WPN Channel sub-page.
2. **Code Ranges Status.** Displays the pulse repetition frequencies that may be entered into any of the 16 preset laser codes.
3. **Code Frequency.** Activates the KU for inputting a pulse repetition frequency into the corresponding laser code.

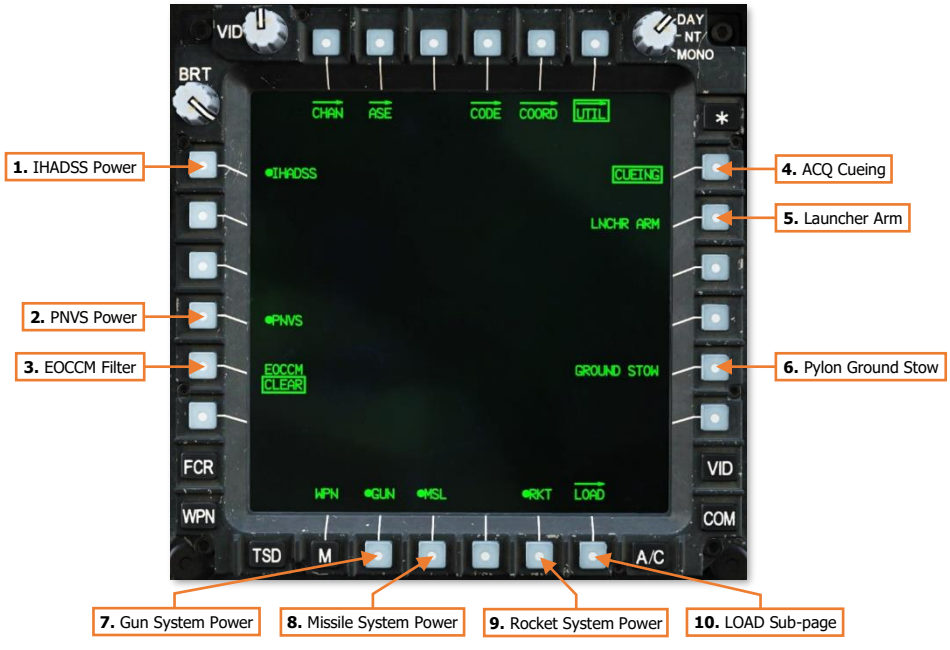
WPN Utility (UTIL) Sub-page

The UTIL sub-page allows either crewmember to enable/disable power to specific sight, sensor, or weapon systems, or modify the settings of such systems. The format of this page is contextual depending on which crewstation is viewing the sub-page, and will only present options that are relevant to that crewstation; although some options are available in both crewstations.

The LOAD sub-page may also be accessed from this sub-page, permitting either crewmember to modify the quantity of rounds loaded into the ammunition handling system or change the warhead ballistic values assigned per rocket launcher zone.

Pilot Crewstation Options

The format of the UTIL sub-page when displayed within the Pilot crewstation is shown below.



1. **IHADSS Power.** Enables/disables the Integrated Helmet And Display Sighting System. This setting is common between crewstations.

2. **PNVS Power.** Enables/disables the Pilot Night Vision System. If either crewmember is using the PNVS as their NVS sensor, this option will be "barriered" and unavailable for selection.

3. **EOCCM Filter.** Selects the electro-optical counter-countermeasure filter setting in use by the NVS sensor assigned to the Pilot crewstation, as protection against optical countermeasures. (N/I)

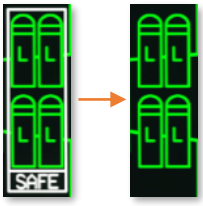
   - **FILTER 1.** Selects EOCCM Filter 1.
   - **CLEAR.** No filter is applied.
   - **FILTER 2.** Selects EOCCM Filter 2.

4. **ACQ Cueing.** Enables/disables cueing symbology to the Pilot's acquisition source. When disabled, the Cued LOS Reticle and Cueing Dots will be removed from the Pilot's HMD symbology.

5. **Launcher Arm.** Manually commands the external ARM/SAFE switches on all M299 missile launchers to rotate to the ARM position.

   This command will not permit AGM-114 missiles to be launched if the A/S button on the Armament Panel is set to SAFE. However, if the external ARM/SAFE switches on the missile launchers themselves are set to SAFE, missiles cannot be launched even if the A/S button is set to ARM.

   NOTE: When ground personnel are rearming the aircraft, they will set the external ARM/SAFE switches on each M299 missile launcher to the SAFE position.



Launcher Arm

   Each time the master armament state is toggled from SAFE to ARM via the A/S button, this arming command is automatically sent to the missile launchers.

6. **Pylon Ground Stow.** Manually commands each wing pylon to the Ground Stow position (-5° relative to the Aircraft Datum Line), which corresponds to the position of the Head Tracker. This will ensure the wing pylons remain level with the surface when the aircraft is landed and facilitates easier loading of munitions by ground personnel.

   NOTE: When the aircraft is weight-on-wheels, the wing pylons are automatically commanded to the Ground Stow position. Four seconds after the weight-on-wheels switch detects the aircraft is airborne, the wing pylons are automatically commanded to the Flight Stow position (+4° relative to the Aircraft Datum Line).

7. **Gun System Power.** Enables/disables the Area Weapon System.

8. **Missile System Power.** Enables/disables the Hellfire Modular Missile System.

9. **Rocket System Power.** Enables/disables the Aerial Rocket Sub-system.

10. **LOAD sub-page.** Displays the WPN Load sub-page.

Copilot/Gunner Crewstation Options

The format of the UTIL sub-page when displayed within the Copilot/Gunner crewstation is shown below.

11. **TADS Power.** Enables/disables the Target Acquisition Designation Sight. If either crewmember is using the TADS as their NVS sensor, or if the CPG is using the TADS as a sight, this option will be "barriered" and unavailable for selection.

12. **FLIR Power.** Enables/disables the TADS FLIR sensor. If either crewmember is using the TADS as their NVS sensor, this option will be "barriered" and unavailable for selection.

    When disabled, a "FLIR OFF" message will be displayed within the Sight Status field of the High Action Display when the CPG's selected sight is TADS.

13. **Laser Power.** Enables/disables the TADS Laser Rangefinder/Designator (LRFD).

14. **TADS Stow.** Manually commands the TADS turret to the stow position, rotating the sensor turret 180° toward the rear, facing inwards. If either crewmember is using the TADS as their NVS sensor, or if the CPG is using the TADS as a sight, this option will be "barriered" and unavailable for selection. If the crewmember that is assigned TADS as their NVS sensor sets their NVS Mode switch to the NORM or FIXED positions, this option will be automatically de-selected.

WPN Utility, Load (LOAD) Sub-page

The LOAD sub-page is not implemented.

AREA WEAPON SYSTEM (AWS)

The Area Weapon System is designed for engaging or suppressing targets at close range and is effective against lightly armored vehicles, unarmored vehicles, and personnel. Although the entire M139 AWS also includes the hydraulically-steered turret, ammunition magazine, and ammo handling system that transports ammunition from the magazine to the turret, the most noticeable component of the AWS is the M230E1 30mm gun (also called the "thirty" or simply the "gun").

The gun may be employed by either crewmember when using the HMD or FCR as the selected sight; or by the CPG when using the TADS. When employed using the HMD as the selected sight, gun engagements are typically performed with the intent to engage or suppress close-range threats to the aircraft, in which the speed of placing "rounds on target" is of greater importance over accuracy and precision. When employed using the TADS as the selected sight, gun engagements may be performed in a more offensive manner in which accuracy and precision is desired.

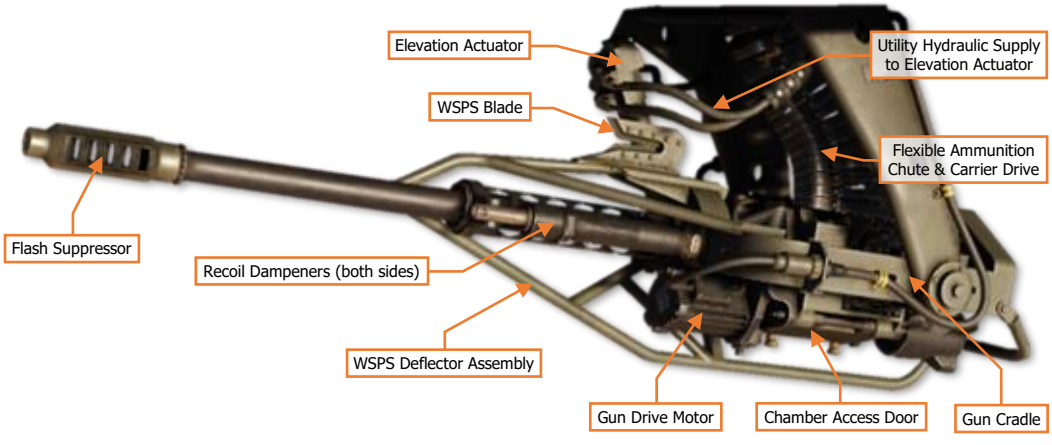
The gun may be used in the normal "flex gun" mode (NORM mode) in which the gun turret is articulated to match the ballistic solution against the target location as calculated by the Weapon Processors; or in a forward-firing "fixed gun" mode (FXD mode) in which the gun is fixed to a ballistic solution of 1,575 meters directly in front of the aircraft, regardless of the selected sight or computed target location.

During major combat operations, the ammunition capacity of the Area Weapon System can hold up to 1,200 rounds if necessary. However, the ammunition magazine may be replaced with an Internal Auxiliary Fuel System (IAFS), which includes a reduced-size 30mm ammunition magazine but extends the range and endurance of the aircraft with an additional 100 gallons of fuel. The IAFS reduces the ammunition storage to just 25% of its full capacity, limiting the total rounds that may be carried to 300.

M230E1 30mm Automatic Gun

The M230 is a single-barrel, automatic chain gun which fires 30x113mm link-less ammunition. The M230 is designed as an anti-material and anti-personnel weapon, employing a high-explosive dual-purpose (HEDP) round that is capable of penetrating light armor while simultaneously producing fragmentation effects against unarmored vehicles or personnel.

As a chain gun, the weapon uses a rotating chain within the receiver assembly to cycle the internal action in loading the next round for firing and clearing the empty casing from the chamber after firing. This contrasts with other weapons which use the expanding gases from the round's explosive charge or the recoil of the round itself to cycle the internal action. The gun action is powered by an external drive motor which is supplied with aircraft electrical power.



The gun turret itself is steered using hydraulic pressure from the Utility hydraulic system and includes Wire Strike Protection System (WSPS) components. The WSPS is intended to divert or sever high-tension wires that may be inadvertently encountered by the aircraft during low-level operations, especially during hours of darkness. The M230 is intended as a "low-signature weapon", in which tracer rounds are not utilized and the gun barrel is equipped with a flash suppressor to reduce visual detection during operations at night.

The M230 has an approximate rate of fire of 625 (±25) rounds per minute, but this may vary slightly between individual aircraft. Two types of ammunition may be employed, each with identical ballistic characteristics.

M789 High-Explosive Dual-Purpose (HEDP). The M789 round uses a shaped charge surrounded by a steel case to provide armor penetration and fragmentation effects.

US Army photo by MAJ Enrique Vasquez

M788 Training/Practice (TP). The M788 round uses an inert round casing with an aluminum tip to simulate the ballistic characteristics of the M789 during live-fire training and exercises.

US Army photo by SGT Sarah Sangster

The M789 and M788 rounds have a relatively low muzzle velocity. As such, they are ill-suited for long-range precision engagements, with an effective range of approximately 1,500 meters; although the AH-64 fire control system will calculate a ballistic solution for the M230 out to 4,200 meters.

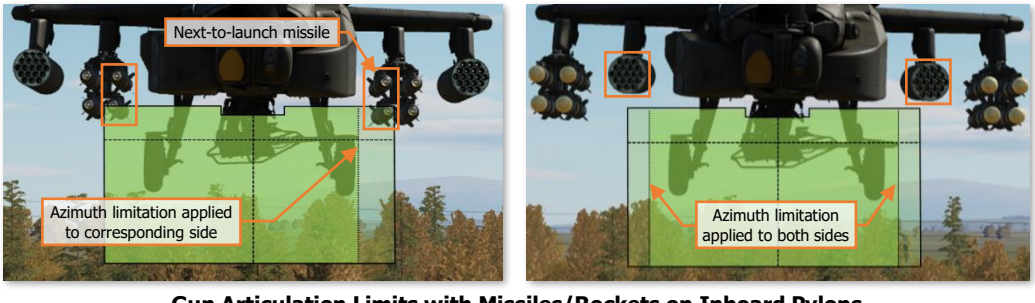
Gun Articulation Limits

The AWS turret can articulate through a maximum range of ±86° in azimuth and +11°/-60° in elevation. However, additional limitations are automatically applied to the turret based on specific conditions.

- If the gun azimuth is within ±10° of the aircraft centerline, the elevation is limited to +9°. This limitation does not apply when the gun is de-actioned and the gun is stowed at +11° in elevation.
- If the aircraft is on the ground (weight-on-wheels), the elevation is limited to -6.45°.

Gun Articulation Limits

- If the gun is actioned while the missiles are also actioned, and the next-to-launch missile is on an inboard launcher rail of an inboard pylon, the gun azimuth will be limited to 52° on the corresponding side of the aircraft to prevent the missile from colliding with the gun barrel.
- If the gun is actioned while the rockets are also actioned, and rocket launchers are installed on the inboard pylons, the gun azimuth will be limited to ±60° to either side to prevent the rockets from colliding with the gun barrel.



Gun Articulation Limits with Missiles/Rockets on Inboard Pylons

Gun Weapon Inhibits

The following conditions will inhibit the gun from being fired or interrupt the firing of the gun if already in in progress. Performance inhibits may be overridden by pulling the trigger to the 2nd detent. Safety inhibits cannot be overridden.

Performance Inhibits

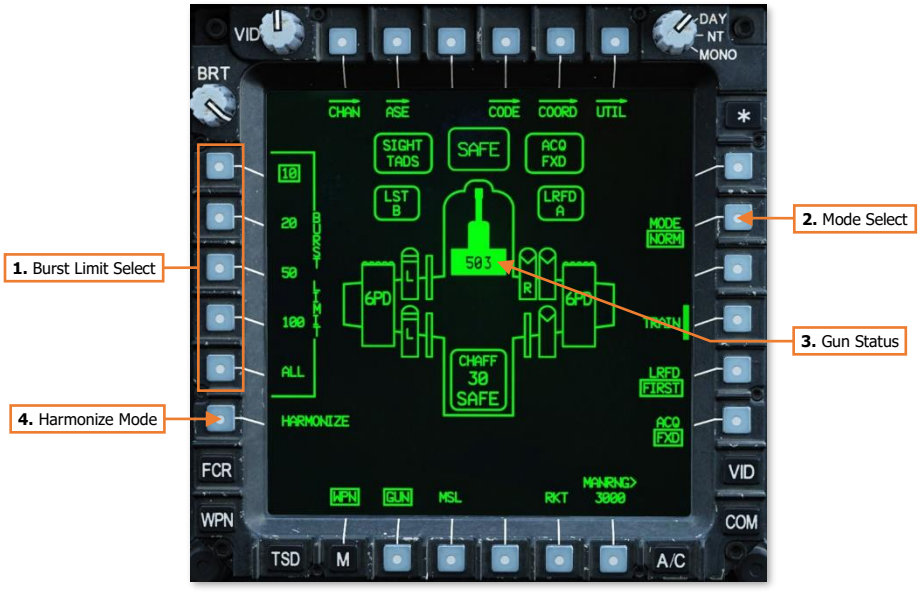
INHIBIT	CONDITION	CORRECTIVE ACTION
BAL LIMIT	The required weapon aiming solution exceeds the ballistics processing capability.	If tactically feasible, engage the target at a closer range.

Safety Inhibits

INHIBIT	CONDITION	CORRECTIVE ACTION
ALT LAUNCH	A missile launch or a rocket salvo is already in progress.	The gun may be fired 2 seconds after the missile launch or rocket salvo is complete.
AZ LIMIT	The gun turret is at an azimuth limit and cannot reach the weapon aiming solution.	Adjust the aircraft heading as necessary to bring the weapon aiming solution within the azimuth limits of the gun turret.
COINCIDENCE	The gun is out of coincidence from the weapon aiming solution.	Wait for the gun to reach the weapon aiming solution. If inhibit message remains, the gun may have experienced a failure and should be de-actioned.
EL LIMIT	The gun turret is at an elevation limit and cannot reach the weapon aiming solution.	Adjust the aircraft pitch attitude as necessary to bring the weapon aiming solution within the elevation limits of the gun turret (e.g., pitch the nose up when engaging a target at long range).
LOS INVALID	The line-of-sight of the selected sight is invalid or has failed; and cannot provide a weapon aiming solution to the gun.	Select a different sight for engagement. If using HMD as the sight and the LOS Reticle is flashing, adjust the helmet position to within the slew limits of the assigned NVS sensor (PNVS or TADS).
SAFE	The master armament state is currently set to SAFE; weapons cannot be fired.	Set the A/S button on the Armament Panel to ARM.

WPN Gun (GUN) Format

When the gun is selected for employment within the crewstation, the WPN page will be set to GUN format.



1. **Burst Limit Select.** Displays the quantity of 30mm rounds that will be fired each time the weapon trigger is pulled and held. When the burst limit is reached, a subsequent trigger pull is required to fire a subsequent burst. This setting is independent between crewstations.
   - **10.** Gun burst is limited to 10 rounds of ammunition.
   - **20.** Gun burst is limited to 20 rounds of ammunition.
   - **50.** Gun burst is limited to 50 rounds of ammunition.
   - **100.** Gun burst is limited to 100 rounds of ammunition.
   - **ALL.** The gun will continuously fire until the ammunition is depleted.
2. **Mode Select.** Displays the selected firing mode of the gun. This setting is independent between crewstations.
   - **NORM.** The gun turret is articulated to match the weapon aiming solution derived from the crewmember's selected sight and range source, as calculated by the Weapon Processors.
   - **FXD.** The gun turret is fixed forward to a weapon aiming solution directly in front of the aircraft at a range of 1,575 meters, regardless of the selected sight or range source.
3. **Gun Status.** Displays the status of the gun and the remaining quantity of ammunition on board the aircraft.
4. **Harmonize Mode (CPG Only).** Not implemented.

Gun Weapon Status Messages

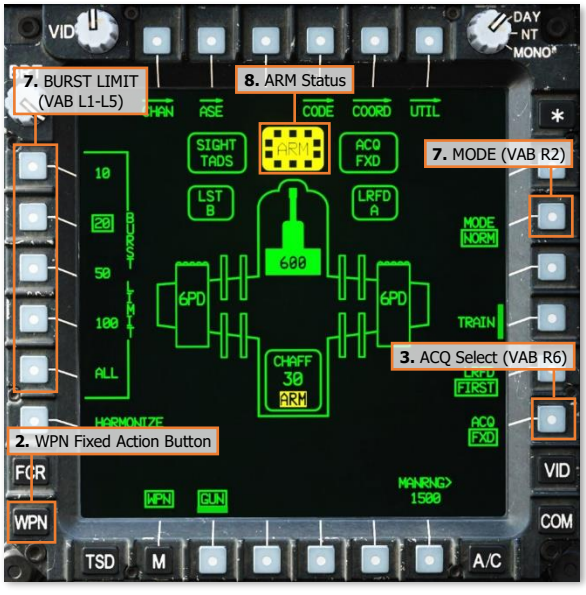
The following messages will be displayed in the High Action Display based on current gun status or weapon page settings when the gun is actioned.

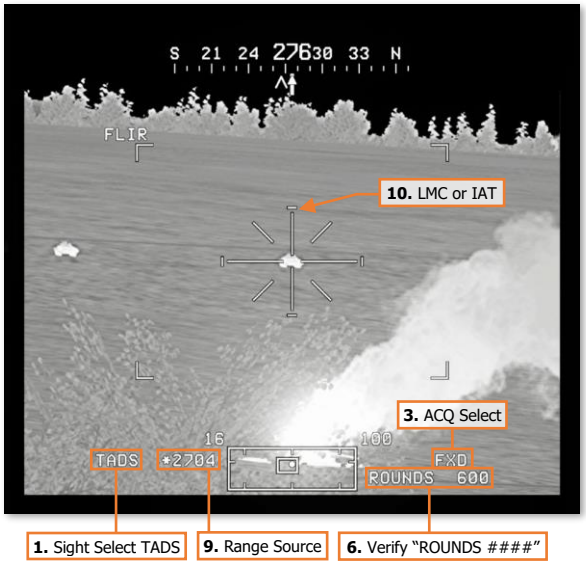
WEAPON STATUS	CONDITION
ROUNDS ####	The gun is actioned and the number of remaining rounds onboard is displayed.
WEAPON?	The weapon trigger has been pulled but no weapon has been actioned.

Gun Engagement using TADS (NORM Mode)

When employing the AWS with the TADS, ballistic compensation for aircraft linear velocities and environmental factors is automatically calculated. If the target is moving, continuous laser designation via the 2nd detent of the laser trigger should be used to incorporate the Target State Estimator (TSE) for lead-angle compensation. TADS LMC and/or IAT may also be used to assist the CPG in stabilizing the TADS LOS Reticle on the target.

To engage a target from the CPG crewstation while using the TADS as the selected sight:





1. CPG Sight Select switch – TADS. (TEDAC Right Handgrip)
2. CPG WPN Fixed Action Button – Press.
3. CPG **(Optional)** Determine the appropriate acquisition source (ACQ) for acquiring the target.
   - If the target is visually acquired by either crewmember, set ACQ to PHS or GHS.
   - If the target is stored as a point within the navigational database, set ACQ to the corresponding point.
4. CPG **(Optional)** SLAVE button – Press, and then press again to de-slave when the TADS has finished slewing.
5. CPG Weapon Action Switch (WAS) – Forward. (TEDAC Left Handgrip)
6. CPG Weapon Status – Verify "ROUNDS ####". (High Action Display)
7. CPG Weapon settings – Verify or select. (WPN page)
   - BURST LIMIT (VAB L1-L5) – Select as desired.
   - MODE (VAB R2) – Select NORM.
8. CPG A/S button – Verified in ARM. (Armament Panel)
9. CPG Range source – Verify or select: Laser, Navigation, Auto, or Manual. (TADS Acquisition and Ranging)
10. CPG If the target or aircraft are moving, engage TADS targeting modes to stabilize the TADS on target.
    - Manual tracking - Engage LMC and employ the Sight Manual Tracker.
    - Automatic tracking - Engage IAT.

11. CPG LRFD Trigger – Pull, if laser ranging is desired. (TEDAC Right Handgrip)

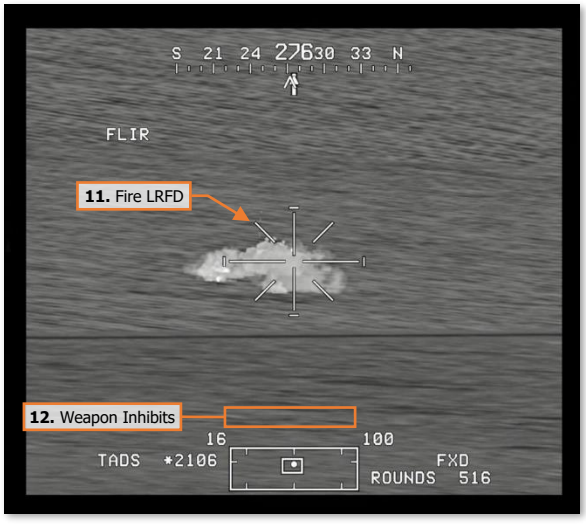
- Target and aircraft are stationary – LRFD trigger, 1st detent, may be pulled momentarily (ranging).
- Target or aircraft are moving – LRFD trigger, 2nd detent, should be pulled and held (designation).

12. CPG Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- COINCIDENCE
- AZ LIMIT
- EL LIMIT
- BAL LIMIT

13. CPG Weapon Trigger – Pull and hold for duration of burst. (TEDAC Left Handgrip)

14. CPG Observe for round impacts – Adjust the TADS LOS Reticle aimpoint and repeat bursts on target as necessary until target effects are achieved.



Gun Engagement using FCR (NORM Mode)

When employing the AWS with the FCR, the NTS target is used for calculating the weapon aiming solution for the AWS turret. Ballistic compensation for aircraft linear velocities and environmental factors is automatically calculated. If the target is moving, the target should be engaged in as short amount of time possible following the completion of the FCR scan to ensure the lead-angle compensation to the target is accurate.

To engage a target from either crewstation while using the FCR as the selected sight:

1. Sight Select switch – FCR. (Collective Mission Grip or TEDAC Right Handgrip)

2. NTS (VAB L1) – Select to advance NTS to desired target for engagement.

or

2. MPD Cursor Controller/Enter – Select desired target for engagement.

3. Weapon Action Switch (WAS) – Forward. (Cyclic Grip or TEDAC Left Handgrip)

4. Weapon Status – Verify "ROUNDS ####". (High Action Display)

5. WPN Fixed Action Button – Press.

6. Weapon settings – Verify or select.

- BURST LIMIT (VAB L1-L5) – Select as desired.
- MODE (VAB R2) – Select NORM.

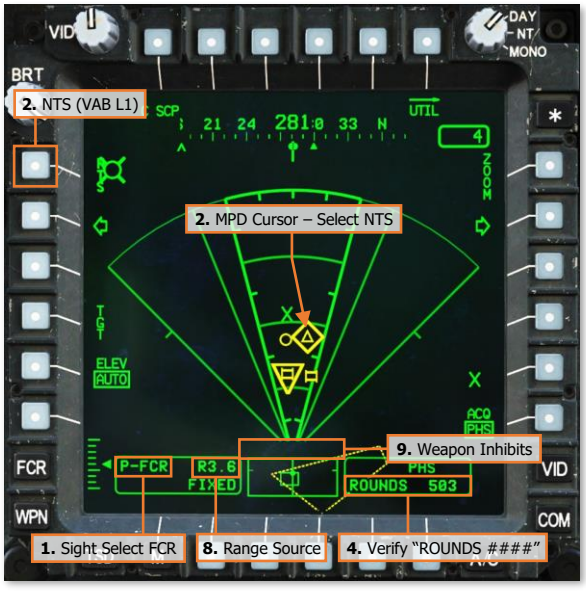
7. A/S button – Verify ARM is illuminated. (Armament Panel)

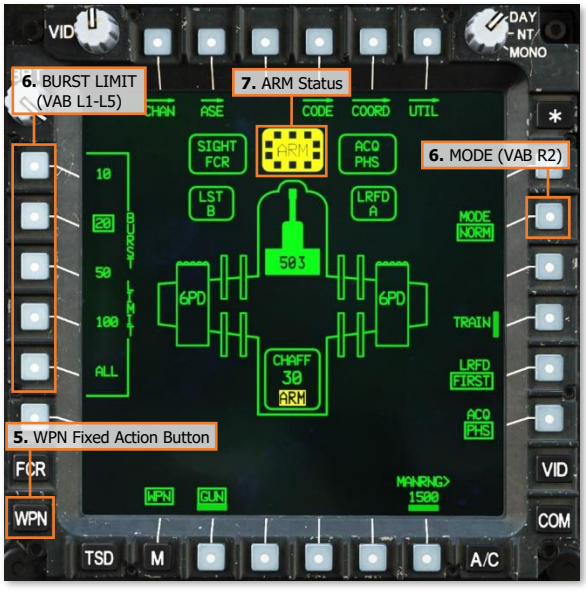
8. Range source – Verify Radar range is within appropriate engagement range.

9. Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- COINCIDENCE
- AZ LIMIT
- EL LIMIT
- BAL LIMIT

10. Weapon Trigger – Pull and hold for duration of burst. (Cyclic Grip or TEDAC Left Handgrip)





Gun Engagement using HMD (NORM Mode)

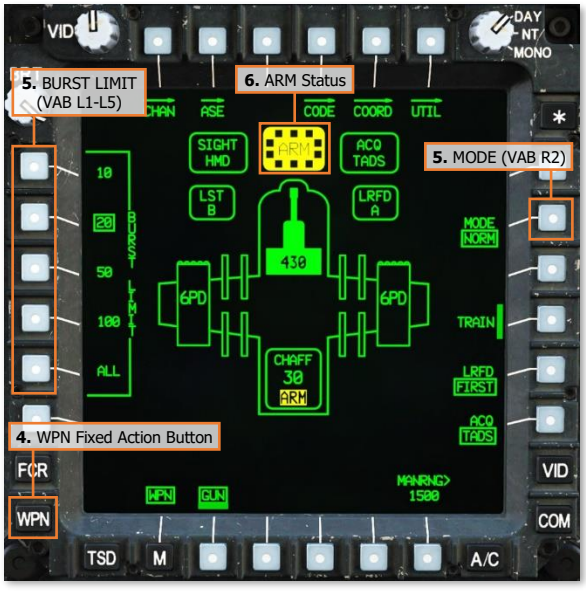
When employing the AWS with the HMD, the gun can be used to rapidly suppress close-in threats to the aircraft. However, unlike the TADS, the HMD does not provide any ballistic compensation for the gun with the exception of range compensation. Lead angle and other linear velocity compensations must be manually provided by the crewmember by adjusting the LOS Reticle of the HMD accordingly.

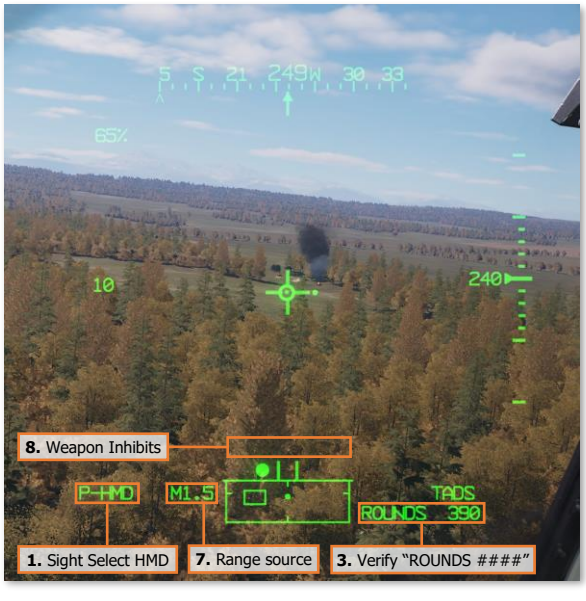
To engage a target from either crewstation while using the HMD as the selected sight:

1. Sight Select switch – HMD. (Cyclic Grip or TEDAC Right Handgrip)
2. Weapon Action Switch (WAS) – Forward. (Cyclic Grip or TEDAC Left Handgrip)

   NOTE: The range source will be automatically set to Manual range based on the WPN page MANRNG> value.
3. Weapon Status – Verify "ROUNDS ####". (High Action Display)
4. WPN Fixed Action Button – Press.
5. Weapon settings – Verify or select.
   - BURST LIMIT (VAB L1-L5) – Select as desired.
   - MODE (VAB R2) – Select NORM.
6. A/S button – Verify ARM is illuminated. (Armament Panel)
7. Range source – Verify or select: Navigation, Auto, or Manual. (HMD Acquisition and Ranging)
8. Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:
   - COINCIDENCE
   - AZ LIMIT
   - EL LIMIT
   - BAL LIMIT
9. Weapon Trigger – Pull and hold for duration of burst. (Cyclic Grip or TEDAC Left Handgrip)

   NOTE: If the CPG actions the gun from the Cyclic Grip, the cyclic weapon trigger must be used. If the CPG actions the gun from the TEDAC Left Handgrip, the TEDAC weapon trigger must be used.
10. Observe for round impacts – Adjust the HMD LOS Reticle aimpoint and repeat bursts on target as necessary until weapon effects are achieved.



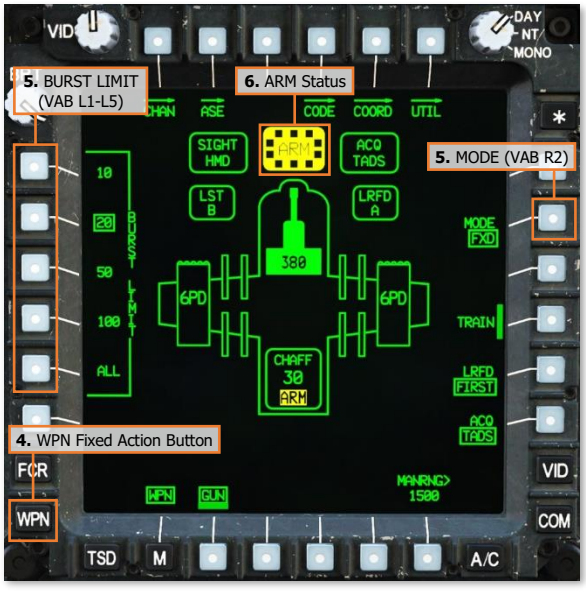


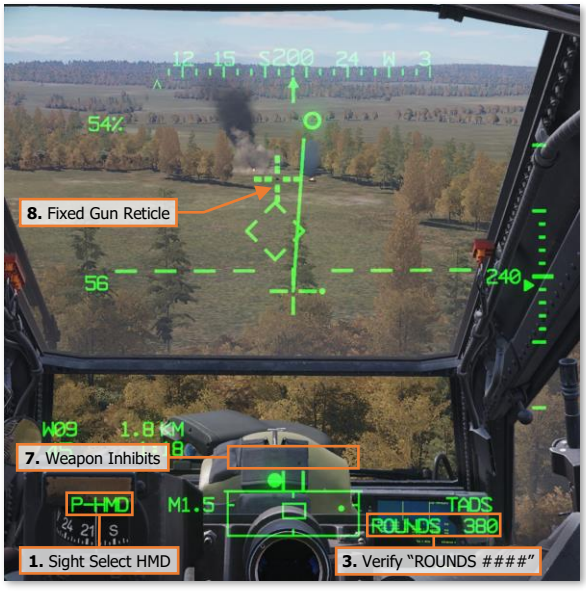
Gun Engagement using HMD (FXD Mode)

When employing the AWS in Fixed mode, the gun is fixed forward at a ballistic solution of 1,575 meters, requiring the pilot to maneuver the aircraft to aim the gun at the target. The Fixed Gun Reticle is identical to the Cued LOS Reticle of the acquisition source (ACQ) and represents the virtual location in front of the aircraft that coincides with the 1,575-meter ballistic solution.

To engage a target from either crewstation while using the gun in Fixed mode and the HMD as the selected sight:

1. Sight Select switch – HMD. (Cyclic Grip)
2. Weapon Action Switch (WAS) – Forward. (Cyclic Grip)
3. Weapon Status – Verify "ROUNDS ####". (High Action Display)
4. WPN Fixed Action Button – Press.
5. Weapon settings – Verify or select. (WPN page)
   - BURST LIMIT (VAB L1-L5) – Select as desired.
   - MODE (VAB R2) – Select FXD.
6. A/S button – Verify ARM is illuminated. (Armament Panel)
7. Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:
   - COINCIDENCE
8. Maneuver aircraft to adjust the HMD Fixed Gun Reticle aimpoint as necessary.
9. Weapon Trigger – Pull and hold for duration of burst. (Cyclic Grip)
10. Observe for round impacts – Maneuver aircraft to adjust the HMD Fixed Gun Reticle aimpoint and repeat bursts on target as necessary until weapon effects are achieved.





AERIAL ROCKET SUB-SYSTEM (ARS)

The Aerial Rocket Sub-system is an aerial rocket bombardment system designed for engaging or suppressing area targets at long range and is effective against groups of vehicles or personnel in the open.

The ARS consists of up to four M261 rocket launchers (also called "rocket pods"), which are capable of firing 2.75-inch unguided rockets of the Hydra-70 rocket family. Each 19-tube pod is "zoned", which permits the carriage of up to three different warhead types when a single pair of launchers are used, or up to five different warhead types when two pairs of launchers are used. Single rocket pods may also be loaded if desired, in the case of reducing overall gross weight as necessary.

Rockets may be employed "independently" by either crewmember when using the HMD or FCR as the selected sight; or by both crewmembers in a "cooperative" manner in which the Pilot aligns the aircraft with the ballistic solution calculated by the CPG's selected sight (usually the TADS).

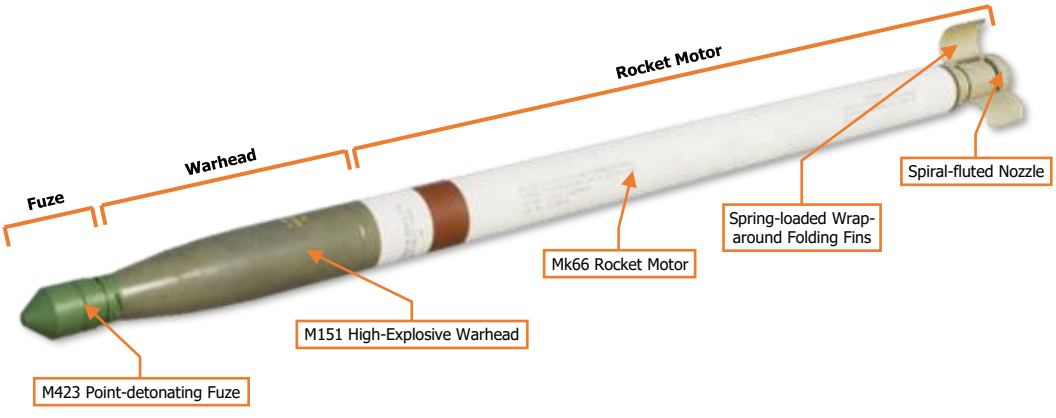
When employed using the HMD as the selected sight, rocket engagements are typically performed at speeds above effective translational lift (ETL), using forward airspeed to increase the stability of the aircraft. These engagements are performed using weapon delivery techniques known as "running fire" or "diving fire", which improves the accuracy of unguided munitions such as rockets. (See Weapon Delivery Techniques for more information.)

When employed using the TADS or FCR as the selected sight, rocket engagements may be performed using a third weapon delivery technique known as "hover fire", in which the aircraft remains stationary while employing unguided rockets against area targets. These engagements may be used in either a "direct fire" mode, in which the target location is directly sighted by the TADS when making aiming adjustments; or an "indirect fire" mode, in which the TADS is slaved to a 3-dimensional target location previously stored using the TADS, detected by the FCR, received via the datalink, or manually input by the aircrew, and the rockets are launched from behind cover without having a direct line-of-sight to the target area.

Hydra-70 2.75-inch Unguided Rockets

Unguided rockets have been in use by military helicopters for decades, with the first large-scale use by UH-1 and AH-1 helicopters during the Vietnam War of the 1960's and early 1970's. Although fire control systems in various military fixed-wing aircraft and helicopters have advanced in accuracy and sophistication, the overall design of the rockets themselves has remained comparatively simple with few changes.

The most commonly used rocket motor by the U.S. Army during the Vietnam War was the Mk40 FFAR (Folding Fin Aerial Rocket), itself derived from the World War 2-era "Mighty Mouse" aerial rocket. The Mk40 was a tube-launched, solid-propellant rocket motor 2.75 inches (70mm) in diameter, with four stabilizing fins that would deploy once the rocket had been expelled from its launcher. The Mk40 rocket motor could be fitted with a variety of compatible warheads, including high-explosives, white phosphorus for target marking, or even flechette-dispensing warheads for anti-personnel.



The Mk66 rocket motor was later developed and gradually replaced the Mk40 as the principal rocket motor for Hydra-70 rocket systems in the U.S. military. The Mk66 included a revised "wrap-around folding fin" design and a more powerful rocket motor with an increased propellant load, allowing it to be employed against targets as far as 7,500 meters. The rocket propellant is expelled through a spiral-fluted nozzle that generates a spinning motion to increase the ballistic stability and accuracy of the rocket after launch. Like the previous Mk40 rocket motors, the Mk66 is compatible with a large number of the same 2.75-inch diameter warheads.

Weapon designations of the Hydra family of rockets are typically denoted by the installed warheads, despite being composed of three distinct components to include the Mk66 rocket motor, warhead, and fuze. Depending on the specific warhead that is installed on the rocket, some fuzes are integrated within the warhead itself while others may be fitted with an external fuze option.

Compatible fuzes are grouped into three categories, based on their method of function. Rocket warheads that may employ these types of fuzes are listed below within each applicable fuze category.

Point-Detonating Fuze

Initiates upon impact.

- **M151** High Explosive
- **M229** High Explosive
- **M274** Training Smoke
- **M156** WP Smoke

Variable Delay Fuze

Initiates based on target range or a variable time delay after impact.

- **M151** High Explosive
- **M229** High Explosive
- **M255A1** Flechette
- **M261** MP Sub-Munition
- **M264** RP Smoke

Fixed Delay Fuze

Initiates based on a fixed time delay after launch.

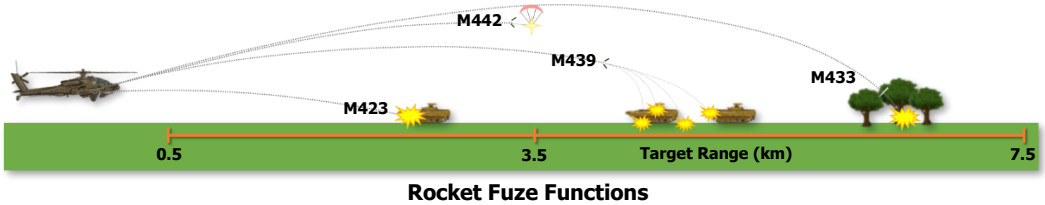
- **M257** Illumination
- **M258** IR Illumination

M423 Point-Detonating (PD) Fuze. The M423 fuze initiates the warhead charge immediately upon impact with any solid surface. This fuze is the most commonly used by M151 and M229 high-explosive warheads, but is also used by the M156 white phosphorus smoke rocket for target marking and by the M274 training rocket.

M433 Resistance Capacitance (RC) Fuze. The M433 is a variable-time delay fuze that uses an electrical charge delivered by the launching aircraft to set the desired time delay based on the specific cockpit selection. The fuze is activated upon impact with a solid surface and initiates the warhead charge after a brief delay, allowing the warhead to penetrate obstructions prior to detonation. This fuze is not commonly used but could be employed to increase the penetration of high-explosive warheads through dense foliage or defensive fortifications.

M439 Air Burst Fuze. The M439 is a variable-time delay fuze that uses an electrical charge delivered by the launching aircraft to set the desired time delay based on the specific cockpit selection. The fuze is activated upon launch and initiates the warhead charge after a delay, allowing the warhead to reach a pre-determined range along its trajectory prior to detonation or delivery of the warhead contents. This fuze is integrated into the M255A1 Flechette, M261 Multi-Purpose Sub-Munition (MPSM), and M264 red phosphorus smoke rockets.

M442 Cargo Fuze. The M442 is a fixed-time delay fuze that initiates the warhead charge approximately 9 seconds following rocket motor burnout. The combined flight time of the rocket motor burn and the subsequent fuze delay deploys the warhead contents approximately 3,500 meters from the launch point and is integrated into the M257 and M278 battlefield illumination rockets.

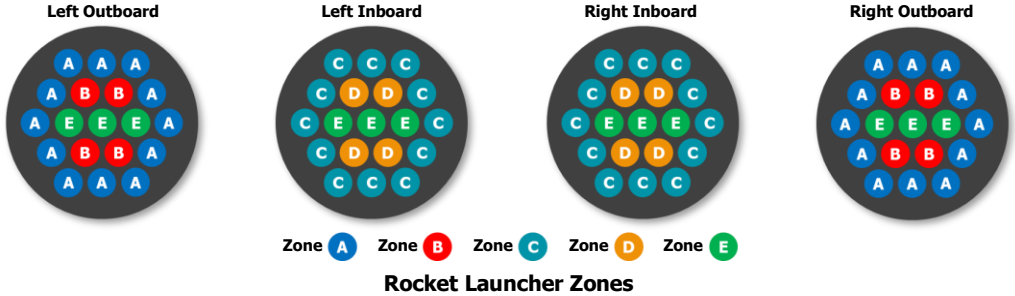


Rocket Fuze Functions

Rocket Launcher Zones

The AH-64 is capable of employing up to five unique rocket warhead types when loaded with four M261 rocket launchers. Each of the 19 individual rocket tubes of each M261 launcher is equipped with independent firing and fuzing circuits, which allow the rockets to be selectively fired based on which tube is physically occupied by a rocket and which warhead "zone" the tube is assigned.

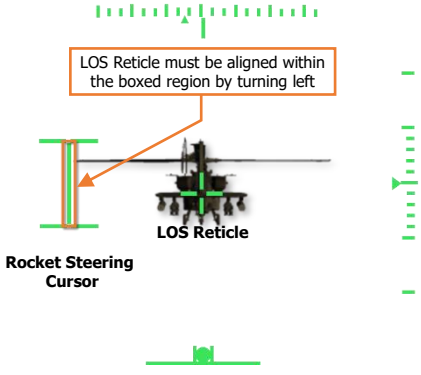
Each zone is permanently allocated to each of the four wing pylons, meaning that zones A and B will only be assigned to M261 launchers mounted under the outboard wing pylons, and zones C and D will only be assigned to launchers mounted under the inboard wing pylons. However, zone E will always be assigned to the center three tubes of any installed launchers.



Rocket Launcher Zones

Rocket Steering Cursor

The Aerial Rocket Sub-system (ARS) enables accurate delivery of massed fires against area targets and provides an AH-64 team with a direct and indirect fire capability akin to a light rocket artillery battery. The fire control system of the AH-64 calculates ballistic trajectories of 2.75-inch unguided rockets out to a range of 7,500 meters, and at such distances most vehicle-sized targets would be difficult to visually acquire, depending on the nature of the terrain. If a target could be seen at such a distance, direct aiming devices would be inadequate in providing the level of aiming precision that would be necessary to ensure unguided munitions, even an area effect weapon such as unguided rockets, could be delivered in the vicinity of the target. This would preclude the use of direct sighting methods such as a Continuously Computed Impact Point (CCIP) or any other reticle that would require adjustments to an aimpoint toward distant target locations.



The key piece of symbology associated with employing rockets is the Rocket Steering Cursor, an I-beam shaped symbol displayed within the crewmembers' sight symbology. The Rocket Steering Cursor is a steering cue which indicates the required position that the nose of the aircraft must be placed in azimuth and elevation, taking into account the limited articulation range of the pylons. When the symbology LOS Reticle is aligned along the "I-beam" between the upper and lower limits of the Rocket Steering Cursor, the aircraft is positioned in which the calculated weapon aiming solution against the intended target is within the articulation range of the wing pylons.

The Rocket Steering Cursor is longitudinally-scaled and is *not* a virtual symbology element; its displayed location does not correspond with a real-world location that is observed "out-the-window" like the Head Tracker or Flight Path Vector. This removes the limitations of direct sighting against long-range targets and allows the AH-64 to employ unguided rockets from behind cover when the aircraft may not have a direct line-of-sight to the target location. This capability facilitates indirect fire against target locations that have been handed off to the AH-64 aircrew from another platform such as another AH-64 team member, a scout helicopter, or friendly ground forces.

To aid the aircrew in aligning the rocket launchers with the calculated weapon aiming solution, the weapon pylons themselves articulate in the vertical axis to account for target range and the pitch attitude of the helicopter at a given airspeed. The pylons have an articulation range of +4° to -15° relative to the Aircraft Datum Line (ADL), which represents the longitudinal axis of the fuselage.

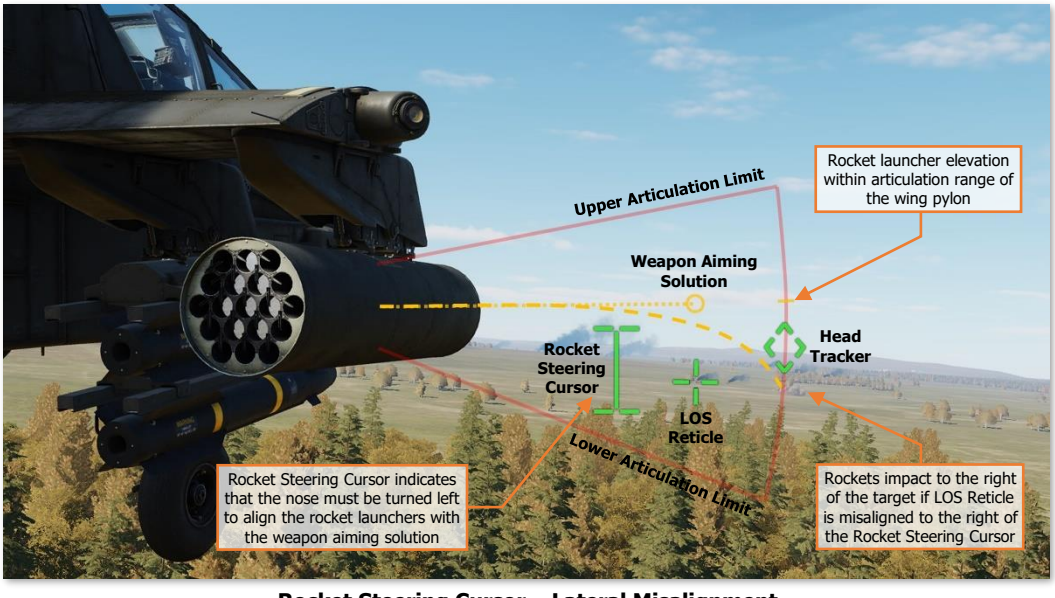
Pylon Articulation Limits

The Head Tracker symbol within the IHADSS Flight symbology is displayed at -4.9° relative to the ADL. In a stable hover with no winds, or when landed, the Head Tracker will be level with the horizon; and is at an approximate mid-point between the upper and lower articulation limits of the pylons.

Rocket Steering Cursor Alignment

The Rocket Steering Cursor is longitudinally positioned within the symbology based on the position of the weapon aiming solution relative to the nose of the aircraft, which is represented by the LOS Reticle. If the Rocket Steering Cursor is displayed to the left of the LOS Reticle, the heading of the aircraft should be adjusted to the left until the Rocket Steering Cursor is aligned with the LOS Reticle, and vice versa if the Rocket Steering Cursor is to the right of the LOS Reticle.

In the example below, the sight's LOS Reticle has been placed over a group of vehicles approximately 3 kilometers away. The LOS Reticle is being used to designate the target location and is also being used to represent the nose of the aircraft as a reference point from which the Rocket Steering Cursor is being displayed. While the Head Tracker is a virtual symbology element representing the real-world position of the aircraft nose, the Rocket Steering Cursor is a longitudinally-scaled symbology element that is displayed relative to the LOS Reticle. As a result, the Rocket Steering Cursor is indicating to the Pilot that the nose of the aircraft must be steered to the left to align the rocket launchers with the weapon aiming solution.



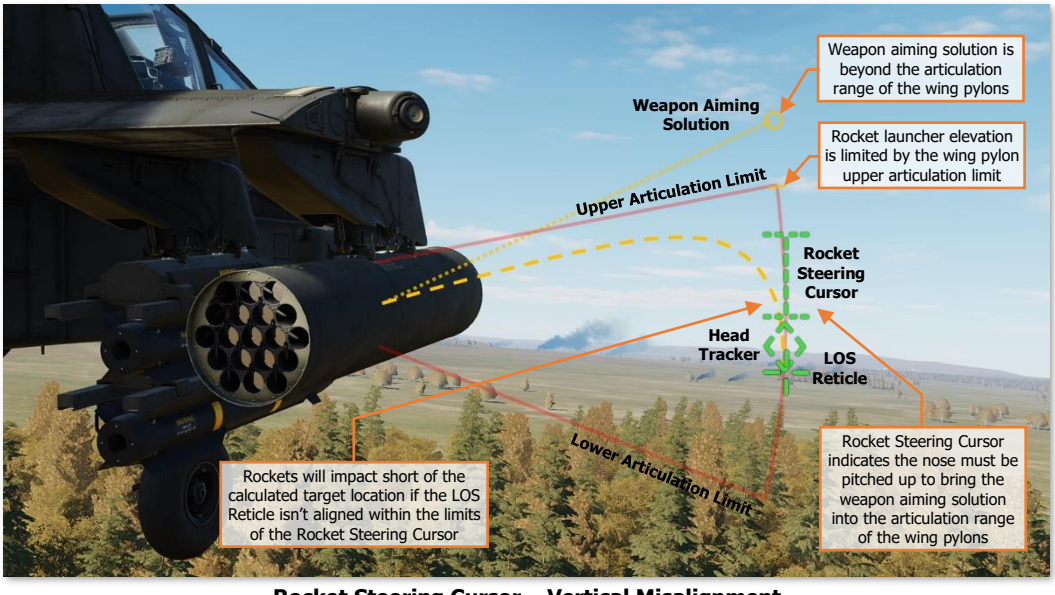
Rocket Steering Cursor – Lateral Misalignment

In this scenario, the LOS Reticle is vertically aligned between the upper and lower limits of the Rocket Steering Cursor, indicating that the weapon aiming solution is within the articulation range of the wing pylons. However, the LOS Reticle is laterally misaligned to the right from the Rocket Steering Cursor, indicating the rockets will impact to the right of the intended target. If the rockets were fired under these conditions, they would impact to the right of the target but would be at the correct range (assuming the ranging data being used by the selected sight is accurate).

To correct lateral misalignment of the Rocket Steering Cursor, the Pilot should turn in the direction of the Rocket Steering Cursor until the LOS Reticle is aligned along the vertical axis of the "I-beam". If in a hover or at low speeds near hover, the Pilot should use the pedals to yaw the aircraft in the direction of the Rocket Steering Cursor. If in forward flight, the Pilot should use the cyclic to bank the aircraft in the direction of the Rocket Steering Cursor while adjusting the pedals to keep the skid/slip indicator ("trim ball") centered.

In the next example below, the sight's LOS Reticle has been placed over a group of vehicles approximately 6 kilometers away, and the aircraft nose is correctly aligned with the weapon aiming solution. However, due to the range between the aircraft and the targets, the weapon aiming solution is beyond the articulation range of the wing pylons. As a result, the Rocket Steering Cursor is indicating to the Pilot that the nose of the aircraft must be elevated to align the rocket launchers with the weapon aiming solution.

In addition, the Rocket Steering Cursor itself is dashed to indicate that a weapon inhibit exists, in this case a performance inhibit, accompanied by the "PYLON LIMIT" inhibit message displayed within the symbology. (See Rocket Steering Cursor Format on the following page for more information.)



Rocket Steering Cursor – Vertical Misalignment

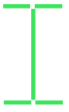
In this scenario, the LOS Reticle is laterally aligned with the Rocket Steering Cursor, indicating that the aircraft is on the correct heading for an accurate rocket delivery. However, the LOS Reticle is vertically misaligned below the Rocket Steering Cursor. If the rockets were fired under these conditions, their ballistic trajectory would be insufficient to achieve the required range and would impact the ground prior to reaching the target.

To correct vertical misalignment of the Rocket Steering Cursor, the Pilot should use the cyclic to adjust the pitch attitude of the aircraft in the direction of the Rocket Steering Cursor until the LOS Reticle is aligned between the upper and lower limits of the "I-beam". This technique uses the pitch attitude of the helicopter to augment the elevation of the rocket launchers and is called "super-elevating".

If in a hover or at low speeds near hover, the Pilot should use caution when super-elevating the nose near obstacles as the pitch-up attitude will induce a backwards acceleration. If sufficient maneuver area is available, it may be advisable to gain some forward speed prior to performing a "super-elevation maneuver" for long-range rocket delivery. Forward airspeeds also increase airflow over the tail, providing the added benefit of improving the helicopter's stability, which will enhance the accuracy of unguided munitions.

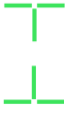
Rocket Steering Cursor Format

The Rocket Steering Cursor is displayed in four formats to indicate whether the weapon aiming solution is within the articulation range of the wing pylons (Valid or Invalid) and the current pylon state (Normal or Ground Stow).



Valid Rocket Steering Cursor (NORM)

Invalid Rocket Steering Cursor (NORM)



Valid Rocket Steering Cursor (GND STOW)

Invalid Rocket Steering Cursor (GND STOW)

If the weapon aiming solution is within the articulation range of the wing pylons and no Weapon Inhibit messages are displayed within the High Action Display, the Rocket Steering Cursor will be displayed as Valid.

If the weapon aiming solution is beyond the articulation range of the wing pylons or any Weapon Inhibit messages are displayed within the High Action Display, the Rocket Steering Cursor will be displayed as Invalid.

If Ground Stow (GND STOW) is disabled on the WPN Utility sub-page, enabling normal articulation functions of the wing pylons, the Rocket Steering Cursor will be displayed as a continuous "I-beam" symbol.

If Ground Stow (GND STOW) is enabled on the WPN Utility sub-page, disabling the normal articulation functions of the wing pylons and setting the pylons to -5° relative to the Aircraft Datum Line (coincident with the Head Tracker symbol within the HMD Flight symbology), the Rocket Steering Cursor will be displayed as a broken "I-beam" symbol.

NOTE: When the Rocket Steering Cursor is displayed in the GND STOW format, the broken "I-beam" symbol will remain referenced from the LOS Reticle based on the calculated weapon aiming solution.

Rocket Weapon Inhibits

The following conditions will inhibit the rockets from being fired or interrupt the firing of the rockets if already in in progress. Performance inhibits may be overridden by pulling the trigger to the 2nd detent. Safety inhibits cannot be overridden.

Performance Inhibits

INHIBIT	CONDITION	CORRECTIVE ACTION
BAL LIMIT	The required weapon aiming solution exceeds the ballistics processing capability.	If tactically feasible, engage the target at a closer range.
PYLON LIMIT (IN FLIGHT)	The commanded position of the rocket launcher(s) exceeds the pylon articulation limits. (+4° to -15°).	Adjust the aircraft pitch attitude as necessary to bring the weapon aiming solution within the articulation range of the wing pylons (e.g., pitch the nose toward the Rocket Steering Cursor).

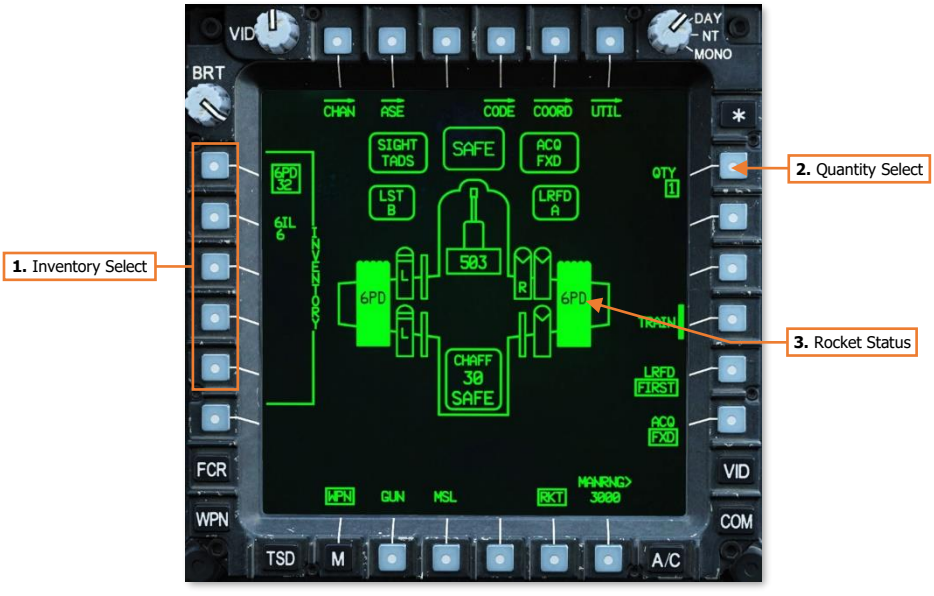
Safety Inhibits

INHIBIT	CONDITION	CORRECTIVE ACTION
ACCEL LIMIT	Vertical acceleration is <0.5 G; the main rotor blades may obstruct the trajectory of the rockets when fired.	Reduce the severity of the current maneuver to increase the positive G load on the aircraft.
ALT LAUNCH	A missile launch is already in progress.	The rockets may be fired 2 seconds after the missile launch is complete.

GUN OBSTRUCT	The gun is out of coincidence from the weapon aiming solution and may obstruct the trajectory of rockets fired from the inboard wing pylons.	If tactically feasible, instruct the crewmember that has actioned the gun to de-action in order to permit the firing of rockets.
LOS INVALID	The line-of-sight of the selected sight is invalid or has failed; and cannot provide a weapon aiming solution to the gun.	Select a different sight for engagement. If using HMD as the sight and the LOS Reticle is flashing, adjust the helmet position to within the slew limits of the assigned NVS sensor (PNVS or TADS).
PYLON ERROR	Indicates that the pylon position is not equal to the commanded pylon position or the rocket launcher positions are unknown.	If inhibit message remains, the corresponding wing pylons may have experienced a failure. A different rocket warhead selection may be made (if available) on a different set of wing pylons; otherwise the rockets should be de-actioned.
PYLON LIMIT (ON GROUND)	The commanded position of the rocket launcher(s) exceeds the pylon articulation limits. (+4° to -5°).	Adjust the weapon aiming solution as necessary to that which may be utilized within the articulation range of the wing pylons.
SAFE	The master armament state is currently set to SAFE; weapons cannot be fired.	Set the A/S button on the Armament Panel to ARM.

WPN Rocket (RKT) Format

When rockets are selected for employment within the crewstation, the WPN page will be set to RKT format.



1. **Inventory Select.** Displays the available rocket warhead types and the remaining quantity onboard for each type. A rocket warhead type may be selected for employment using VAB L1-L5, with the current selection boxed. This setting is independent between crewstations unless COOP mode is entered.

   NOTE: All rocket zones that are loaded with the same warhead type are consolidated into a single selection.

2. **Quantity Select.** Displays the selected quantity of rockets that will be fired within a salvo. Selection of VAB R1 will display the Quantity Select menu that permits a different quantity to be selected. Available options are 1, 2, 4, 8, 16, 24 or ALL.

3. **Rocket Status.** Indicates a rocket launcher is installed onto the corresponding wing pylon. The launcher icon appearance and text label indicate the status and warhead inventory selection of the launcher.

Rocket Weapon Status Messages

The following messages will be displayed in the High Action Display based on current rocket status or weapon page settings when rockets are actioned.

WEAPON STATUS	CONDITION
LIMITS	The commanded position of the rocket launcher(s) exceeds the pylon articulation limits.
NO ROCKETS	Rockets are actioned but no rockets are available.
RKT G-S	Rockets are actioned. Ground stow is enabled on the WPN Utility sub-page and rocket launchers are not articulating.
RKT NORM	Rockets are actioned. Rocket launchers are articulating to the weapon aiming solution.
RKT TOF=##	The remaining time of flight (in seconds) for the most recent rocket salvo that has been fired.
TYPE?	Rockets are actioned but a rocket type has not been selected from the INVENTORY on the WPN page; or the previous type has been depleted and another rocket type must be selected.
WEAPON?	The weapon trigger has been pulled but no weapon has been actioned.

Rocket Engagement using TADS (Direct Fire in COOP Mode)

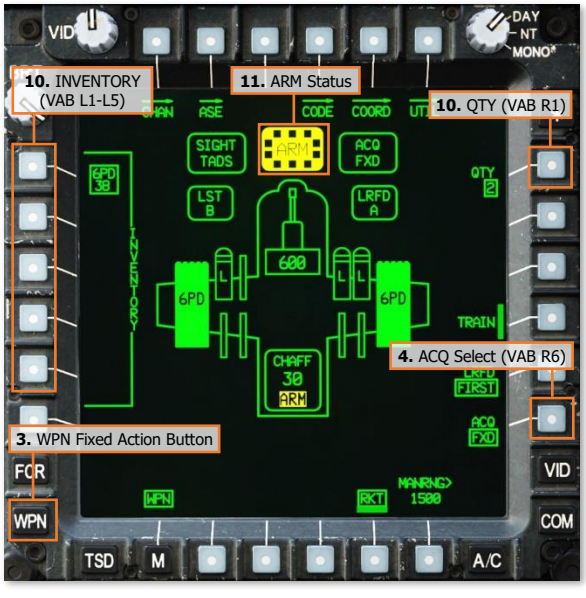
When employing unguided rockets in Cooperative (COOP) mode, the TADS is used by the CPG to calculate the weapon aiming solution while the Pilot maneuvers the aircraft to align the Rocket Steering Cursor. If the target is moving, continuous laser designation via the 2nd detent of the laser trigger should be used to incorporate the Target State Estimator (TSE) for lead-angle compensation. TADS LMC and/or IAT may also be used to assist the CPG in stabilizing the TADS LOS Reticle on the target.

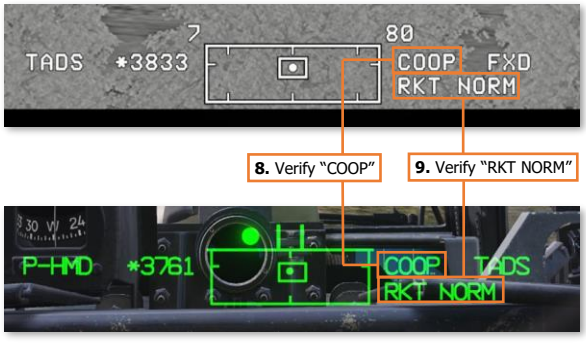
Cooperative mode can only be entered when the CPG actions rockets on the TEDAC Left Handgrip and the Pilot actions rockets on the Cyclic Grip.

When COOP mode is entered, the Pilot's WPN page settings in the RKT format will default to the setting s of the CPG. However, when in COOP mode, these settings are common between crewstations in that changing the INVENTORY (VAB L1-L5) or QTY (VAB R1) settings in one crewstation will change them in the other.

To engage a target with Direct Fire rockets in Cooperative mode, using the TADS as the selected sight:

1. PLT Sight Select switch – HMD. (Collective Mission Grip)
2. CPG Sight Select switch – TADS. (TEDAC Right Handgrip)
3. CPG WPN Fixed Action Button – Press.
4. CPG **(Optional)** Determine the appropriate acquisition source (ACQ) for acquiring the target.
   - If the target is visually acquired by either crewmember, set ACQ to PHS or GHS.
   - If the target is stored as a point within the navigational database, set ACQ to the corresponding point.
5. CPG **(Optional)** SLAVE button – Press, and then press again to de-slave when the TADS has finished slewing.
6. PLT Weapon Action switch (WAS) – Left. (Cyclic Grip)
7. CPG Weapon Action Switch (WAS) – Left. (TEDAC Left Handgrip)
8. PLT & CPG Weapon Control Status – Verify "COOP". (High Action Display)
9. PLT & CPG Weapon Status – Verify "RKT NORM". (High Action Display)
10. PLT / CPG Weapon settings – Verify or select. (WPN page)
    - © TYPE (VAB L1-L5) – Select as desired.
    - © QTY (VAB R1) – Select as desired.





11. CPG © A/S button – Verified in ARM. (Armament Panel)

12. CPG Range source – Verify or select: Laser, Navigation, Auto, or Manual. (TADS Acquisition and Ranging)

13. CPG If the target or aircraft are moving, engage TADS targeting modes to stabilize the TADS on target.

- Manual tracking - Engage LMC and employ the Sight Manual Tracker.
- Automatic tracking - Engage IAT.

14. CPG LRFD Trigger – Pull, if laser ranging is desired. (TEDAC Right Handgrip)

- Target and aircraft are stationary – LRFD trigger, 1st detent, may be pulled momentarily (ranging).
- Target or aircraft are moving – LRFD trigger, 2nd detent, should be pulled and held (designation).

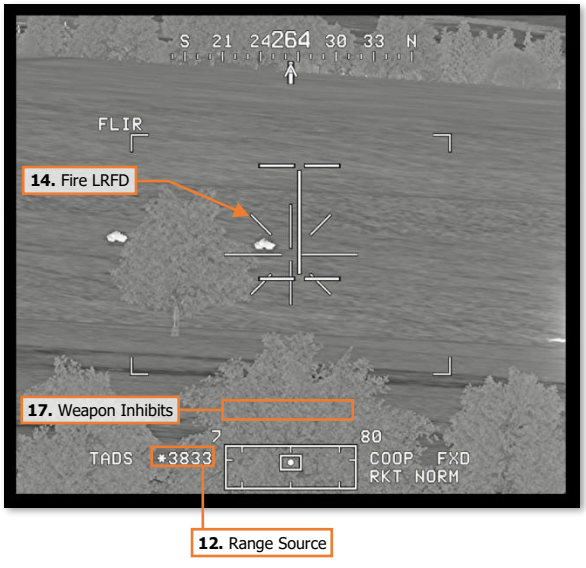
15. CPG Instruct the Pilot to align the aircraft with the Rocket Steering Cursor and fire – "Match and Shoot."

16. PLT Rocket Steering Cursor – Align with the HMD LOS Reticle.

- Running/Diving Fire – Apply cyclic inputs in the direction of the Rocket Steering Cursor while applying pedal inputs to maintain aerodynamic trim.
- Hover Fire – Apply pedal inputs in the direction of the Rocket Steering Cursor.

17. PLT & CPG Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON LIMIT



18. PLT Weapon Trigger – Pull and hold for duration of salvo. (Cyclic Grip)

19. CPG TADS Field-Of-View (FOV) - Decrease by one level. (e.g., switch FLIR from Narrow to Medium FOV)

20. PLT & CPG Observe for rocket impacts – Adjust the TADS LOS Reticle aimpoint and repeat rocket salvo as necessary until target effects are achieved.

Rocket Engagement using TADS (Indirect Fire in COOP Mode)

When employing unguided rockets in Cooperative (COOP) mode, the TADS is used by the CPG to calculate the weapon aiming solution while the Pilot maneuvers the aircraft to align the Rocket Steering Cursor. When employed in an indirect fire manner in which the target cannot be directly observed by the aircraft sensors, the TADS is slaved to a point within the navigational database corresponding with the target's 3-dimensional location. This point may be stored using the TADS, manually input by the crew, or received from another team member.

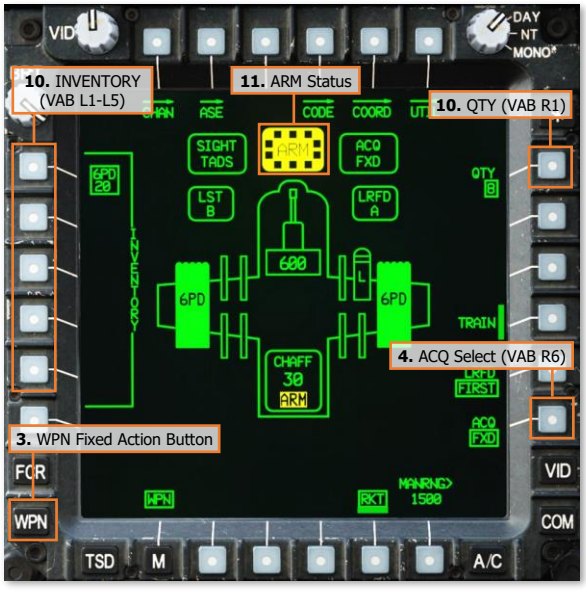
Cooperative mode can only be entered when the CPG actions rockets on the TEDAC Left Handgrip and the Pilot actions rockets on the Cyclic Grip.

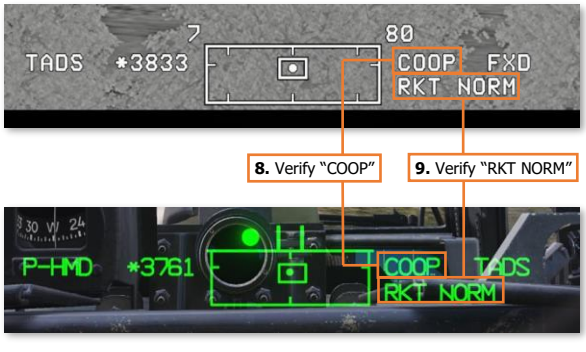
When COOP mode is entered, the Pilot's WPN page settings in the RKT format will default to the settings of the CPG. However, when in COOP mode, these settings are common between crewstations in that changing the INVENTORY (VAB L1-L5) or QTY (VAB R1) settings in one crewstation will change them in the other.

To engage a target with Indirect Fire rockets in Cooperative mode, using the TADS as the selected sight:

1. PLT Sight Select switch – HMD. (Collective Mission Grip)
2. CPG Sight Select switch – TADS. (TEDAC Right Handgrip)
3. CPG WPN Fixed Action Button – Press.
4. CPG Determine the appropriate acquisition source (ACQ) for acquiring the target.
   - COORD (VAB T5) – Select.
   - Point (VAB L1-L6) – Select; or use paging controls to locate the target point within the database.

   NOTE: If the target location is not already present in the navigational database, the target point must be received via the datalink or manually input on the POINT sub-page. (See the Datalink chapter or TSD Point sub-page for more information.)
5. CPG SLAVE button – Press.
6. PLT Weapon Action switch (WAS) – Left. (Cyclic Grip)
7. CPG Weapon Action Switch (WAS) – Left. (TEDAC Left Handgrip)
8. PLT & CPG Weapon Control Status – Verify "COOP". (High Action Display)
9. PLT & CPG Weapon Status – Verify "RKT NORM". (High Action Display)





10. PLT / CPG Weapon settings – Verify or select. (WPN page)

- © TYPE (VAB L1-L5) – Select as desired.
- © QTY (VAB R1) – Select as desired.

11. CPG A/S button – Verified in ARM. (Armament Panel)

12. CPG Range source – Verify Navigation. (TADS Acquisition and Ranging)

13. CPG Instruct the Pilot to align the aircraft with the Rocket Steering Cursor and fire – "Match and Shoot."

14. PLT Rocket Steering Cursor – Align with the HMD LOS Reticle.

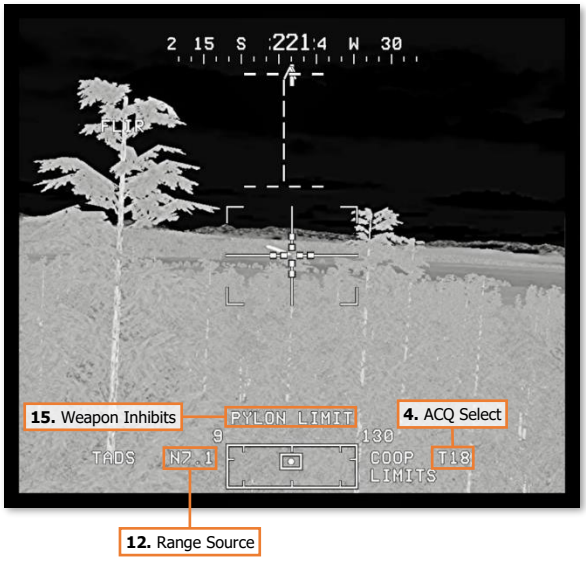
- Running Fire – Apply cyclic inputs in the direction of the Rocket Steering Cursor while applying pedal inputs to maintain aerodynamic trim.
- Hover Fire – Apply pedal inputs in the direction of the Rocket Steering Cursor.

15. PLT & CPG Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON LIMIT

16. PLT Weapon Trigger – Pull and hold for duration of salvo. (Cyclic Grip)

17. PLT & CPG If no observers are able to provide a damage assessment after rockets are fired, it may be necessary to un-mask and observe the target area to determine if the desired target effects are achieved.



Rocket Engagement using FCR (Direct Fire or Indirect Fire)

When employing unguided rockets independently from either crewstation using the FCR, the NTS target is used for calculating the weapon aiming solution for the Rocket Steering Cursor. If the target is moving, the target should be engaged in as short amount of time possible following the completion of the FCR scan to ensure the lead-angle compensation to the target is accurate.

Since the 3-dimensional location of the NTS target is used for calculating the weapon aiming solution, unguided rockets may be employed in a direct fire manner in which the target can be directly observed by the aircraft sensors, or in an indirect fire manner in which the target cannot be directly observed by the aircraft sensors.

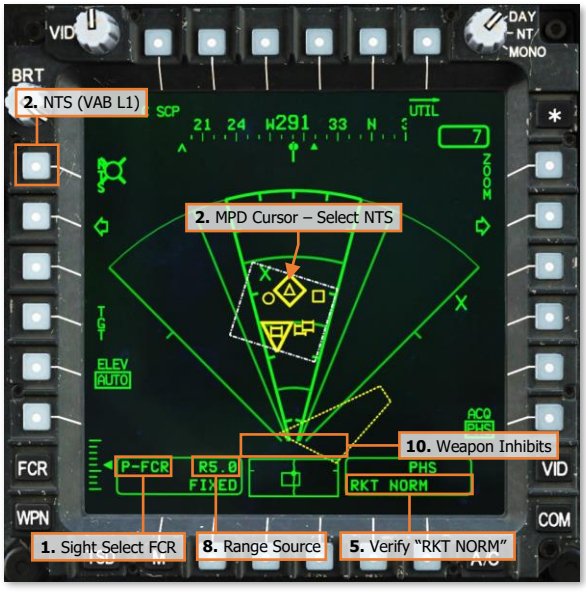
When employing unguided rockets in Cooperative (COOP) mode, the FCR is used by the CPG to calculate the weapon aiming solution while the Pilot maneuvers the aircraft to align the Rocket Steering Cursor. Cooperative mode can only be entered when the CPG actions rockets on the TEDAC Left Handgrip and the Pilot actions rockets on the Cyclic Grip.

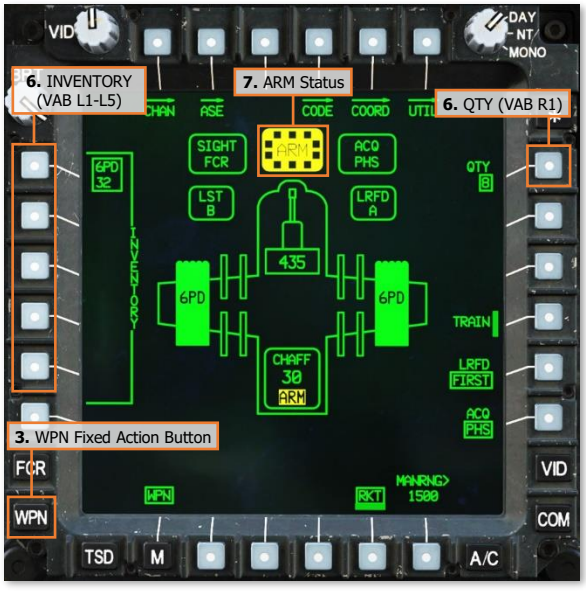
To engage a target from either crewstation while using the FCR as the selected sight:

1. Sight Select switch – FCR. (Collective Mission Grip or TEDAC Right Handgrip)
2. NTS (VAB L1) – Select to advance NTS to desired target for engagement.

   or

2. MPD Cursor Controller/Enter – Select desired target for engagement.
3. WPN Fixed Action Button – Press.
4. Weapon Action switch (WAS) – Left. (Cyclic Grip)
5. Weapon Status – Verify "RKT NORM". (High Action Display)
6. Weapon settings – Verify or select. (WPN page)
   - TYPE (VAB L1-L5) – Select as desired.
   - QTY (VAB R1) – Select as desired.
7. A/S button – Verified in ARM. (Armament Panel)





8. Range source – Verify Radar range is within appropriate engagement range.

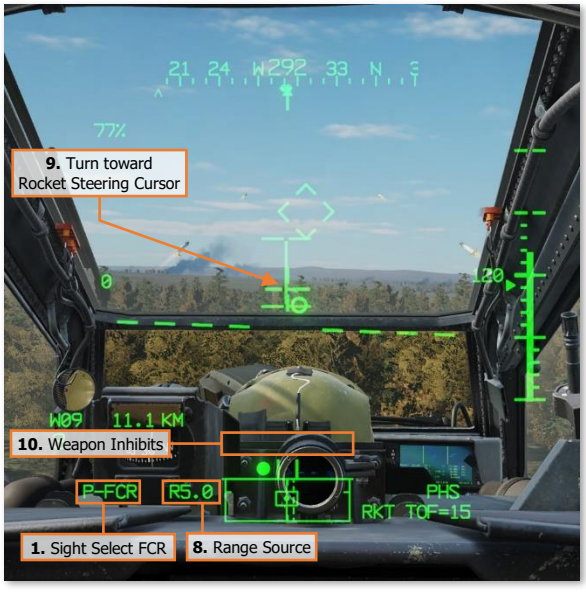
9. Rocket Steering Cursor – Align with the HMD LOS Reticle.

- Running/Diving Fire – Apply cyclic inputs in the direction of the Rocket Steering Cursor while applying pedal inputs to maintain aerodynamic trim.
- Hover Fire – Apply pedal inputs in the direction of the Rocket Steering Cursor.

10. Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON LIMIT

11. Weapon Trigger – Pull and hold for duration of salvo. (Cyclic Grip)



Rocket Engagement using HMD (Direct Fire)

When employing unguided rockets independently from either crewstation, the crewmember uses the HMD to calculate the weapon aiming solution while maneuvering the aircraft to align the Rocket Steering Cursor. Since the HMD LOS Reticle designates the target location, the helmet position must be maintained on the target to provide continuous and accurate steering cues via the Rocket Steering Cursor.

To engage a target with Direct Fire rockets, using the HMD as the selected sight:

1. Sight Select switch – HMD. (Collective Mission Grip)

2. WPN Fixed Action Button – Press.

3. Weapon Action switch (WAS) – Left. (Cyclic Grip)

4. Weapon Status – Verify "RKT NORM". (High Action Display)

5. Weapon settings – Verify or select. (WPN page)

- TYPE (VAB L1-L5) – Select as desired.
- QTY (VAB R1) – Select as desired.

6. A/S button – Verified in ARM. (Armament Panel)

7. Range source – Verify or select: Navigation, Auto, or Manual. (HMD Acquisition and Ranging)

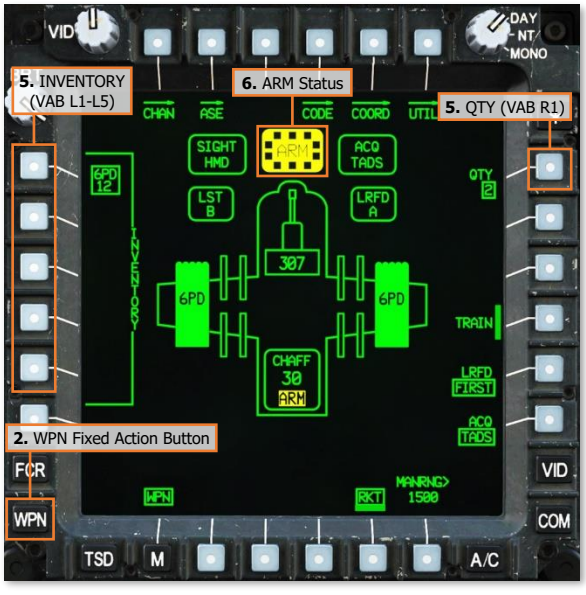
8. HMD LOS Reticle – Designate the target.

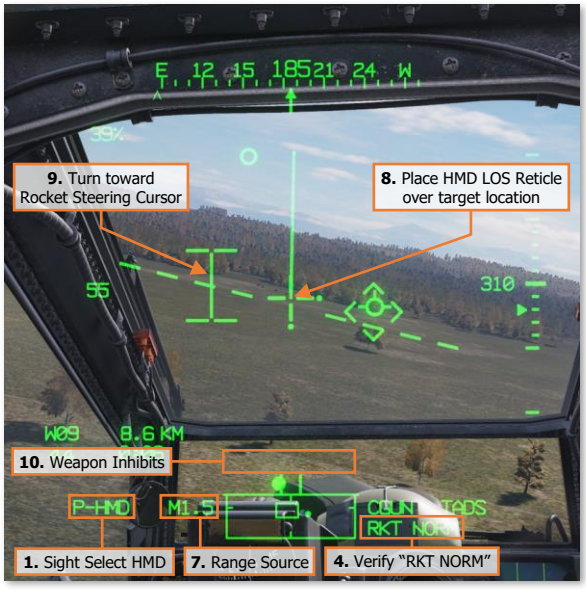
9. Rocket Steering Cursor – Align with the HMD LOS Reticle while maintaining the HMD LOS Reticle on the target.

- Running/Diving Fire – Apply cyclic inputs in the direction of the Rocket Steering Cursor while applying pedal inputs to maintain aerodynamic trim.
- Hover Fire – Apply pedal inputs in the direction of the Rocket Steering Cursor.

10. Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON LIMIT





11. Weapon Trigger – Pull and hold for duration of salvo. (Cyclic Grip)

12. Observe for rocket impacts – Adjust the HMD LOS Reticle aimpoint and repeat rocket salvo as necessary until target effects are achieved.

HELLFIRE MODULAR MISSILE SYSTEM (HMMS)

The Hellfire Modular Missile System is the primary weapon system of the AH-64D, capable of employing any variant of the AGM-114 Hellfire missile family. The AGM-114 was designed as a highly accurate anti-armor munition, capable of engaging point targets at long range across a wide variety of battlefield conditions.

The HMMS consists of up to four M299 Hellfire missile launchers (also called "HML's"), which can carry up to four AGM-114 missiles of any model. Each individual launcher rail is processed by the aircraft electronics independently of the others, essentially equipping the AH-64 with up to 16 individual missile stations. Any combination of M299 missile launchers may be used in conjunction with the M261 rocket pods, to include such possibilities of three missile launchers and one rocket pod, or a single missile launcher and a single rocket pod in the case of reducing overall gross weight.

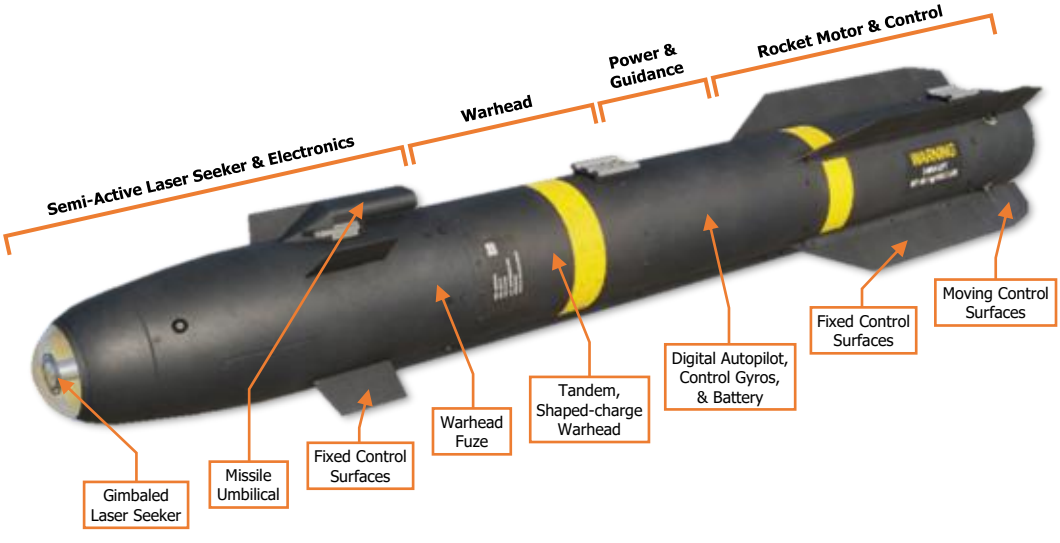
The HMMS provides various levels of automation for managing the missile inventory, allowing the crew to focus on targeting and engagement of ground targets while minimizing the duration the AH-64D is un-masked and exposed to enemy detection and weapons fire. AGM-114 missiles may be employed by either crewmember when using the HMD or FCR as the selected sight, or by the CPG when using the TADS. However, only specific missile types (SAL or RF) may be employed depending on the selected sight within the crewstation.

- **HMD.** When the selected sight is HMD, only Semi-Active Laser (SAL) AGM-114 missiles may be selected and fired from the crewstation. When employed by the CPG, an offboard source of laser designation is required. When employed by the Pilot, an offboard laser designation is required or the CPG may provide designation using the TADS.
- **FCR.** When the selected sight is FCR, only Radio Frequency (RF) AGM-114 missiles may be selected and fired from the crewstation.
- **TADS**. When the CPG's selected sight is TADS, either SAL or RF missiles may be selected and fired, depending on the CPG's Weapon (WPN) page settings.

AGM-114K Semi-Active Laser-homing (SAL) Missile

The AGM-114 family of anti-tank missiles entered service in the early 1980's alongside the AH-64A. The laser-guided Hellfire missiles were proven to be much more capable compared to the wire-guided BGM-71 TOW missiles which they were to replace, with the ability to be guided to a target by the launching platform or by any other target designation system capable of emitting a matching laser code. In addition, the AGM-114's increased range, speed, and its ability to employ one of several post-launch trajectories added to its versatility on the battlefield. The first generation of missiles, commonly referred to as "Basic Hellfire" variants, included the A-, B-, C- and F-models, and were used to a high degree of success during Operation Desert Storm in 1991.

Although the early variants of the AGM-114 missile were quite successful in combat, development of a second generation of AGM-114 missiles, commonly referred to as "Hellfire II" variants, entered service in the late 1990's. These new AGM-114 variants featured numerous improvements and enhancements over the first generation, including a new digital autopilot to replace the original analog electronics, an electronic arming fuze, countermeasure hardening, and an integrated tandem warhead for defeating reactive armor. As a side note, the AGM-114F did include a second warhead for defeating reactive armor, giving it a noticeable increase in length compared to other AGM-114 variants, leading to the F-model being referred to as "Interim Hellfire".



The AGM-114K was the first model of "Hellfire II" variants produced. Like the initial "Basic Hellfire", the laser frequency and post-launch trajectory are selectable from the cockpit and are immediately uploaded through the missile's umbilical, giving the aircrew the ability to rapidly configure the missile as needed. This flexibility, along with the AGM-114K's tandem shaped-charge warhead, which is capable of defeating any known armor on the battlefield, makes the "Kilo" a versatile precision-strike weapon.

The AGM-114K may be employed in either a Lock-On-Before-Launch (LOBL) or a Lock-On-After-Launch (LOAL) mode. If the missile's laser seeker detects a laser designation that matches its assigned laser code prior to launch, regardless of whether that laser designation is provided by the launching aircraft or by an offboard source such as another aircraft or a ground-based designator, the missile will be launched in LOBL mode.

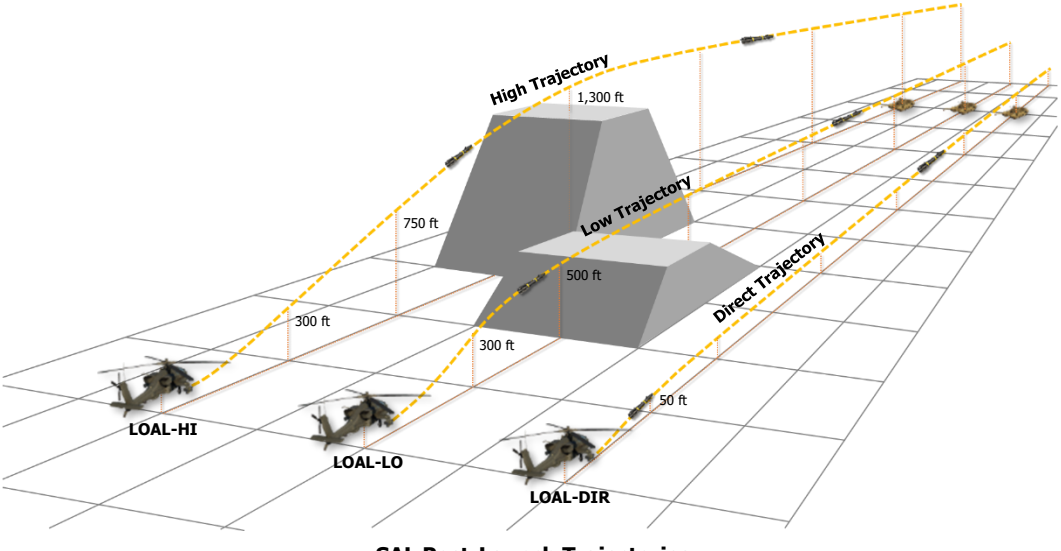
When tracking a laser designation in LOBL mode the acceptable launch envelope, referred to as the "missile launch constraints", is significantly more permissive when compared to LOAL. However, LOBL requires the launching aircraft have a direct line-of-sight to the target prior to launch, which may expose the aircraft to enemy detection and weapons fire.

SAL Post-Launch Trajectories

The acceptable launch envelope when firing the missile in LOAL is more restrictive than LOBL to ensure the missile is fired into the general vicinity of the intended target prior to designation. However, this allows the launching aircraft to fire the missile while remaining behind cover and hidden from enemy detection. When a SAL missile is launched while using LOAL, the crew may select one of three trajectories for the missile to utilize while enroute to the target, depending on the range and any obstructions between the aircraft and the target.

- **High (HI) Trajectory.** When employed using a High trajectory, the missile will use a maximum loft climb after launch, ascending approximately 1,300 feet above the aircraft within 2,000 meters before leveling off and continuing along a level altitude. The High trajectory should be utilized when the missile needs to clear significant terrain obstructions between the launching aircraft and the intended target, or to maximize the missile's kinematic range.
- **Low (LO) Trajectory.** When employed using a Low trajectory, the missile will use a moderate loft climb after launch, ascending approximately 500 feet above the aircraft within 1,000 meters before leveling off and continuing along a level altitude. The Low trajectory should be utilized when the missile needs to clear low terrain obstructions between the launching aircraft and the intended target, or to increase the missile's kinematic range.
- **Direct (DIR) Trajectory.** When employed using a Direct trajectory, the missile will use a minimum loft climb after launch, ascending approximately 50 feet above the aircraft within 500 meters, but will continue along its launch azimuth in a very slight climb, reaching a peak altitude of 250 feet within 5 kilometers. The Direct trajectory should be utilized when there are no terrain obstructions between the launching aircraft and the intended target, or if the target is at a relatively close range.

  NOTE: The trajectory option on the WPN page should be set to Direct (DIR) if the missile is intended to be employed in a Lock-On-Before-Launch mode. (See Missile Constraints Box for more information.)



SAL Post-Launch Trajectories

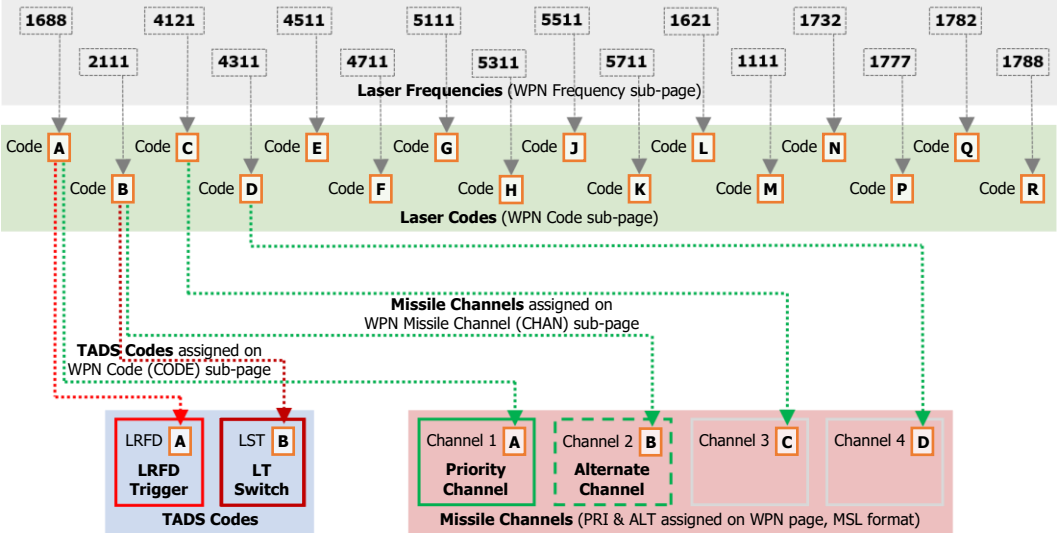
Regardless of which trajectory is selected, the AGM-114K will continue along the same azimuth following launch until it detects a laser designation with a matching laser code, at which point it will dive onto the designated target. If no laser designation is detected, the missile will gradually lose altitude as its kinematic energy is depleted and it impacts the ground.

Laser Codes & Missile Channels

The AH-64D allocates laser frequencies using a combination of alphabetical laser codes and preset missile channels to increase cockpit efficiency. Up to 16 distinct laser frequencies may be programmed and assigned to laser codes "A" through "R", excluding I and O to prevent confusion with one and zero respectively. These laser codes are then allocated amongst other team members to ensure each AH-64D can designate targets independently of one other, enabling simultaneous laser-guided missile engagements without mutual interference. (See WPN Code sub-page for more information.)

The pre-programmed laser codes also allow rapid switching of the TADS Laser Rangefinder/Designator (LRFD) and Laser Spot Tracker (LST) coding, without needing to manually input a 4-digit pulse repetition frequency using the Keyboard Unit each time a change is required. Although it is rare that an AH-64D crew will need to change their LRFD code from that which was assigned to their aircraft during a mission, the LST code may be changed several times throughout the mission, depending on the nature of any target handovers received from other laser-capable platforms within the battlespace.

Once the laser codes have been programmed and assigned to the TADS LRFD and LST sensors, the appropriate laser codes must be assigned to the missile channels. Missile channels permit rapid re-coding of SAL missiles directly from the main WPN page, independently of the ownship's TADS LRFD and LST code assignments, and determine which laser designations SAL missiles will scan for and track. (See WPN Channel sub-page for more information.)



Laser Coding & Missile Channels

If the WPN page is displayed in MSL format, any of the four missile channels may be selected as the Priority or Alternate channels for SAL missile coding. The Priority missile channel determines how the next launched SAL missile will be coded, as in which laser pulse repetition frequency it will scan for and track. The Alternate missile channel is only used when the missile mode is set to Ripple (RIPL) and determines how the subsequently launched SAL missile will be coded. (See WPN Missile format and Missile Modes on the following page for more information.)

Missile Modes

The AH-64's missile management mode may be set to either Normal, Ripple, or Manual, which dictates the manner in which the next and subsequent missiles are selected and coded for laser designations. For more information regarding Manual mode, see WPN Missile format.

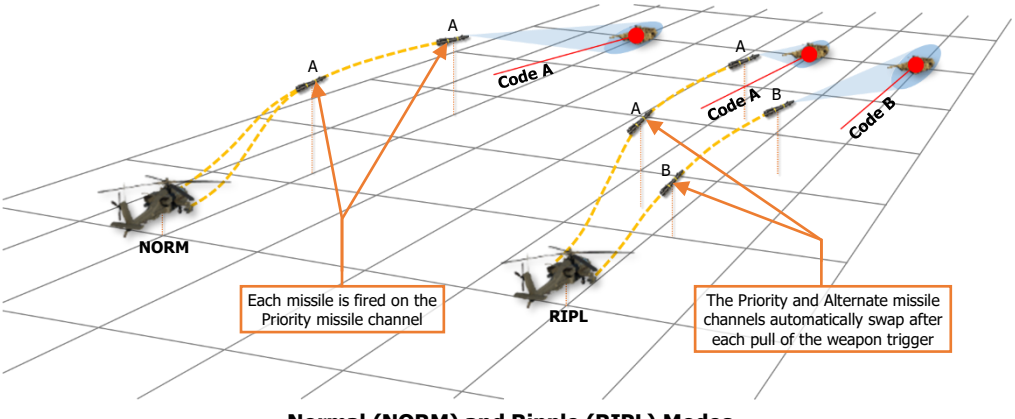
In Normal mode, each missile that is launched is coded to a single missile channel (set as the Priority channel on the WPN page), meaning each missile searches for and tracks laser designations of a single laser pulse frequency.

Normal (NORM) Missile Mode

When set to Ripple mode, each missile that is launched is coded to one of two missile channels (set as the Priority and Alternate channels on the WPN page), which automatically cycles between the two channels every time a missile is fired. This allows missiles to be employed against two separate laser pulse frequencies that are providing simultaneous target designations without needing to manually switch the Priority missile channel between each pull of the weapon trigger.

Ripple (RIPL) Missile Mode

It should be noted that the selected missile mode only provides a means of managing how each subsequent missile is coded prior to launch, and does not directly correlate with how targets are designated, or whether the target is designated by the launching aircraft, another aircraft in the vicinity, or a ground-based designator. In the figure below, the aircraft launching in NORM mode may or may not be the source of laser designation against the intended target. NORM mode simply results in each missile being coded to the Priority missile channel.

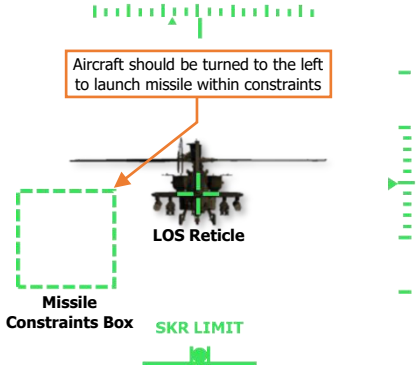


Normal (NORM) and Ripple (RIPL) Modes

Likewise, the aircraft launching in RIPL mode may or may not be one of the sources of laser designation against the intended targets. Either of the designation sources could be provided by the launching aircraft, another aircraft in the vicinity, or a ground-based designator. RIPL mode simply results in the cycling of the Priority and Alternate channels following each launch to permit engagement of multiple targets using two designation sources.

SAL Missile Constraints Box

The key piece of symbology associated with employing the AGM-114K is the Missile Constraints Box displayed within the crewmember's sight symbology. The Missile Constraints Box is a steering cue and launch mode indicator which indicates the launch mode of the missile and whether the missile is within acceptable launch constraints.



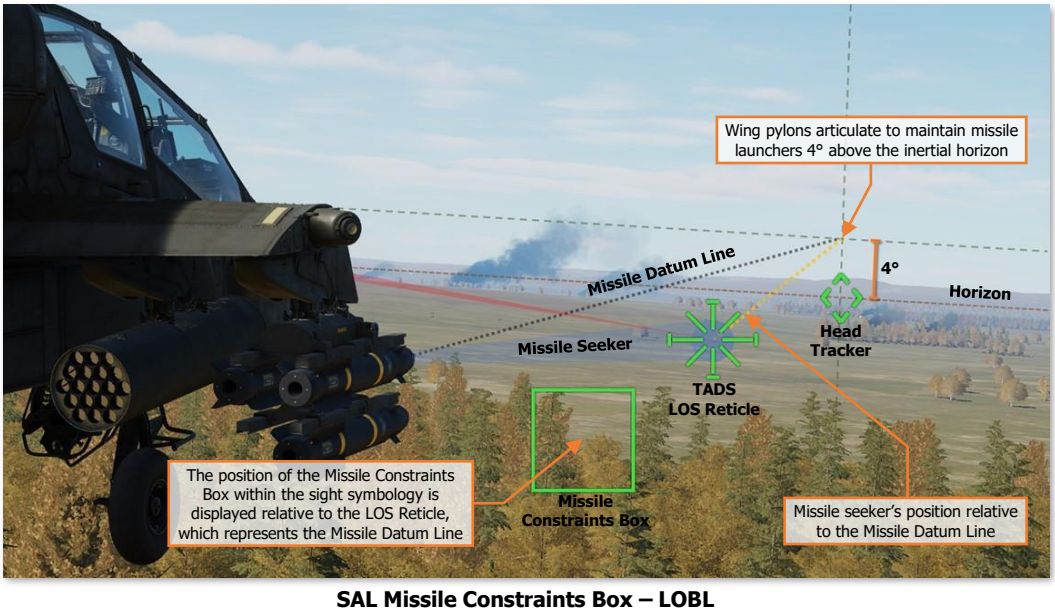
The Missile Constraints Box is longitudinally-scaled and is *not* a virtual symbology element; its displayed location does not correspond with a real-world location that is observed "out-the-window" like the Head Tracker or Flight Path Vector. The position of the Missile Constraints Box is referenced from the LOS Reticle, which corresponds to the Missile Datum Line (0° in azimuth and elevation from the longitudinal axis of the missile body). However, the referenced position of which the Missile Constraints Box represents is dependent on whether the missile is in LOBL or LOAL mode; and when in LOAL mode, which post-launch trajectory has been selected by the crewmember.

To augment the missiles' post-launch trajectory and to ensure the missiles do not strike the ground, the wing pylons articulate in the vertical axis to maintain the pylon angle of each missile launcher 4° above the inertial horizon when the missiles are actioned. This results in the Missile Datum Line of each missile being stabilized 4° above the horizon regardless of the aircraft pitch attitude.

Lock-On-Before-Launch Mode (LOBL)

When the missile seeker detects a laser designation that matches its assigned laser code, the missile enters LOBL mode. When in LOBL mode, the Missile Constraints Box corresponds with the position of the missile's seeker, in azimuth and elevation, relative to the Missile Datum Line.

The maximum allowable offset angle when the missile is in LOBL mode is 20°, ensuring the missile will be able to maintain track on the laser designation after launch; otherwise, the Constraints Box will be displayed as invalid, indicating the missile is outside of launch constraints. (See Missile Constraints Box Format for more information.)



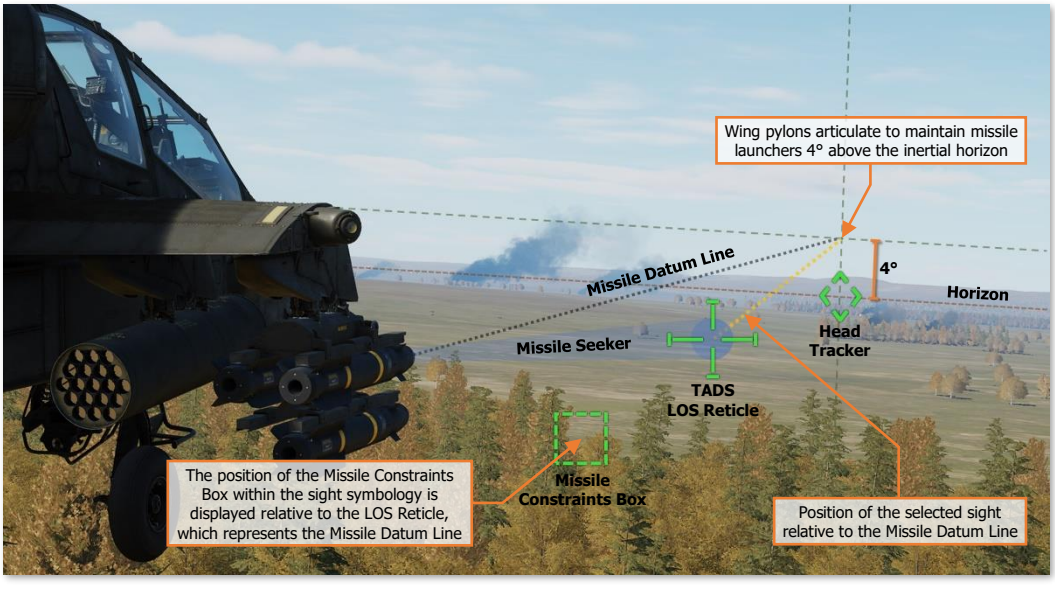
SAL Missile Constraints Box – LOBL

Lock-On-After-Launch Mode, Direct Trajectory (LOAL-DIR)

When the missile seeker is not detecting a laser designation that matches its assigned laser code, the missile is in LOAL mode. If the post-launch trajectory is set to DIR, the missile seeker is slaved to the crewmember's selected sight and the Missile Constraints Box corresponds with the position of the selected sight (HMD or TADS), in azimuth and elevation, relative to the Missile Datum Line.

When the CPG pulls the LRFD trigger on the TEDAC Right Handgrip to the 2nd detent to designate the target, the seeker is de-slaved, allowing the missile to track the laser designation from the launching aircraft. When the LRFD trigger is released, the missile seeker is once again slaved to the crewmember's selected sight.

The maximum allowable offset angle when the missile is in LOAL mode is 7.5°. This ensures the missile is fired in the vicinity of the target location and that the missile's flight path will carry it close enough for the seeker to detect a laser designation after launch. Otherwise, the Constraints Box will be displayed as invalid, indicating the missile is outside of launch constraints. (See Missile Constraints Box Format for more information.)



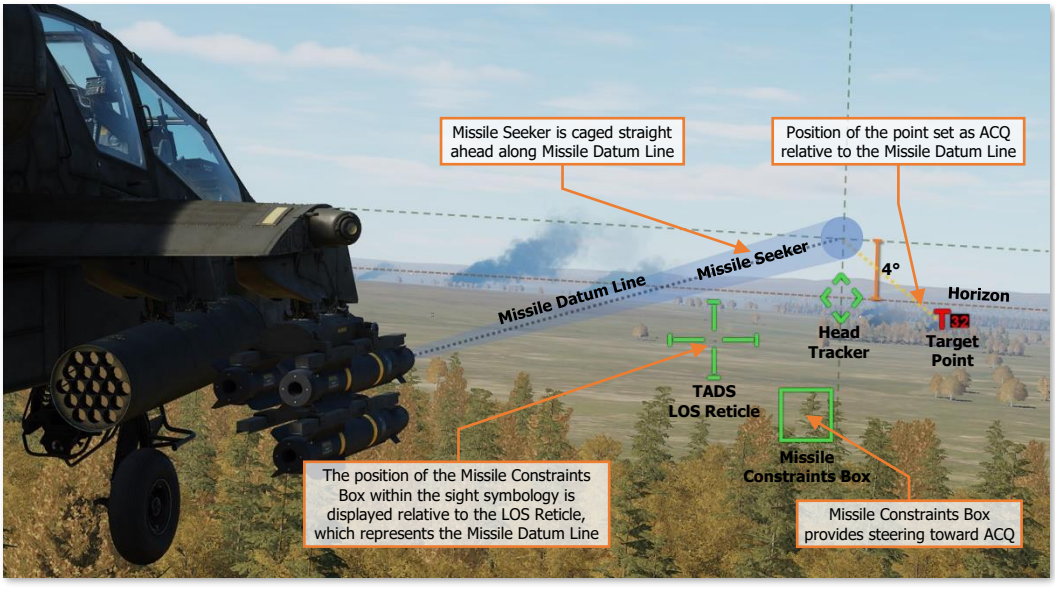
SAL Missile Constraints Box – LOAL-DIR

Lock-On-After-Launch Mode, Low/High Trajectory (LOAL-LO or LOAL-HI)

When the missile seeker is not detecting a laser designation that matches its assigned laser code, the missile is in LOAL mode. If the post-launch trajectory is set to LO or HI, the missile seeker is caged directly ahead and the Missile Constraints Box corresponds with the position of the acquisition source (ACQ), in azimuth and elevation, relative to the Missile Datum Line when the ACQ is set to a point within the navigational database. If the ACQ is not set to a point from the database, the Constraints Box will be displayed as invalid and be positioned at the LOS Reticle, indicating the launch constraints are unknown.

The Missile Constraints Box indicates the azimuth to which the aircraft should be aligned to launch the missile toward the point set as the crewmember's ACQ. These trajectories are typically used when launching a laser-guided AGM-114 toward a target that will be designated by an offboard designation source; in which the target coordinates have been relayed to the launching aircraft in advance. (See Remote Fire for more information.)

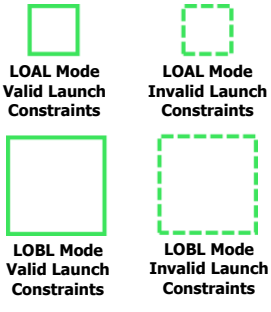
The maximum allowable offset angle when the missile is in LOAL mode is 7.5°. This ensures the missile is fired in the vicinity of the target location and that the missile's flight path will carry it close enough for the seeker to detect a laser designation after launch. Otherwise, the Constraints Box will be displayed as invalid, indicating the missile is outside of launch constraints. (See Missile Constraints Box Format for more information.)



SAL Missile Constraints Box – LOAL-LO or LOAL-HI

SAL Missile Constraints Box Format

The Missile Constraints Box is displayed in four formats to indicate the missile's launch mode (LOBL or LOAL) and whether the missile is within acceptable launch constraints (Valid or Invalid).



If the missile seeker is not tracking a laser designation that matches its assigned laser code, the missile will launch in Lock-On-After-Launch (LOAL) mode.

If the missile seeker is tracking a laser designation that matches its assigned laser code, the missile will launch in Lock-On-Before-Launch (LOBL) mode.

If the missile is within acceptable launch constraints and no Weapon Inhibit messages are displayed within the High Action Display, the Missile Constraints Box will be displayed as Valid.

If the missile is outside acceptable launch constraints or any Weapon Inhibit messages are displayed within the High Action Display, the Missile Constraints Box will be displayed as Invalid.

The acceptable launch constraints for SAL missiles are dependent on the launch mode and the selected LOAL trajectory (if applicable).

- **LOBL Constraints.** Missile seeker LOS is offset ≤ 20° from Missile Datum Line.
- **LOAL-DIR Constraints.** Selected sight (HMD or TADS LOS) is offset ≤ 7.5° from Missile Datum Line.
- **LOAL-LO or LOAL-HI Constraints.** Line-of-sight (LOS) to the location of the point currently set as the acquisition source (ACQ) is offset ≤ 7.5° from Missile Datum Line.

SAL Missile Weapon Inhibits

The following conditions will inhibit the SAL missiles from being fired. Performance inhibits may be overridden by pulling the trigger to the 2nd detent. Safety inhibits cannot be overridden.

Performance Inhibits

INHIBIT	CONDITION	CORRECTIVE ACTION
BAL LIMIT	The required weapon aiming solution exceeds the ballistics processing capability.	If tactically feasible, engage the target at a closer range.
PYLON ANGLE	The position of the missile launcher(s) is ≥10° from the optimum launch position or the pylon position is unknown.	Wait for the missile launchers to reach the optimum launch position. If inhibit message remains, missiles may still be fired but the missile launcher positions should be visually confirmed to ensure the appropriate considerations may be made for a successful engagement.
PYLON LIMIT (IN FLIGHT)	The commanded position of the missile launcher(s) exceeds the pylon articulation limits. (+4° to -15°).	Adjust the aircraft pitch attitude as necessary to bring the articulation range of the wing pylons to +4° above the inertial horizon.
RATE LIMIT	The pitch, roll, and/or yaw rates are excessive.	Stabilize the aircraft attitude prior to launch.
ROLL LIMIT	The roll angle of the aircraft is excessive.	Reduce the roll attitude of the aircraft prior to launch.
SKR LIMIT	When the missile is in LOBL mode, the missile seeker has reached a gimbal limit.	Adjust the heading or pitch attitude of the aircraft to bring the target within the missile seeker field-of-view. (e.g., turn toward the Missile Constraints box).
YAW LIMIT	When the missile is in LOAL mode, the target position relative to the aircraft heading is excessive.	Adjust the heading of the aircraft to bring the target position closer to the aircraft centerline. (e.g., turn toward the Missile Constraints box).

Safety Inhibits

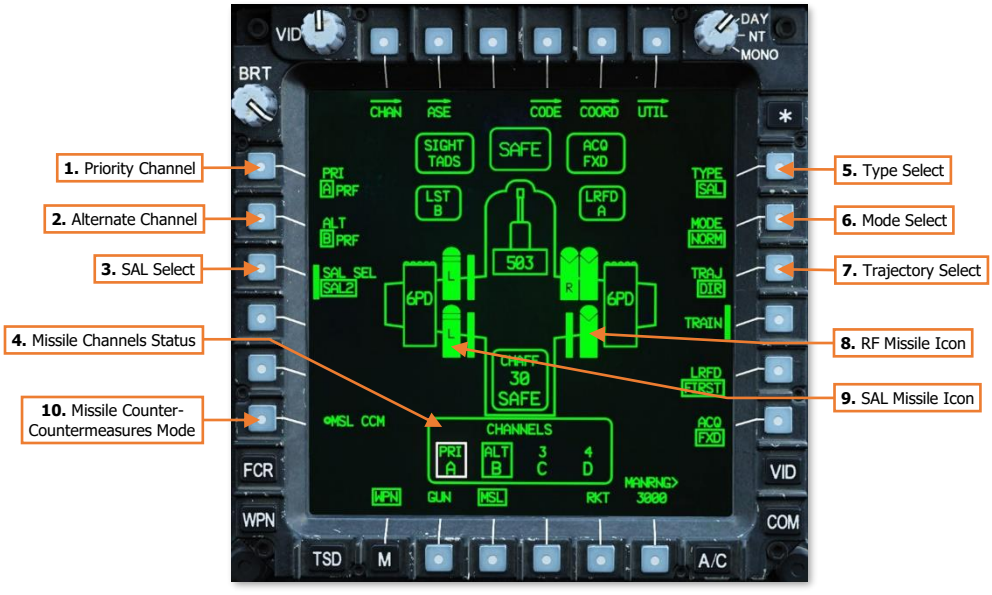
INHIBIT	CONDITION	CORRECTIVE ACTION
ACCEL LIMIT	Vertical acceleration is <0.5 G; the main rotor blades may obstruct the trajectory of the missile when fired.	Reduce the severity of the current maneuver to increase the positive G load on the aircraft.
ALT LAUNCH	The firing of a rocket salvo is already in progress.	The missile may be fired 2 seconds after the rocket salvo is complete.
BACK SCATTER	The TADS LRFD is firing and the difference between the SAL missile seeker line-of-sight and the TADS line-of-sight is >2°.	The missile is not tracking the TADS laser designation, possibly due to atmospheric obscurance between the aircraft and the target such as dust or smoke. Release the laser trigger to slave the missile seeker back to the TADS line-of-sight and attempt to designate again.

GUN OBSTRUCT	The gun is out of coincidence from the weapon aiming solution and may obstruct the trajectory of missiles fired from the inboard wing pylons.	If tactically feasible, instruct the crewmember that has actioned the gun to de-action in order to permit the firing of missiles. A different missile may be manually selected by setting the Mode to MAN and pressing the Missile Advance button.
LOS INVALID	The line-of-sight of the selected sight is invalid or has failed.	Select a different sight for engagement.
MSL NOT RDY	The SAL priority missile channel is set to NONE in NORM or RIPL mode. A missile has not been selected in MAN mode.	Select a priority missile channel for SAL engagement. Press the Missile Advance button to select the next missile in MAN mode.
PYLON ERROR	The aircraft is on the ground (weight-on-wheels) and the missile launcher positions are unknown.	If inhibit message remains, the corresponding wing pylons may have experienced a failure and the missiles should be de-actioned.
PYLON LIMIT (ON GROUND)	The commanded position of the missile launcher(s) exceeds the pylon articulation limits. (+4° to -5°).	The missiles should be de-actioned.
SAFE	The master armament state is currently set to SAFE; weapons cannot be fired.	Set the A/S button on the Armament Panel to ARM.

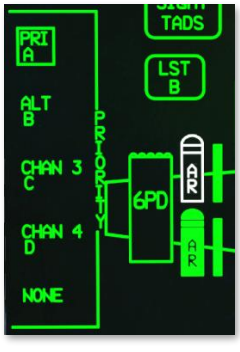
WPN Missile (MSL) Format – SAL Missile Settings

When SAL missiles are selected for employment within the crewstation, the WPN page will display SAL missile settings when set to MSL format.

NOTE: The only SAL missile variant of the AGM-114 missile family that is simulated in DCS: AH-64D is the AGM-114K, which is of the Hellfire II series of sub-variants. As a result, only SAL2 missile icons will be displayed and available for employment.



1. **Priority Channel.** Displays the missile channel selection menu for selecting one of the four missile channels as the Priority channel, with the current channel selection boxed and displayed as "PRI". This setting is common between crewstations.

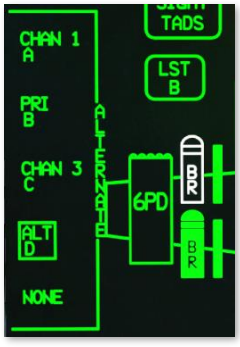


- **Channel 1.** Missile channel 1 will be selected as the Priority channel. The next SAL missile to be fired will be coded to the laser code assigned to channel 1.
- **Channel 2.** Missile channel 2 will be selected as the Priority channel. The next SAL missile to be fired will be coded to the laser code assigned to channel 2.
- **Channel 3.** Missile channel 3 will be selected as the Priority channel. The next SAL missile to be fired will be coded to the laser code assigned to channel 3.
- **Channel 4.** Missile channel 4 will be selected as the Priority channel. The next SAL missile to be fired will be coded to the laser code assigned to channel 4.
- **NONE.** No missile channels will be selected as the Priority channel. SAL missiles will not be coded and are inhibited from launch. ALT channel selection (VAB L2) is inhibited and automatically set to NONE.

NOTE: A missile channel cannot be selected as both the Priority and Alternate channels simultaneously. If the Alternate channel is selected as Priority, the Priority and Alternate channels will simply be swapped.

2. **Alternate Channel.** Displays the missile channel selection menu for selecting one of the four missile channels as the Alternate channel, with the current channel selection boxed and displayed as "ALT". This setting is common between crewstations.

   When the Mode is set to RIPL, SAL missiles will be coded in an alternating sequence between the two missile channels designated as Priority and Alternate.



   - **Channel 1.** Missile channel 1 will be selected as the Alternate channel.
   - **Channel 2.** Missile channel 2 will be selected as the Alternate channel.
   - **Channel 3.** Missile channel 3 will be selected as the Alternate channel.
   - **Channel 4.** Missile channel 4 will be selected as the Alternate channel.
   - **NONE.** No missile channels will be selected as the Alternate channel. RIPL mode is inhibited from selection within the MODE selection menu (VAB R2).

   NOTE: A missile channel cannot be selected as both the Priority and Alternate channels simultaneously. If the Priority channel is selected as Alternate, the Priority and Alternate channels will simply be swapped.

3. **SAL Select.** Selects the sub-variant of SAL missiles to be employed, between Basic Hellfire (SAL1), Hellfire II (SAL2), or automatic selection between the two sub-variants. (N/I)

4. **Missile Channels Status.** Displays the laser code assignments to each of the four missile channels and which channels are designated as Priority (PRI, white box) and Alternate (ALT, green box).

5. **Type Select.** Displays the selected missile type for employment. This setting is independent between crewstations and is contextually dependent on the selected sight within the crewstation.

   - **SAL.** SAL missiles are selected for employment from the crewstation. The High Action Display will display relevant symbology for SAL missile employment and the WPN page will display SAL missile settings when set to MSL format.
     - If the selected sight is set to HMD, SAL is automatically selected as the missile type and crewmember selection will be inhibited.
   - **RF.** RF missiles are selected for employment from the crewstation. The High Action Display will display relevant symbology for RF missile employment and the WPN page will display RF missile settings when set to MSL format.
     - If the selected sight is set to FCR, RF is automatically selected as the missile type and crewmember selection will be inhibited.

6. **Mode Select.** Selects the mode of missile inventory management. This setting is common between crewstations.

   - **RIPL.** Missile inventory, coding, and launch sequencing is managed automatically. Missile launches will be alternated between each wing station to maintain center-of-gravity, as appropriate.
     - The first three missiles that are designated for launch will be coded in an alternating sequence, with the first and third missiles coded to the Priority channel and the second missile coded to the Alternate channel. As each missile is fired, subsequent missiles are progressively coded in the same alternating sequence.
   - **NORM.** Missile inventory, coding, and launch sequencing is managed automatically. Missile launches will be alternated between each wing station to maintain center-of-gravity, as appropriate.
     - The first three missiles that are designated for launch will be coded to the Priority channel. As each missile is fired, subsequent missiles are progressively coded to the Priority channel.

- **MAN.** Missile inventory, coding, and launch sequencing is managed manually by the aircrew. Missile launches may lead to asymmetric loading and may cause center-of-gravity issues.
  - A single missile is selected and coded. The Missile Advance button on the Collective Mission Grip or the TEDAC Right Handgrip may be used to select the next missile for launch. As each missile is fired, the Missile Advance button must be used to select and code the next missile.

7. Trajectory Select. Selects the post-launch trajectory that will be employed by the SAL missile when fired in Lock-On After Launch (LOAL) mode. This setting is independent between crewstations.

- **HI.** If the missile seeker does not detect a laser designation, the missile will employ a high-altitude loft trajectory along its launch azimuth.
- **LO.** If the missile seeker does not detect a laser designation, the missile will employ a low-altitude loft trajectory along its launch azimuth.
- **DIR.** If the missile seeker does not detect a laser designation, the missile will employ a direct trajectory with minimal loft along its launch azimuth.

8. RF Missile Icon. Indicates an AGM-114L missile is loaded onto the corresponding missile launcher rail. The missile icon appearance and text label indicate the operational state and status of the missile. (See RF Missile Type Settings for more information.)

9. SAL Missile Icon. Indicates an AGM-114K missile is loaded onto the corresponding missile launcher rail. The missile icon appearance and text label indicate the operational state and status of the missile.

A SAL2 missile is loaded onto the corresponding missile launcher rail.

A solid missile icon is displayed when the WPN page is in MSL format.

A hollow, white, flashing missile icon indicates the next missile to be fired.

No laser code is assigned. Missile is in a Standby status.

Laser code "A" is assigned. Missile is in a Ready status.

Laser code "A" is assigned. Missile is in a Tracking status.

10. Missile Counter-Countermeasures Mode. Not implemented.

SAL Missile Weapon Status Messages

The following messages will be displayed in the High Action Display based on current missile status or weapon page settings when missiles are actioned and the missile type is set to SAL.

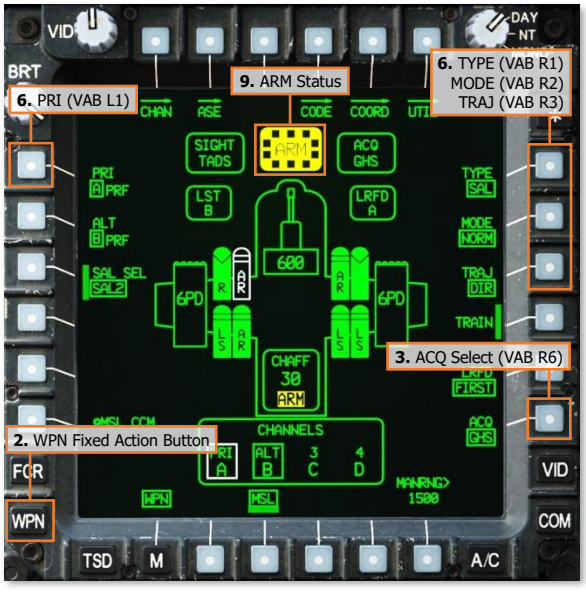
WEAPON STATUS	CONDITION
2 CHAN TRK	Missiles coded to the Priority and Alternate missile channels are tracking corresponding laser designations in RIPL mode. Missiles are in LOBL mode.
ALT CHAN TRK	A missile coded to the Alternate missile channel is tracking a corresponding laser designation in RIPL mode. Missile is in LOBL mode.
DIR MAN	LOAL trajectory is set to DIR. Missile management mode is set to MAN.
DIR NORM	LOAL trajectory is set to DIR. Missile management mode is set to NORM.
DIR RIPL	LOAL trajectory is set to DIR. Missile management mode is set to RIPL.
FIRE MSLS	8 seconds has elapsed since the last launch of a SAL missile and one or more SAL missiles are remaining onboard the aircraft and set to the Priority missile channel that matches the laser code set to the TADS LRFD.
HF TOF=##	The remaining time of flight (in seconds) for the next SAL missile that was set to a Priority channel that matches the laser code set to the TADS LRFD.
HI MAN	LOAL trajectory is set to HI. Missile management mode is set to MAN.
HI NORM	LOAL trajectory is set to HI. Missile management mode is set to NORM.
HI RIPL	LOAL trajectory is set to HI. Missile management mode is set to RIPL.
LASE ## TRGT	12 seconds time of flight remains for the next SAL missile that was set to a Priority channel that matches the laser code set to the TADS LRFD, requiring terminal guidance be provided by the TADS LRFD.
LO MAN	LOAL trajectory is set to LO. Missile management mode is set to MAN.
LO NORM	LOAL trajectory is set to LO. Missile management mode is set to NORM.
LO RIPL	LOAL trajectory is set to LO. Missile management mode is set to RIPL.
MSL LAUNCH	A launch has been commanded of the next SAL missile that was set to a Priority channel that matches the laser code set to the TADS LRFD.
MSL SELECT	Missiles are actioned but the Priority missile channel is set to NONE.
MSL TYPE?	Missiles are actioned but no missiles of the selected type (SAL or RF) are available.
NO MISSILES	Missiles are actioned but no SAL or RF missiles are available.
PRI CHAN TRK	A missile coded to the Priority missile channel is tracking a corresponding laser designation in MAN, NORM, or RIPL mode. Missile is in LOBL mode.
WEAPON?	The weapon trigger has been pulled but no weapon has been actioned.

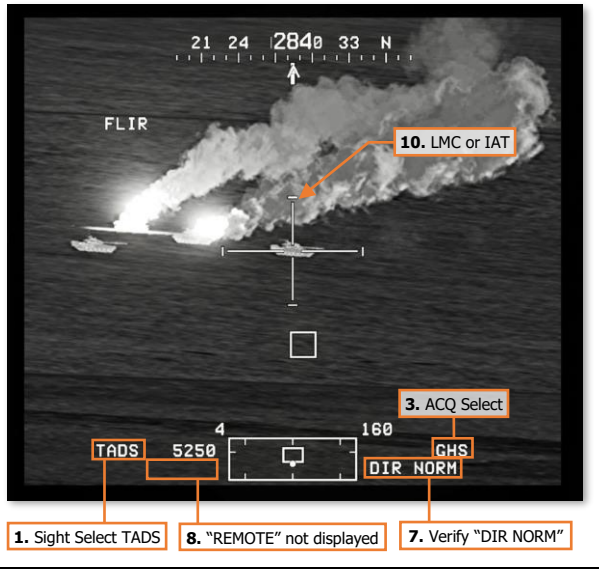
Laser-guided Hellfire Engagement (LOBL)

When employing a SAL missile in Lock-On-Before-Launch (LOBL) mode, the TADS LRFD is used by the CPG to continuously designate the target prior to missile launch and throughout the missile's flight until it impacts the target. TADS LMC and/or IAT targeting modes may be used to assist the CPG in stabilizing the TADS LOS Reticle on the target. When missiles are actioned in the CPG crewstation, the Missile Constraints Box will also be displayed in the Pilot crewstation to ensure the aircraft is maneuvered to within acceptable launch constraints.

To engage a target with a SAL missile in LOBL mode, using the TADS as the selected sight to self-designate:

1. CPG Sight Select switch – TADS. (TEDAC Right Handgrip)
2. CPG WPN Fixed Action Button – Press.
3. CPG **(Optional)** Determine the appropriate acquisition source (ACQ) for acquiring the target.
   - If the target is visually acquired by either crewmember, set ACQ to PHS or GHS.
   - If the target is stored as a point within the navigational database, set ACQ to the corresponding point.
4. CPG **(Optional)** SLAVE button – Press, and then press again to de-slave when the TADS has finished slewing.
5. CPG Weapon Action Switch (WAS) – Right. (TEDAC Left Handgrip)
6. CPG Weapon settings – Verify or select. (WPN page)
   - TYPE (VAB R1) – SAL.
   - © MODE (VAB R2) – NORM or MAN.
   - TRAJ (VAB R3) – DIR.
   - © PRI (VAB L1) – Verify Priority missile channel is set to the same laser code as the LRFD.
7. CPG Weapon Status – Verify "DIR NORM" or "DIR MAN". (High Action Display)
8. CPG Sight Status – Verify "REMOTE" *is not* displayed. (High Action Display)
9. CPG A/S button – Verified in ARM. (Armament Panel)





10. CPG If the target or aircraft are moving, engage TADS targeting modes to stabilize the TADS on target.

- Manual tracking - Engage LMC and employ the Sight Manual Tracker.
- Automatic tracking - Engage IAT.

11. CPG LRFD Trigger – Pull and hold, 2nd detent. (TEDAC Right Handgrip)

12. CPG Weapon Status – Verify "PRI CHAN TRK". (High Action Display)

13. CPG Instruct the Pilot to align the aircraft with the Missile Constraints Box – "Constraints."

14. PLT Missile Constraints Box – Align toward the HMD LOS Reticle.

- Running/Diving Fire – Apply cyclic inputs in the direction of the Missile Constraints Box.
- Hover Fire – Apply pedal inputs in the direction of the Missile Constraints Box.

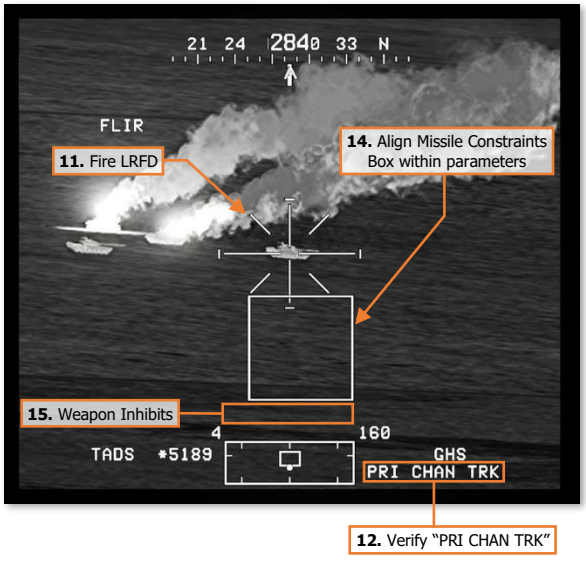
15. CPG Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- BACK SCATTER
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON ANGLE
- PYLON LIMIT
- RATE LIMIT
- ROLL LIMIT
- SKR LIMIT

16. CPG Weapon Trigger – Pull. (TEDAC Left Handgrip)

17. CPG Weapon Status – Verify "MSL LAUNCH". (High Action Display)

18. CPG LRFD Trigger – Maintain designation, 2nd detent, until the missile impacts the target. (TEDAC Right Handgrip)

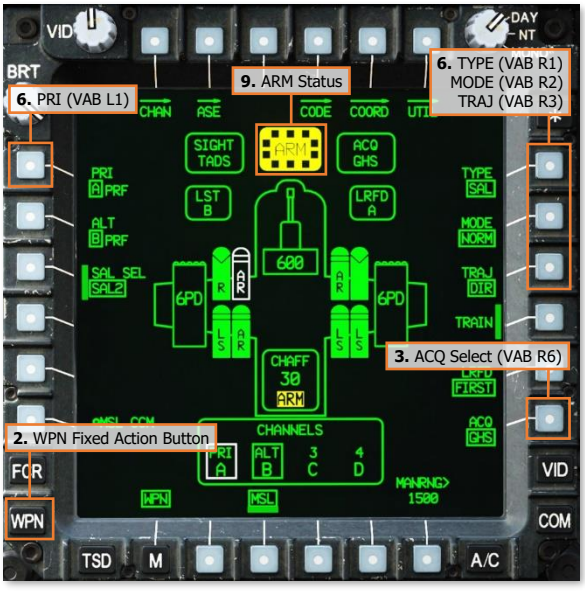


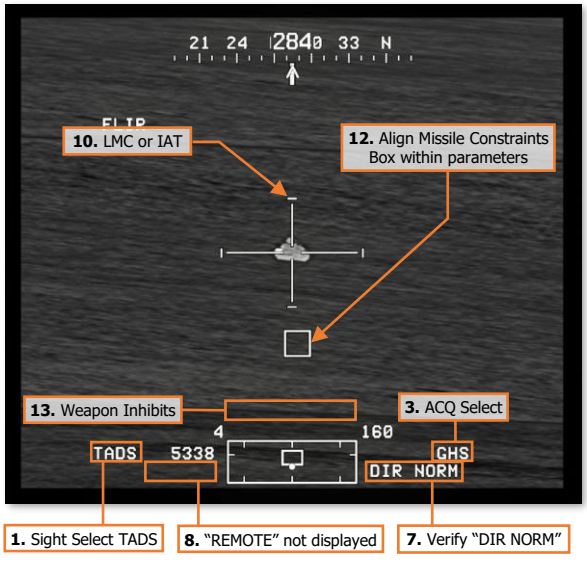
Laser-guided Hellfire Engagement (LOAL, DIR Trajectory)

When employing a SAL missile in Lock-On-After-Launch (LOAL) mode, the TADS LRFD is used by the CPG to designate the target after missile launch and throughout the remainder of the missile's flight until it impacts the target. TADS LMC and/or IAT targeting modes may be used to assist the CPG in stabilizing the TADS LOS Reticle on the target. When missiles are actioned in the CPG crewstation, the Missile Constraints Box will also be displayed in the Pilot crewstation to ensure the aircraft is maneuvered to within acceptable launch constraints.

To engage a target with a SAL missile in LOAL-DIR mode, using the TADS as the selected sight to self-designate:

1. CPG Sight Select switch – TADS. (TEDAC Right Handgrip)
2. CPG WPN Fixed Action Button – Press.
3. CPG **(Optional)** Determine the appropriate acquisition source (ACQ) for acquiring the target.
   - If the target is visually acquired by either crewmember, set ACQ to PHS or GHS.
   - If the target is stored as a point within the navigational database, set ACQ to the corresponding point.
4. CPG **(Optional)** SLAVE button – Press, and then press again to de-slave when the TADS has finished slewing.
5. CPG Weapon Action Switch (WAS) – Right. (TEDAC Left Handgrip)
6. CPG Weapon settings – Verify or select. (WPN page)
   - TYPE (VAB R1) – SAL.
   - © MODE (VAB R2) – NORM or MAN.
   - TRAJ (VAB R3) – DIR.
   - © PRI (VAB L1) – Verify Priority missile channel is set to the same laser code as the LRFD.
7. CPG Weapon Status – Verify "DIR NORM" or "DIR MAN". (High Action Display)
8. CPG Sight Status – Verify "REMOTE" *is not* displayed. (High Action Display)
9. CPG A/S button – Verified in ARM. (Armament Panel)





10. CPG If the target or aircraft are moving, engage TADS targeting modes to stabilize the TADS on target.

- Manual tracking - Engage LMC and employ the Sight Manual Tracker.
- Automatic tracking - Engage IAT.

11. CPG Instruct the Pilot to align the aircraft with the Missile Constraints Box – "Constraints."

12. PLT Missile Constraints Box – Align toward the HMD LOS Reticle.

- Running/Diving Fire – Apply cyclic inputs in the direction of the Missile Constraints Box.
- Hover Fire – Apply pedal inputs in the direction of the Missile Constraints Box.

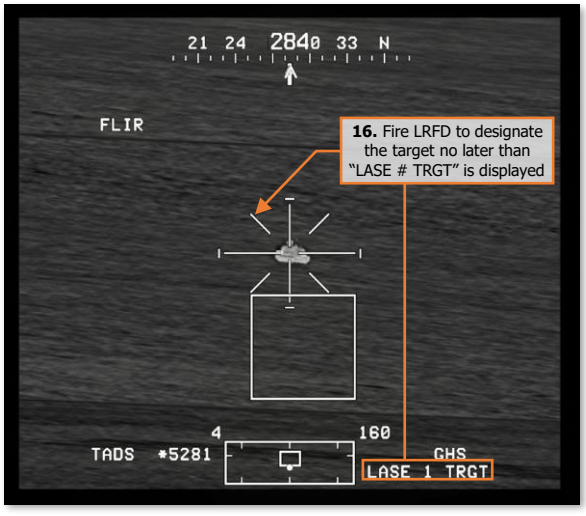
13. CPG Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- BACK SCATTER
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON ANGLE
- PYLON LIMIT
- RATE LIMIT
- ROLL LIMIT
- YAW LIMIT

14. CPG Weapon Trigger – Pull. (TEDAC Left Handgrip)

15. CPG Weapon Status – Verify "MSL LAUNCH". (High Action Display)

16. CPG LRFD Trigger – Pull, 2nd detent, after the missile clears the missile rail but no later than "LASE # TRGT" is displayed in the Weapon Status field, and hold until the missile impacts the target. (TEDAC Right Handgrip)

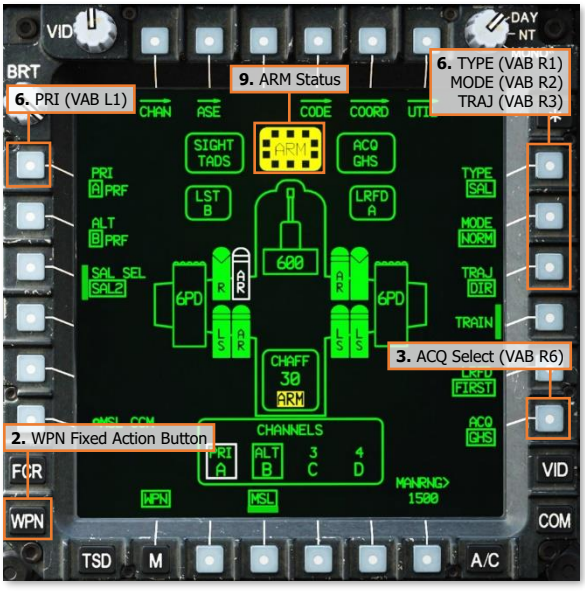


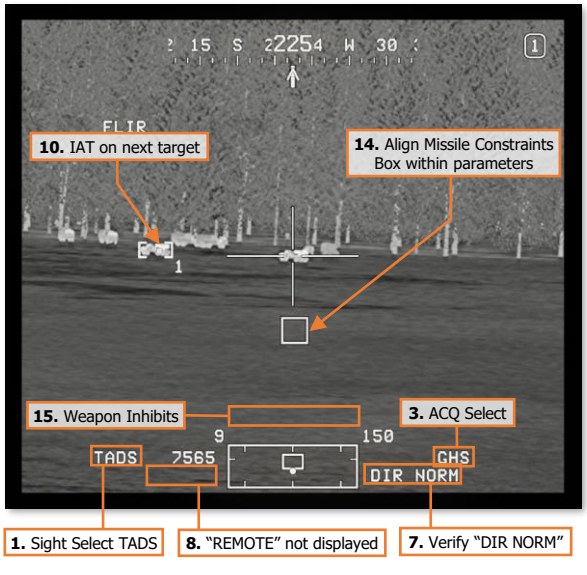
Laser-guided Hellfire Engagement (Rapid Fire)

When employing SAL missiles using Rapid Fire against multiple targets, the TADS LRFD is used by the CPG to designate each target in sequence while multiple missiles are in flight simultaneously. After the first missile impacts its target, the laser designation is shifted to the next target, which will divert the next missile while in flight. The TADS Multi-Target Tracker may be used to assist the CPG in shifting the TADS LOS Reticle to each subsequent target. (See TADS Targeting Modes for more information)

To rapidly engage multiple targets with SAL missiles, using the TADS as the selected sight to self-designate:

1. CPG Sight Select switch – TADS. (TEDAC Right Handgrip)
2. CPG WPN Fixed Action Button – Press.
3. CPG **(Optional)** Determine the appropriate acquisition source (ACQ) for acquiring the target.
   - If the target is visually acquired by either crewmember, set ACQ to PHS or GHS.
   - If the target is stored as a point within the navigational database, set ACQ to the corresponding point.
4. CPG **(Optional)** SLAVE button – Press, and then press again to de-slave when the TADS has finished slewing.
5. CPG Weapon Action Switch (WAS) – Right. (TEDAC Left Handgrip)
6. CPG Weapon settings – Verify or select. (WPN page)
   - TYPE (VAB R1) – SAL.
   - © MODE (VAB R2) – NORM or MAN.
   - TRAJ (VAB R3) – DIR.
   - © PRI (VAB L1) – Verify Priority missile channel is set to the same laser code as the LRFD.
7. CPG Weapon Status – Verify "DIR NORM" or "DIR MAN". (High Action Display)
8. CPG Sight Status – Verify "REMOTE" *is not* displayed. (High Action Display)
9. CPG A/S button – Verified in ARM. (Armament Panel)





10. CPG If the targets or aircraft are moving, engage TADS targeting modes to stabilize the TADS on target.

- Manual tracking - Engage LMC and employ the Sight Manual Tracker.
- Automatic tracking - Engage IAT on subsequent targets using MTT.

11. CPG LRFD Trigger – Pull and hold, 2nd detent, if engaging in LOBL mode. (TEDAC Right Handgrip)

12. CPG Weapon Status – Verify "PRI CHAN TRK" if engaging in LOBL mode. (High Action Display)

13. CPG Instruct the Pilot to align the aircraft with the Missile Constraints Box – "Constraints."

14. PLT Missile Constraints Box – Align toward the HMD LOS Reticle.

- Running/Diving Fire – Apply cyclic inputs in the direction of the Missile Constraints Box.
- Hover Fire – Apply pedal inputs in the direction of the Missile Constraints Box.

15. CPG Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- BACK SCATTER
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON ANGLE
- PYLON LIMIT
- RATE LIMIT
- ROLL LIMIT
- SKR LIMIT
- YAW LIMIT

16. CPG Weapon Trigger – Pull. (TEDAC Left Handgrip)

17. CPG Weapon Status – Verify "MSL LAUNCH". (High Action Display)

18. CPG LRFD Trigger – Pull and hold after the missile clears the missile rail and hold, 2nd detent, if not already lasing in LOBL mode. (TEDAC Right Handgrip)

19. CPG Weapon Status – Verify "FIRE MSLS" 8 seconds after the first missile launch. (High Action Display)

20. CPG Weapon Trigger – Pull. (TEDAC Left Handgrip)

21. CPG Weapon Status – Verify "MSL LAUNCH". (High Action Display)

22. CPG When the first missile impacts the first target, shift the TADS LOS Reticle to the next target while continuing to hold the LRFD Trigger. (TEDAC Right Handgrip)

    - Manual tracking – Use Sight Manual Tracker to shift TADS LOS Reticle to next target.
    - Automatic tracking – Use IAT/OFS switch to shift TADS LOS Reticle to next target. (See Image Auto-Track for more information.)

23. CPG LRFD Trigger – Maintain designation, 2nd detent, until the second missile impacts the second target. (TEDAC Right Handgrip)

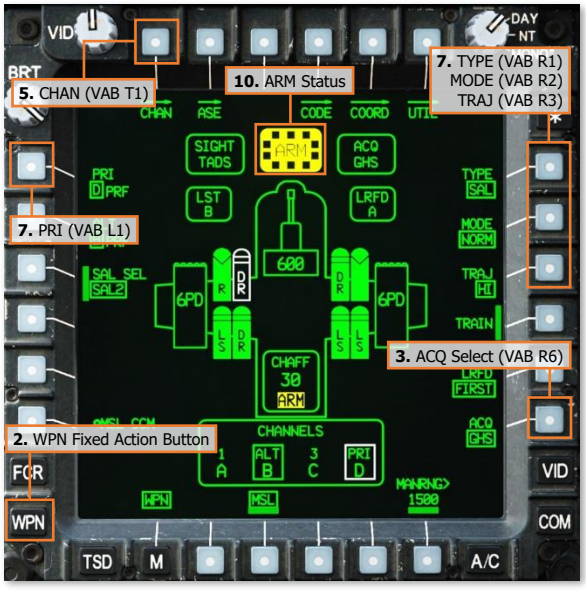
NOTE: A minimum of 8 seconds is required between missile launches to ensure the TADS LOS Reticle may be shifted to the next target with sufficient time to guide the next missile to its intended target. However, this is based on the assumption that each target is relatively close to the next. If the targets are widely spaced, the CPG should increase the interval between missile launches to ensure there is sufficient time to shift the laser designation to the next target before the missile reaches the designation.

A good rule of thumb is to only use the Rapid Fire technique if each target is simultaneously visible within the same TADS field-of-view that will be used for laser designation, and to ensure that each subsequent target is at the same range or further than the previous target.

Laser-guided Hellfire Engagement (Remote Fire, LO or HI Trajectory)

When employing a SAL missile using Remote Fire, the missile is fired in Lock-On-After-Launch (LOAL) mode toward a target location, after which an offboard source of laser designation provides terminal guidance onto the intended target. Remote Fire is conducted in similar fashion to an artillery fire mission, in which the designating platform relays the target location to which the munition should be delivered and the designator's laser code.

To engage a target with a SAL missile in LOAL-LO or LOAL-HI mode, with another platform remotely providing terminal guidance to the missile:

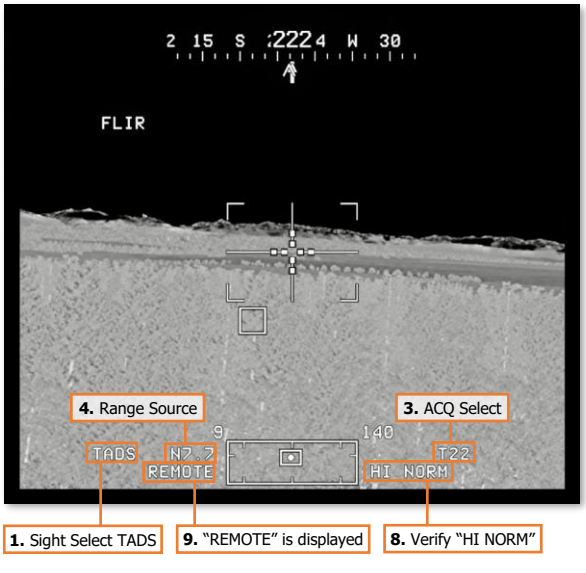


1. CPG Sight Select switch – TADS. (TEDAC Right Handgrip)
2. CPG WPN Fixed Action Button – Press.
3. CPG Determine the appropriate acquisition source (ACQ) for acquiring the target.
   - COORD (VAB T5) – Select.
   - Point (VAB L1-L6) – Select; or use paging controls to locate the target point within the database.

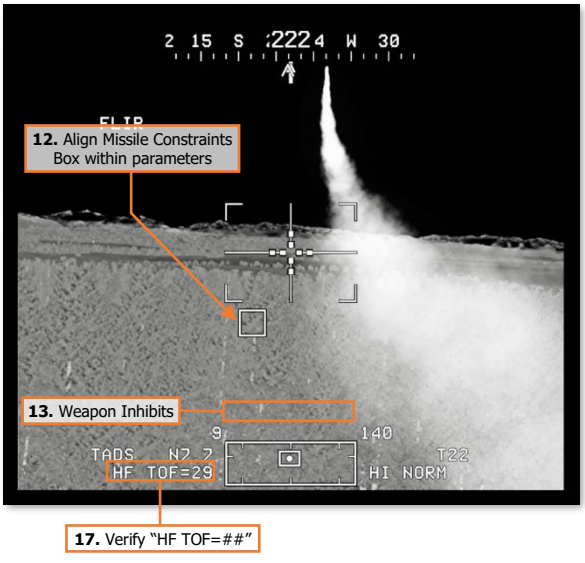
   NOTE: If the target location is not already present in the navigational database, the target point must be received via the datalink or manually input on the POINT sub-page. (See the Datalink chapter or TSD Point sub-page for more information.)
4. CPG SLAVE button – Press, and evaluate Navigation range to target.

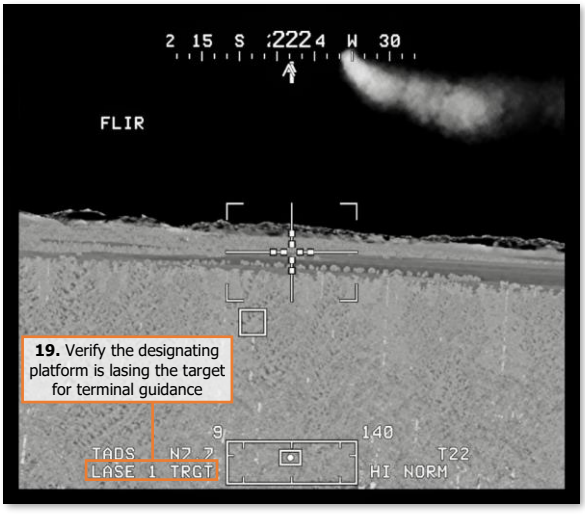
   NOTE: If range to target exceeds 8 kilometers, instruct the Pilot to re-position the aircraft as necessary prior to launch.
5. CPG CHAN (VAB T1) – Select. (WPN page)
   - © CHANNEL (VAB T2-T5) – Select any un-used missile channel.
   - © Code Selection – Select the laser code that corresponds with the designating platform.

   NOTE: If the designating platform is using a laser code that is not already present on the CHAN sub-page, the code must be manually input on the FREQ sub-page. (See WPN Frequency sub-page for more information.)
6. CPG Weapon Action Switch (WAS) – Right. (TEDAC Left Handgrip)



7. CPG Weapon settings – Verify or select. (WPN page)
   - TYPE (VAB R1) – SAL.
   - © MODE (VAB R2) – NORM or MAN.
   - TRAJ (VAB R3) – LO or HI.
   - © PRI (VAB L1) – Select, and set the missile channel corresponding with the designating platform as Priority.
8. CPG Weapon Status – Verify "LO NORM" or "LO MAN"; or "HI NORM" or "HI MAN". (High Action Display)
9. CPG Sight Status – Verify "REMOTE" is displayed. (High Action Display)
10. CPG A/S button – Verified in ARM. (Armament Panel)
11. CPG Instruct the Pilot to align the aircraft with the Missile Constraints Box – "Constraints."
12. PLT Missile Constraints Box – Align toward the HMD LOS Reticle.
    - Running/Diving Fire – Apply cyclic inputs in the direction of the Missile Constraints Box.
    - Hover Fire – Apply pedal inputs in the direction of the Missile Constraints Box.
13. CPG Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:
    - ACCEL LIMIT
    - ALT LAUNCH
    - GUN OBSTRUCT
    - PYLON ERROR
    - BAL LIMIT
    - PYLON ANGLE
    - PYLON LIMIT
    - RATE LIMIT
    - ROLL LIMIT
    - YAW LIMIT
14. PLT / CPG Verify the designating platform is ready to designate the target.
15. CPG Weapon Trigger – Pull. (TEDAC Left Handgrip)





16. CPG Sight Status – Verify "MSL LAUNCH". (High Action Display)
17. PLT / CPG Notify designating platform that the missile has been launched and the approximate time of flight.
18. CPG Sight Status – Observe "LASE # TRGT". (High Action Display)
19. PLT / CPG Verify the designating platform is lasing the target for terminal guidance.

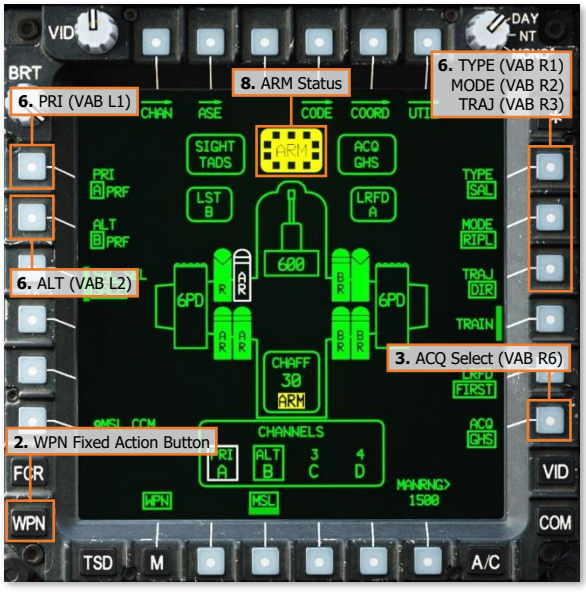
Laser-guided Hellfire Engagement (Ripple Fire)

When employing SAL missiles using Ripple (RIPL) mode against multiple targets, the missile management logic will automatically cycle the Priority and Alternate channels each time a missile is launched, allowing each missile to be guided by two separate sources of laser designation. Ripple Fire may conducted using a combination of several missile engagement techniques:

- **Lock-On-Before-Launch (LOBL).** One or both laser designators are lasing prior to launch.
- **Lock-On-After-Launch (LOAL).** One or both laser designators begin lasing after launch.
- **Remote Fire.** One or both missiles are being remotely guided by an offboard source of laser designation.
- **Rapid Fire.** Multiple missiles may be guided by each source of laser designation, with the designating platforms shifting laser designations to subsequent targets following each preceding missile impact.

In each case, the launching aircraft may or may not be providing one of the sources of laser designation. However, regardless of which platforms are providing terminal guidance to the SAL missiles, it is critical that the Priority and Alternate channels correspond with the correct laser codes, and that sufficient coordination between the launching platform and designating platform(s) is performed for a successful engagement. As an example in the procedure below, the launching aircraft will designate for the first missile while a second AH-64D team member will designate for the second missile. Both aircraft will begin designation prior to launch in LOBL mode to ensure each missile is tracking their corresponding laser codes.

To rapidly engage multiple targets with SAL missiles, using the TADS as the selected sight to self-designate for the first missile while another platform designates for the second missile:



1. CPG Sight Select switch – TADS. (TEDAC Right Handgrip)
2. CPG WPN Fixed Action Button – Press.
3. CPG **(Optional)** Determine the appropriate acquisition source (ACQ) for acquiring the target.
   - If the target is visually acquired by either crewmember, set ACQ to PHS or GHS.
   - If the target is stored as a point within the navigational database, set ACQ to the corresponding point.
4. CPG **(Optional)** SLAVE button – Press, and then press again to de-slave when the TADS has finished slewing.
5. CPG Weapon Action Switch (WAS) – Right. (TEDAC Left Handgrip)
6. CPG Weapon settings – Verify or select. (WPN page)
   - TYPE (VAB R1) – SAL.
   - © MODE (VAB R2) – RIPL.
   - TRAJ (VAB R3) – DIR.
   - © PRI (VAB L1) – Verify Priority missile channel is set to the same laser code as the LRFD.

- © ALT (VAB L2) – Verify Alternate missile channel is set to the same laser code as the team member that will be designating the second target.

7. CPG Weapon Status – Verify "DIR RIPL". (High Action Display)

8. CPG A/S button – Verified in ARM. (Armament Panel)

9. CPG If the targets or aircraft are moving, engage TADS targeting modes to stabilize the TADS on target.
   - Manual tracking - Engage LMC and employ the Sight Manual Tracker.
   - Automatic tracking - Engage IAT on each target using MTT.

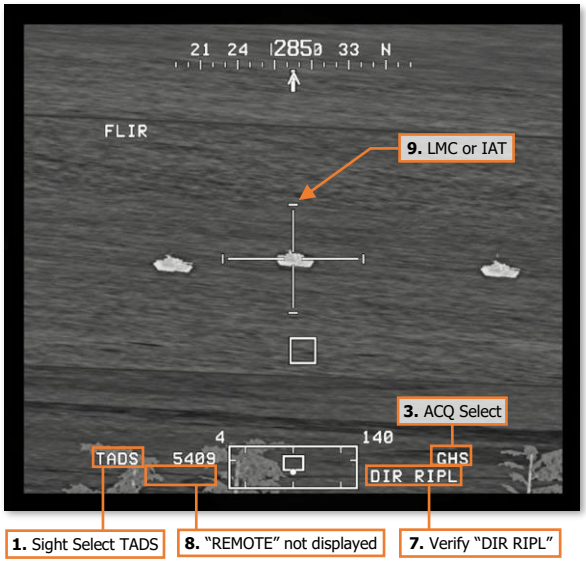
10. PLT / CPG Instruct the team member to begin designating their target.

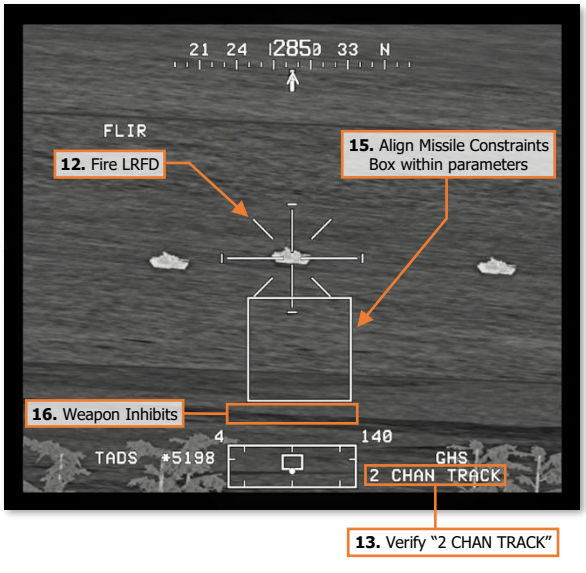
11. CPG Weapon Status – Verify "ALT CHAN TRK" is displayed after team member begins designating. (High Action Display)

12. CPG LRFD Trigger – Pull and hold, 2nd detent. (TEDAC Right Handgrip)

13. CPG Weapon Status – Verify "2 CHAN TRACK". (High Action Display)

    NOTE: If "PRI CHAN TRK" is displayed in the Weapon Status field of the High Action Display, the first missile to be launched is tracking a source of laser designation. If "ALT CHAN TRK" is displayed, the second missile to be launched is tracking a source of laser designation. If "2 CHAN TRACK" is displayed, both sources of laser designation are being tracked by the corresponding missiles.





14. CPG Instruct the Pilot to align the aircraft with the Missile Constraints Box – "Constraints."

15. PLT Missile Constraints Box – Align toward the HMD LOS Reticle.
    - Running/Diving Fire – Apply cyclic inputs in the direction of the Missile Constraints Box.
    - Hover Fire – Apply pedal inputs in the direction of the Missile Constraints Box.

16. CPG Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:
    - ACCEL LIMIT
    - ALT LAUNCH
    - BACK SCATTER
    - GUN OBSTRUCT
    - PYLON ERROR
    - BAL LIMIT
    - PYLON ANGLE
    - PYLON LIMIT
    - RATE LIMIT
    - ROLL LIMIT
    - SKR LIMIT
    - YAW LIMIT
17. CPG Weapon Trigger – Pull to launch first missile. (TEDAC Left Handgrip)
18. CPG Weapon Status – Verify "MSL LAUNCH". (High Action Display)
19. CPG Weapon Trigger – Pull to launch second missile. (TEDAC Left Handgrip)
20. CPG Weapon Status – Verify "MSL LAUNCH". (High Action Display)
21. PLT / CPG Notify the designating team member that the missiles have been launched.
22. CPG LRFD Trigger – Maintain designation, 2nd detent, until the first missile impacts the target being designated by the ownship's TADS. (TEDAC Right Handgrip)

AGM-114L Radio Frequency (RF) Missile

The AGM-114L was the first and only model of Hellfire missile that was designed to utilize radar-based guidance in lieu of laser guidance. The missile itself utilizes the same components and features of the AGM-114K, including the digital autopilot and integrated tandem warhead for defeating reactive armor, but replaced the forward nose section with a millimeter-wave radar seeker and its associated electronics. Like the "Kilo", the "Lima" was designed to destroy 21st century main battle tanks and other heavy armor. But unlike the "Kilo", the "Lima" was specifically developed to be used in conjunction with the newly fielded AH-64D.

The forward section of the "Lima" is occupied by an active-radar seeker that can detect and track moving or stationary ground targets, with a limited capacity to engage slow-moving air targets such as other helicopters. Although the missile is most effective when employed using the AN/APG-78 Fire Control Radar (FCR), the AGM-114L may also be employed when using the AN/ASQ-170 Target Acquisition Designation Sight (TADS). Prior to launch, the missile receives a handover of the target location, whether the target location data was generated by the FCR or the TADS, at which time it utilizes inertial guidance to navigate to its target.

When initially powered, the AGM-114L requires an alignment of its inertial guidance system to ensure it can properly navigate to its target. An "inertial handover" of attitude and linear velocity is provided by the AH-64D's INU to the RF missiles as a means of rapid alignment, after which the missile is ready to receive a target handover. However, due to the increased amount of electronics within the "Lima" compared to the "Kilo", the missiles may potentially overheat if the missile remains powered for extended periods of time. To mitigate this risk, the AH-64D automatically manages the missile power amongst all RF missiles loaded on the weapon stations. The automatic missile power logic will only keep a portion of the RF missile inventory powered at any given time; and will cycle power to the next sub-set of the missile inventory every 10 minutes to permit the remaining missiles to cool while keeping a number of RF missiles ready for immediate engagement.

(See WPN Missile format for more information regarding missile power management.)

Just as in the case of the AGM-114K, the AGM-114L may be employed in either a Lock-On-Before-Launch (LOBL) mode or a Lock-On-After-Launch (LOAL) mode. However, the electronics within the AGM-114L missile itself performs an automatic determination of which mode it should utilize, based on the nature of the target handover it receives. The aircrew does not have any direct control over which mode the missile defaults to, but it is possible to inhibit the RF missiles from utilizing LOBL mode, if necessary.

RF LOBL/LOAL Selection Logic

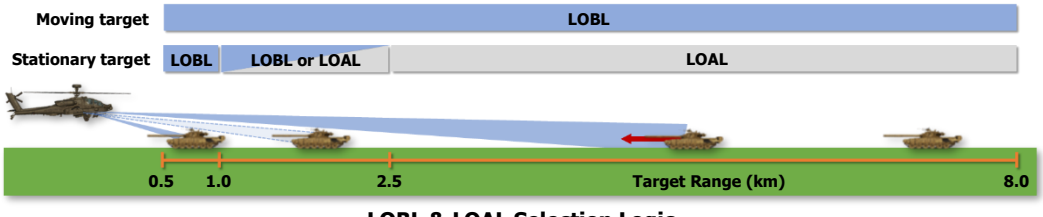
Unlike the SAL missile variants, the RF missile performs its own determination of which launch mode (LOBL or LOAL) is optimal for target acquisition, based on the nature of the target handover it receives.

Lock-On-Before-Launch (LOBL). LOBL is used to increase the likelihood of a successful engagement if the target is moving or is at a close range to the aircraft (<2.5 km). If the missile determines the optimal mode is LOBL, which will be indicated by "LOBL" being displayed in the Weapon Status field of the crewmember's High Action Display, it will immediately activate its onboard radar seeker and scan the vicinity of the target location in an attempt to acquire and track its target. If a target is successfully acquired, "RF MSL TRACK" will be displayed in the High Action Display.

- If the target is stationary but less than 1 km in range, there is insufficient time to acquire the target after launch and LOBL is necessary for a successful engagement. If target acquisition is unsuccessful, "NO ACQUIRE" will be displayed in the High Action Display, and engagement should not be attempted.
- If the target is stationary and between 1 and 2.5 km in range, there may be insufficient time to acquire the target after launch and LOBL increases the likelihood of a successful engagement. If target acquisition is unsuccessful, "LOAL" will be displayed in the High Action Display to indicate that LOAL is acceptable.
- If the target is moving at any range, LOBL is necessary for a successful engagement. If target acquisition is unsuccessful, "NO ACQUIRE" will be displayed in the High Action Display, and engagement should not be attempted.

If target acquisition has failed and it is desired to make another attempt to acquire the target prior to launch, the crewmember should de-action the missile system, which will erase the target handover data from the missile. The missiles may then be actioned once more and another target handover may be attempted. However, if ambient temperatures are high, multiple and repeated attempts to force the missile to activate its onboard radar and acquire a target may increase the likelihood of the missile overheating.

NOTE: The "LOBL" or "LOAL" messages displayed in the Weapon Status field of the High Action Display indicate the launch mode that the missile has entered; "LOBL" does not indicate the missile has acquired its target when in a LOBL state. If "LOBL" is still displayed when the RF missile is launched, prior to "RF MSL TRACK" being displayed and accompanied by a large Missile Constraints Box, the missile will launch in a LOAL state and may not successfully acquire the target after launch. (See RF Missile Constraints Box for more information)



LOBL & LOAL Selection Logic

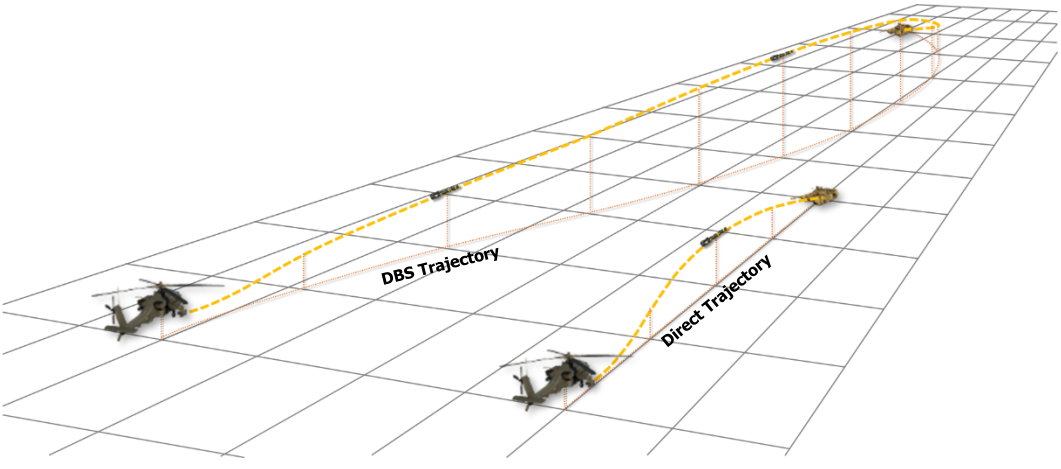
Lock-On-After-Launch (LOAL). LOAL is used if LOBL is not required to ensure a successful engagement, if the target cannot be acquired prior to launch and there is sufficient time to acquire the target after launch, or if LOBL INHIBIT is enabled on the WPN page. If the missile determines the optimal mode is LOAL, which will be indicated by "LOAL" being displayed in the Weapon Status field of the crewmember's High Action Display, it should be launched as soon as the target handover is complete to ensure a successful engagement.

- If the target is stationary and between 1 and 2.5 km in range, and LOBL is unsuccessful, "LOAL" will be displayed in the High Action Display to indicate that LOAL is acceptable.
- If the target is stationary and greater than 2.5 km in range, "LOAL" will be displayed in the High Action Display to indicate that LOAL is acceptable.

RF Post-Launch Trajectories

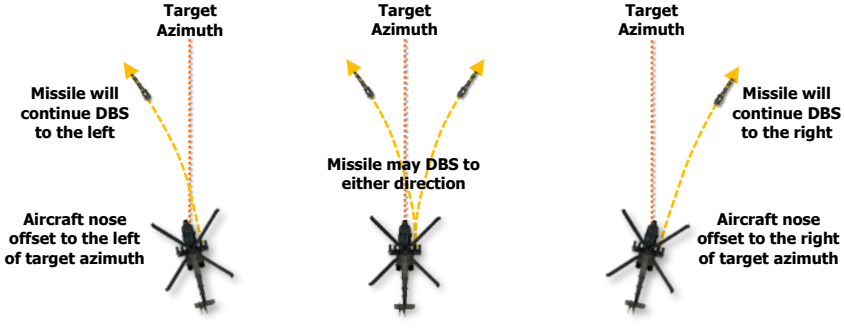
When an RF missile is launched, the missile will utilize one of two trajectories based on the missiles ability to acquire and track the target. If the missile cannot acquire or maintain a track on the target, it will utilize an off-axis flight profile to increase its radar resolution of the target amongst the ground clutter. Otherwise, the missile will use a direct flight profile toward the target.

- **Doppler Beam Sharpening (DBS) Trajectory.** When employing an off-axis flight profile, the RF missile leverages a radar processing principle known as Doppler beam sharpening to increase the radar processing resolution in order to acquire or maintain track of its target. A DBS trajectory is more likely to occur when the target is at sufficient range in which such a maneuver is possible, or when the missile is employed in LOAL launch mode. (See Doppler Beam Sharpening on the following page for more information.)
- **Direct Trajectory.** When employed against targets that are easily acquired and tracked, or against targets that are at close range with insufficient maneuver space to perform a DBS trajectory, the missile will use a direct trajectory toward the target.



RF Post-Launch Trajectories

NOTE: The RF missile may impact obstructions when utilizing a DBS trajectory after launch, such as when employed near high terrain or tall urban structures. If necessary, the nose of the aircraft may be offset to either side of the target azimuth to force the missile to execute a DBS trajectory in the corresponding direction.



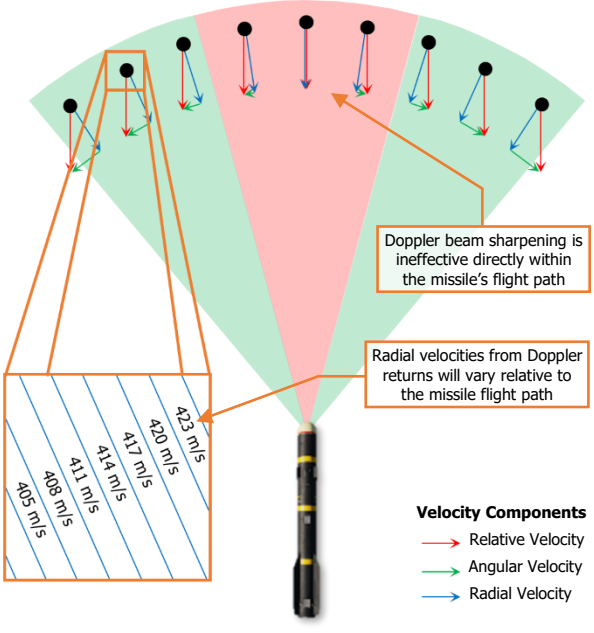
DBS Trajectory Direction

Doppler Beam Sharpening (DBS)

Doppler beam sharpening is a method of processing received radar returns to produce a higher resolution radar map and is used in many applications in the world today, even outside of military aviation. Typical real-beam radar mapping is limited in resolution, whereas Doppler beam sharpening uses differences in radial velocity to achieve a more detailed radar image. However, Doppler beam sharpening is limited by the relative aspect angle of the radar returns in relation to the movement of the transmitting radar antenna across the surface.

As the radar antenna moves across the surface, whether it is mounted to an aircraft like the F-16 or a missile like the AGM-114L, radar returns are received from terrain and objects such as vegetation, structures, or vehicles. Even if all detected objects are stationary, the velocity of the missile itself generates a measurable shift in the frequency of the electromagnetic radar energy reflected back toward the missile seeker; a Doppler effect. However, radar reflections that are received from either side of the missile's track across the surface will generate a lower Doppler shift due to their lower radial velocity compared to those directly in front of the missile. The greater the angular offset from the missile's flight path, the lower the measured radial velocity.

As the radar returns are processed for these small differences in Doppler shift, the returns from any location within the radar image can be calculated and further separated into distinct points to account for the deviations in radial velocity. This results in a more refined and higher resolution radar image.

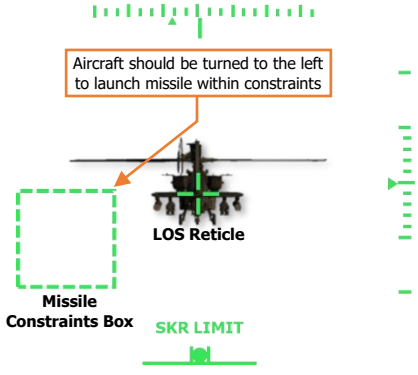


Doppler Beam Sharpening Processing Method

Since Doppler beam sharpening relies on a sufficient difference in Doppler frequency within a measurable area, such calculations cannot be performed when the radar is scanning an area directly in front of the missile's flight path (nor directly abeam). As a result, Doppler beam sharpening is rendered ineffective unless the scanned area is sufficiently offset to either side of the missile's flight path. When Doppler beam sharpening is necessary to acquire and track a given target, the AGM-114L will fly an off-axis DBS trajectory to permit this processing method.

RF Missile Constraints Box

The key piece of symbology associated with employing the AGM-114L is the Missile Constraints Box displayed within the crewmember's sight symbology. The Missile Constraints Box is a steering cue and launch mode indicator which indicates the launch mode of the missile and whether the missile is within acceptable launch constraints.



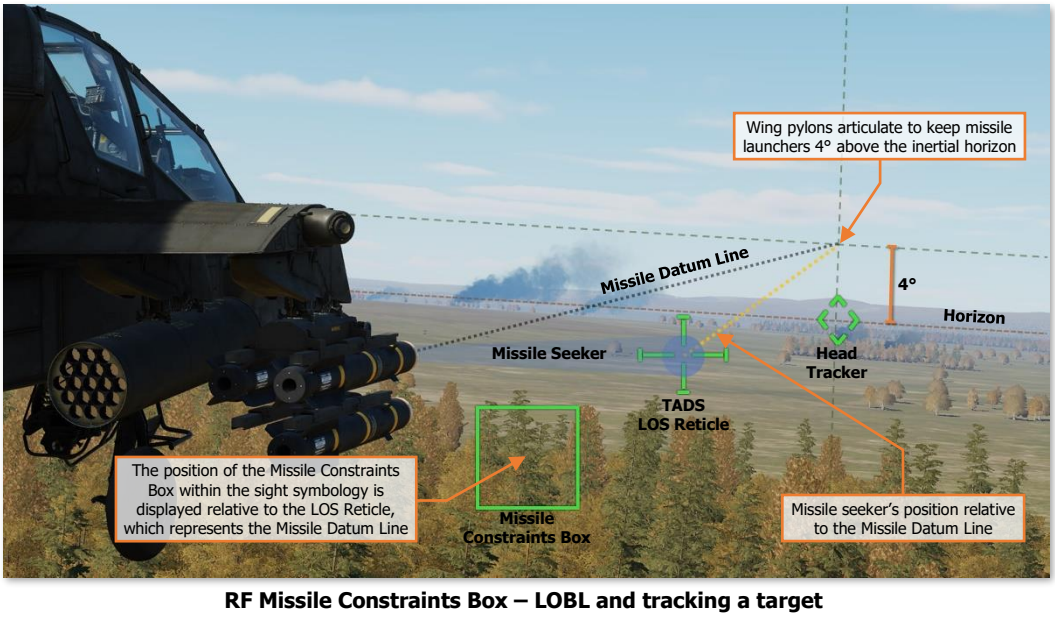
The Missile Constraints Box is longitudinally-scaled and is *not* a virtual symbology element; its displayed location does not correspond with a real-world location that is observed "out-the-window" like the Head Tracker or Flight Path Vector. The position of the Missile Constraints Box is referenced from the LOS Reticle, which corresponds to the Missile Datum Line (0° in azimuth and elevation from the longitudinal axis of the missile body). However, the referenced position of which the Missile Constraints Box represents is either the target location relative to the Missile Datum Line; or ,specifically in the case when TADS is the selected sight and a target handover has not yet been performed, the Missile Constraints Box is derived from the position of the TADS turret relative to the Missile Datum Line.

To augment the missiles' post-launch trajectory and to ensure the missiles do not strike the ground, the wing pylons articulate in the vertical axis to maintain the pylon angle of each missile launcher 4° above the inertial horizon when the missiles are actioned. This results in the Missile Datum Line of each missile being stabilized 4° above the horizon regardless of the aircraft pitch attitude.

Lock-On-Before-Launch Mode (LOBL), Missile Tracking (RF MSL TRACK)

If the missile is in LOBL mode and is tracking a target with its onboard seeker, the Missile Constraints Box corresponds with the position of the missile's seeker, in azimuth and elevation, relative to the Missile Datum Line.

The maximum allowable offset angle for the RF missile in LOBL mode is 20° for targets at a range of 1 km or greater, or 5° for targets at ranges less than 1 km; otherwise, the Constraints Box will be displayed as invalid, indicating the missile is outside of launch constraints. (See Missile Constraints Box Format for more information.)

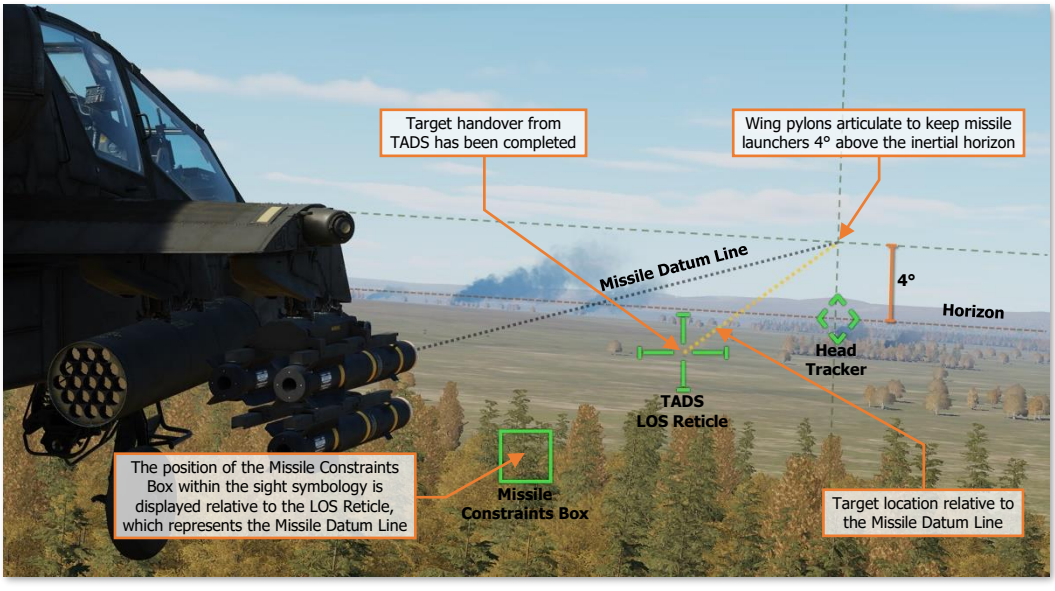


RF Missile Constraints Box – LOBL and tracking a target

Lock-On-After-Launch Mode (LOAL), Target Handover Complete

If the missile has received a target handover and is in LOAL mode, the Missile Constraints Box corresponds with the location of the target, in azimuth and elevation, relative to the Missile Datum Line.

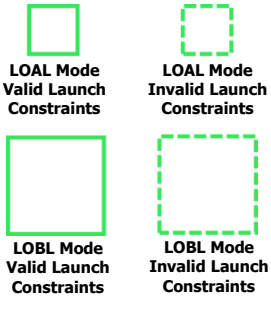
The maximum allowable offset angle for the RF missile in LOAL mode is 20° for targets at a range of 1 kilometer or greater; otherwise, the Constraints Box will be displayed as invalid, indicating the missile is outside of launch constraints. (See Missile Constraints Box Format for more information.)



RF Missile Constraints Box – LOAL with a successful target handover

RF Missile Constraints Box Format

The Missile Constraints Box is displayed in four formats to indicate the missile's launch mode (LOBL or LOAL) and whether the missile is within acceptable launch constraints (Valid or Invalid).



If the missile seeker is not tracking a target after receiving a target handover, the missile will be launched in Lock-On-After-Launch (LOAL) mode.

If the missile seeker acquired and is tracking a target, the missile will be launched in Lock-On-Before-Launch (LOBL) mode.

If the missile is within acceptable launch constraints and no Weapon Inhibit messages are displayed within the High Action Display, the Missile Constraints Box will be displayed as Valid.

If the missile is outside acceptable launch constraints or any Weapon Inhibit messages are displayed within the High Action Display, the Missile Constraints Box will be displayed as Invalid.

- **LOBL Constraints (< 1 km).** Missile seeker LOS is offset ≤ 5° from the Missile Datum Line.
- **LOBL Constraints (≥ 1 km).** Missile seeker LOS is offset ≤ 20° from the Missile Datum Line.
- **LOAL Constraints (≥ 1 km).** Line-of-sight (LOS) to the target is offset ≤ 20° from the Missile Datum Line.

RF Missile Weapon Inhibits

The following conditions will inhibit the RF missiles from being fired. Performance inhibits may be overridden by pulling the trigger to the 2nd detent. Safety inhibits cannot be overridden.

Performance Inhibits

INHIBIT	CONDITION	CORRECTIVE ACTION
BAL LIMIT	The required weapon aiming solution exceeds the ballistics processing capability.	If tactically feasible, engage the target at a closer range.
PYLON ANGLE	The position of the missile launcher(s) is ≥10° from the optimum launch position or the pylon position is unknown.	Wait for the missile launchers to reach the optimum launch position. If inhibit message remains, missiles may still be fired but the missile launcher positions should be visually confirmed to ensure the appropriate considerations may be made for a successful engagement.
PYLON LIMIT (IN FLIGHT)	The commanded position of the missile launcher(s) exceeds the pylon articulation limits. (+4° to -15°).	Adjust the aircraft pitch attitude as necessary to bring the articulation range of the wing pylons to +4° above the inertial horizon.
RATE LIMIT	The pitch, roll, and/or yaw rates are excessive.	Stabilize the aircraft attitude prior to launch.
ROLL LIMIT	The roll angle of the aircraft is excessive.	Reduce the roll attitude of the aircraft prior to launch.
SKR LIMIT	The missile seeker has reached a gimbal limit.	Adjust the heading or pitch attitude of the aircraft to bring the target within the missile seeker field-of-view. (e.g., turn toward the Missile Constraints box).
YAW LIMIT	When the missile is in LOAL mode, the target position relative to the aircraft heading is excessive.	Adjust the heading of the aircraft to bring the target position closer to the aircraft centerline. (e.g., turn toward the Missile Constraints box).

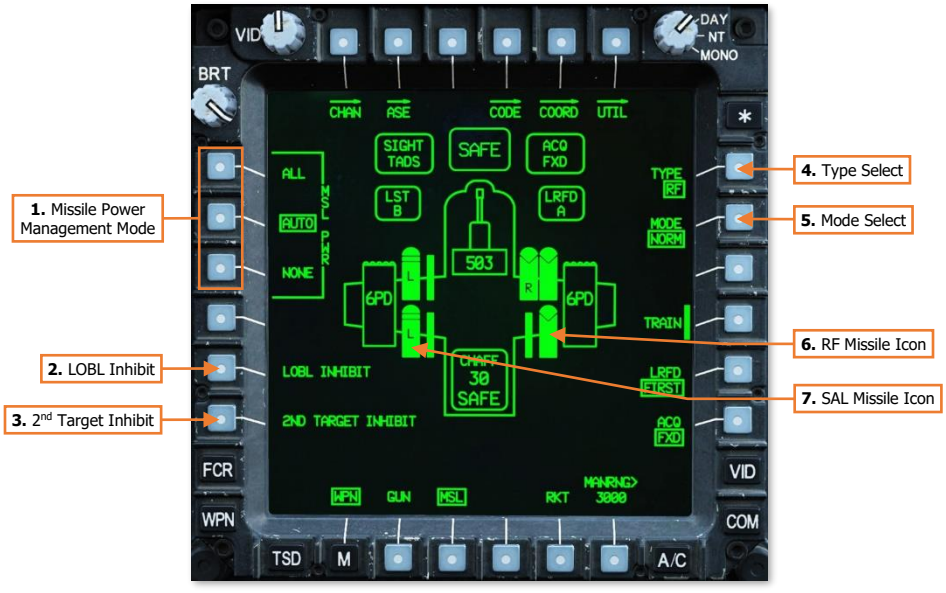
Safety Inhibits

INHIBIT	CONDITION	CORRECTIVE ACTION
ACCEL LIMIT	Vertical acceleration is <0.5 G; the main rotor blades may obstruct the trajectory of the missile when fired.	Reduce the severity of the current maneuver to increase the positive G load on the aircraft.
ALT LAUNCH	The firing of a rocket salvo is already in progress.	The missile may be fired 2 seconds after the rocket salvo is complete.
GUN OBSTRUCT	The gun is out of coincidence from the weapon aiming solution and may obstruct the trajectory of missiles fired from the inboard wing pylons.	If tactically feasible, instruct the crewmember that has actioned the gun to de-action in order to permit the firing of missiles. A different missile may be manually selected by setting the Mode to MAN and pressing the Missile Advance button.

LOS INVALID	The line-of-sight of the selected sight is invalid or has failed.	Select a different sight for engagement.
MSL NOT RDY	No RF missiles have received an inertial alignment from the aircraft. A missile has not been selected in MAN mode.	Ensure MSL PWR is set to ALL or AUTO to permit RF missiles to receive inertial alignment. Press the Missile Advance button to select the next missile in MAN mode.
PYLON ERROR	The aircraft is on the ground (weight-on-wheels) and the missile launcher positions are unknown.	If inhibit message remains, the corresponding wing pylons may have experienced a failure and the missiles should be de-actioned.
PYLON LIMIT (ON GROUND)	The commanded position of the missile launcher(s) exceeds the pylon articulation limits. (+4° to -5°).	The missiles should be de-actioned.
SAFE	The master armament state is currently set to SAFE; weapons cannot be fired.	Set the A/S button on the Armament Panel to ARM.

WPN Missile (MSL) Format – RF Missile Settings

When RF missiles are selected for employment within the crewstation, the WPN page will display RF missile settings when set to MSL format.



1. **Missile Power Management Mode.** When the Mode is set to NORM, selects the power management setting for all AGM-114L missiles loaded on the aircraft. This setting is common between crewstations.
   - **ALL.** All RF missiles are powered on. All RF missiles perform an inertial alignment and self-test, and are ready to receive target handovers, but may overheat if left in this state for an extended period.
   - **AUTO.** Power to RF missiles is automatically managed based on missile inventory quantity. Sub-sets of the missile inventory are powered and aligned in 10-minute intervals. After 10 minutes have elapsed, the missiles are powered off and the next sub-set of the inventory is powered and aligned. This ensures that a portion of the inventory is ready to receive target handovers while mitigating the risk of missiles overheating.
     - If 8 or more RF missiles are loaded, 4 missiles are kept in a "Ready" state.
     - If 4 to 7 RF missiles are loaded, 2 missiles are kept in a "Ready" state.
     - If 2 or 3 RF missiles are loaded, 1 missile is kept in a "Ready" state.
     - If 1 RF missile is loaded, the missile will be powered on to a "Ready" state when either crewstation actions missiles with TYPE (VAB R1) set to RF. If the missiles are de-actioned or if the TYPE is set to SAL, the singular RF missile will be powered off.
   - **NONE.** All RF missiles are powered off. All RF missiles remain unaligned and are unable to receive target handovers, but are prevented from overheating.
2. **LOBL Inhibit.** RF missiles are inhibited from emitting radar signals prior to launch. This will prevent AGM-114L missiles from entering LOBL mode or tracking assigned targets prior to launch.
3. **2nd Target Inhibit.** Not implemented.

4. **Type Select.** Displays the selected missile type for employment. This setting is independent between crewstations and is contextually dependent on the selected sight within the crewstation.
   - **SAL.** SAL missiles are selected for employment from the crewstation. The High Action Display will display relevant symbology for SAL missile employment and the WPN page will display SAL missile settings when set to MSL format.
     - If the selected sight is set to HMD, SAL is automatically selected as the missile type and crewmember selection will be inhibited.
   - **RF.** RF missiles are selected for employment from the crewstation. The High Action Display will display relevant symbology for RF missile employment and the WPN page will display RF missile settings when set to MSL format.
     - If the selected sight is set to FCR, RF is automatically selected as the missile type and crewmember selection will be inhibited.
5. **Mode Select.** Selects the mode of missile inventory management. This setting is common between crewstations.
   - **NORM.** Missile inventory, power management, and launch sequencing is managed automatically. Missile launches will be alternated between each wing station to maintain center-of-gravity, as appropriate.
     - Missile power management will be in accordance with the MSL PWR selection (VAB L1-L3).
   - **MAN.** Missile inventory, power management, and launch sequencing is managed manually by the aircrew. Missile launches may lead to asymmetric loading and may cause center-of-gravity issues. Improper power management may lead to missile over-temperature conditions.
     - A single missile is selected and powered. The Missile Advance button on the Collective Mission Grip or the TEDAC Right Handgrip may be used to select the next missile for launch. As each missile is fired, the Missile Advance button must be used to select and power the next missile.
6. **RF Missile Icon.** Indicates an AGM-114L missile is loaded onto the corresponding missile launcher rail. The missile icon appearance and text label indicate the operational state and status of the missile.

An RF missile is loaded onto the corresponding missile launcher rail.

A solid missile icon is displayed when the WPN page is in MSL format.

A hollow, white, flashing missile icon indicates the next missile to be fired.

Missile is in a Standby status while a built-in-test is performed.

Missile is powered and in a Ready status.

Next missile to be fired is in a Tracking status.

Missile is powered and indicating it is in an over-temperature status.

7. **SAL Missile Icon.** Indicates an AGM-114K missile is loaded onto the corresponding missile launcher rail. The missile icon appearance and text label indicate the operational state and status of the missile. (See SAL Missile Type Settings for more information.)

RF Missile Weapon Status Messages

The following messages will be displayed in the High Action Display based on current missile status or weapon page settings when missiles are actioned and the missile type is set to RF.

INHIBIT	CONDITION
HF TOF=##	The remaining time of flight (in seconds) for the next RF missile.
LOAL MAN	The next-to-launch RF missile is in LOAL mode. Missile management mode is set to MAN.
LOAL NORM	The next-to-launch RF missile is in LOAL mode. Missile management mode is set to NORM.
LOBL INHIBIT	LOBL INHIBIT has been enabled on the WPN page. The next-to-launch RF missile is forced to LOAL mode.
LOBL MAN	The next-to-launch RF missile is in LOBL mode and attempting to acquire a target. Missile management mode is set to MAN.
LOBL NORM	The next-to-launch RF missile is in LOBL mode and attempting to acquire a target. Missile management mode is set to NORM.
MSL LAUNCH	A launch has been commanded of the next RF missile.
MSL TYPE?	Missiles are actioned but no missiles of the selected type (SAL or RF) are available.
NO ACQUIRE	The next-to-launch missile requires LOBL for a successful engagement but has failed to acquire at target. Launch should not be attempted.
NO MISSILES	Missiles are actioned but no SAL or RF missiles are available.
RF MSL TRACK	The next-to-launch missile is in LOBL mode and is tracking a target.
WEAPON?	The weapon trigger has been pulled but no weapon has been actioned.

Radar-guided Hellfire Engagement (FCR, Ground Targeting Mode)

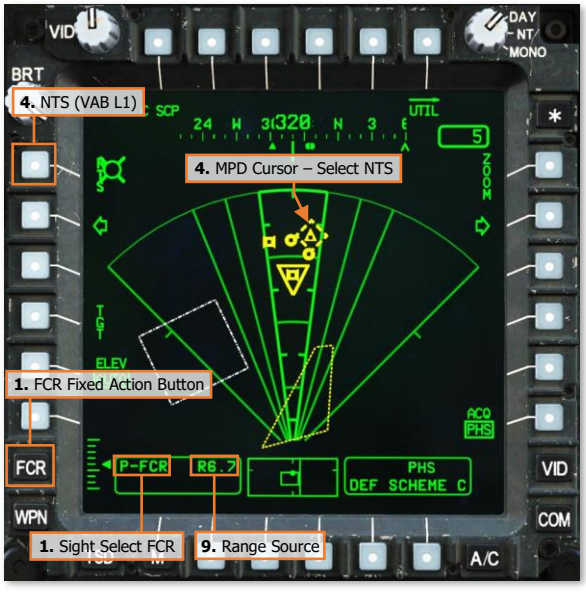
When employing an RF missile from either crewstation using the FCR, the target data is transferred to the AGM-114L when the missiles are actioned and an NTS target is selected. When missiles are actioned in the CPG crewstation, the Missile Constraints Box will also be displayed in the Pilot crewstation to ensure the aircraft is maneuvered to within acceptable launch constraints.

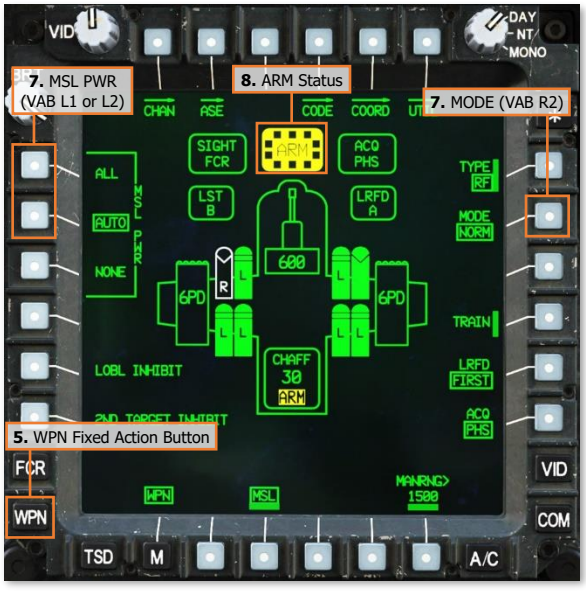
To engage a ground target with an RF missile while using the FCR in GTM to generate a target handover:

1. Sight Select switch – FCR. (Collective Mission Grip or TEDAC Right Handgrip)
2. FCR Mode switch – GTM. (Collective Mission Grip or TEDAC Left Handgrip)
3. FCR Scan switch – S-SCAN. (Collective Mission Grip or TEDAC Left Handgrip)
4. NTS (VAB L1) – Select NTS target.

   or

4. MPD Cursor Controller/Enter – Select desired target for engagement.
5. WPN Fixed Action Button – Press.
6. Weapon Action Switch (WAS) – Right. (Cyclic Grip or TEDAC Left Handgrip)
7. Weapon settings – Verify or select. (WPN page)
   - © MODE (VAB R2) – NORM or MAN.
   - © MSL PWR (VAB L1 or L2) – ALL or AUTO.
8. A/S button – Verified in ARM. (Armament Panel)
9. Range source – Verify Radar range is within appropriate engagement range.





Launch Mode Selection (LOBL/LOAL)

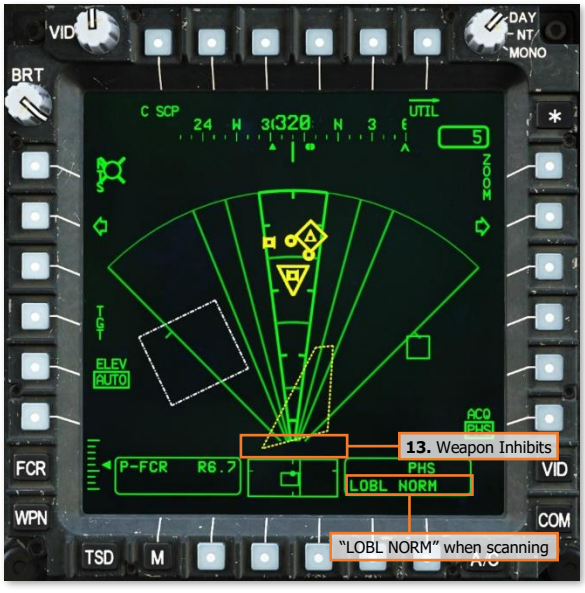
After the target data has been received, the RF missile will automatically select LOBL or LOAL mode based on the nature of the target data itself. (See RF LOBL/LOAL Selection Logic for more information.)

If the missile is attempting to lock on to a target, "LOBL NORM" or "LOBL MAN" will be displayed within the Weapon Status field of the High Action Display.

If the missile successfully acquires a target in LOBL mode, "RF MSL TRACK" will be displayed in the Weapon Status field.

If the missile fails to acquire a target that is moving or is less than 1 kilometer in range, "NO ACQUIRE" will be displayed in the Weapon Status field. The missile may still be fired in LOAL mode, but the missile may not hit the target. The missiles should be de-actioned to erase the target handover and re-actioned to attempt another target handover.

If the missile is not attempting to lock on to a target or has failed to acquire a stationary target between 1 and 2.5 kilometer in range, "LOAL NORM" or "LOAL MAN" will be displayed within the Weapon Status field.



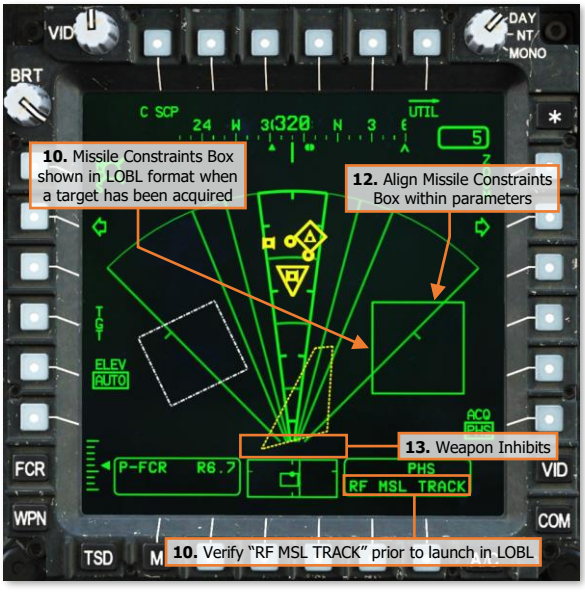
10. Weapon Status – Verify "RF MSL TRACK", "LOAL NORM", or "LOAL MAN". (High Action Display)

NOTE: "LOBL INHIBIT" may also be displayed if enabled on the WPN page.

11. CPG **(If CPG)** Instruct the Pilot to align the aircraft with the Missile Constraints Box – "Constraints."

12. PLT Missile Constraints Box – Align toward the HMD LOS Reticle.

- Running/Diving Fire – Apply cyclic inputs in the direction of the Missile Constraints Box.
- Hover Fire – Apply pedal inputs in the direction of the Missile Constraints Box.



13. Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON ANGLE
- PYLON LIMIT
- RATE LIMIT
- ROLL LIMIT
- SKR LIMIT
- YAW LIMIT

14. Weapon Trigger – Pull. (Cyclic or TEDAC Left Handgrip)

15. Weapon Status – Verify "MSL LAUNCH". (High Action Display)

NOTE: When engaging a target with an RF missile in LOAL mode, the Pilot should align the aircraft within launch constraints and the missile should be fired as soon as possible after target handover to the missile.

Radar-guided Hellfire Engagement (FCR, Air Targeting Mode)

When employing an RF missile from either crewstation using the FCR, the target data is transferred to the AGM-114L when the missiles are actioned and an NTS target is selected. When missiles are actioned in the CPG crewstation, the Missile Constraints Box will also be displayed in the Pilot crewstation to ensure the aircraft is maneuvered to within acceptable launch constraints.

To engage an airborne target with an RF missile while using the FCR in ATM to generate a target handover:

1. Sight Select switch – FCR. (Collective Mission Grip or TEDAC Right Handgrip)

2. FCR Mode switch – ATM. (Collective Mission Grip or TEDAC Left Handgrip)

3. FCR Scan switch – S-SCAN. (Collective Mission Grip or TEDAC Left Handgrip)

4. NTS (VAB L1) – Select NTS target.

or

4. MPD Cursor Controller/Enter – Select desired target for engagement.

5. WPN Fixed Action Button – Press.

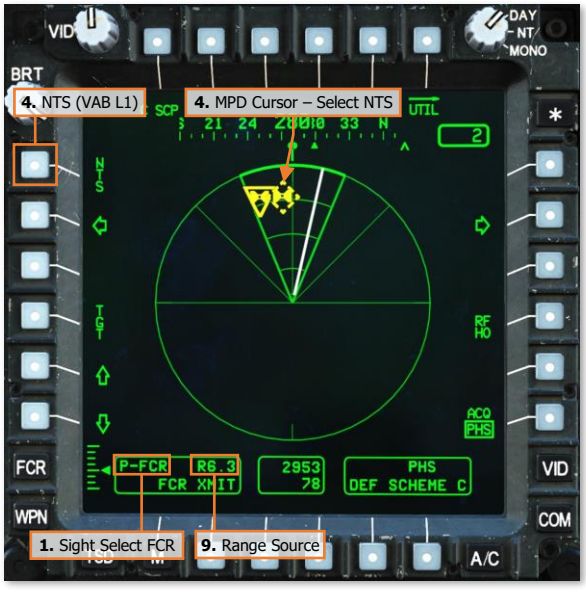
6. Weapon Action Switch (WAS) – Right. (Cyclic Grip or TEDAC Left Handgrip)

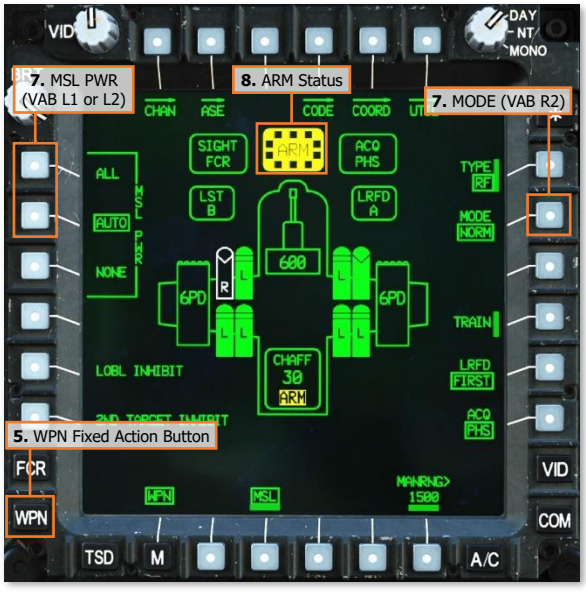
7. Weapon settings – Verify or select. (WPN page)

- © MODE (VAB R2) – NORM or MAN.
- © MSL PWR (VAB L1 or L2) – ALL or AUTO.

8. A/S button – Verified in ARM. (Armament Panel)

9. Range source – Verify Radar range is within appropriate engagement range.





Launch Mode Selection (LOBL/LOAL)

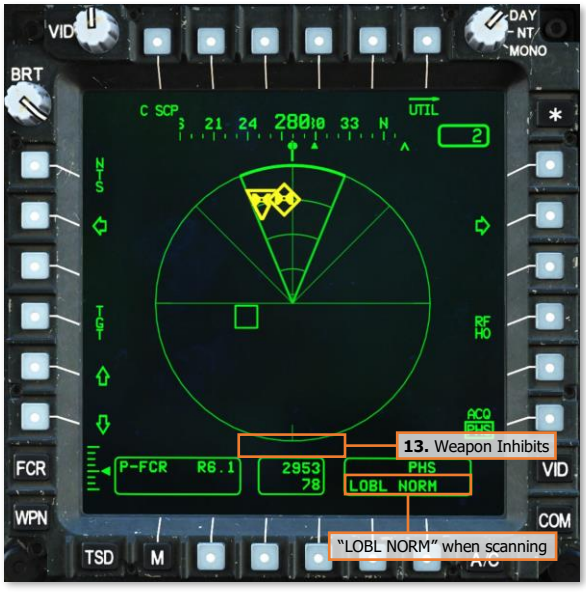
After the target data has been received, the RF missile will automatically select LOBL or LOAL mode based on the nature of the target data itself. (See RF LOBL/LOAL Selection Logic for more information.)

If the missile is attempting to lock on to a target, "LOBL NORM" or "LOBL MAN" will be displayed within the Weapon Status field of the High Action Display.

If the missile successfully acquires a target in LOBL mode, "RF MSL TRACK" will be displayed in the Weapon Status field.

If the missile fails to acquire a target that is moving or is less than 1 kilometer in range, "NO ACQUIRE" will be displayed in the Weapon Status field. The missile may still be fired in LOAL mode, but the missile may not hit the target. The missiles should be de-actioned to erase the target handover and re-actioned to attempt another target handover.

If the missile is not attempting to lock on to a target or has failed to acquire a stationary target between 1 and 2.5 kilometer in range, "LOAL NORM" or "LOAL MAN" will be displayed within the Weapon Status field.



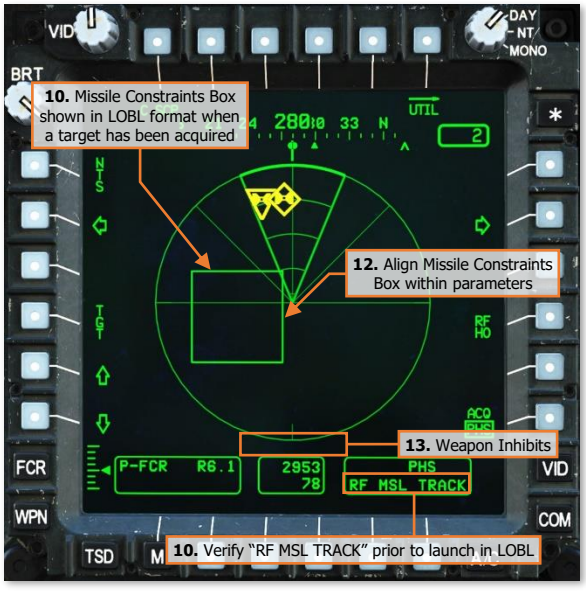
10. Weapon Status – Verify "RF MSL TRACK", "LOAL NORM", or "LOAL MAN". (High Action Display)

NOTE: "LOBL INHIBIT" may also be displayed if enabled on the WPN page.

11. CPG **(If CPG)** Instruct the Pilot to align the aircraft with the Missile Constraints Box – "Constraints."

12. PLT Missile Constraints Box – Align toward the HMD LOS Reticle.

- Running/Diving Fire – Apply cyclic inputs in the direction of the Missile Constraints Box.
- Hover Fire – Apply pedal inputs in the direction of the Missile Constraints Box.



13. Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON ANGLE
- PYLON LIMIT
- RATE LIMIT
- ROLL LIMIT
- SKR LIMIT
- YAW LIMIT

14. Weapon Trigger – Pull. (Cyclic or TEDAC Left Handgrip)

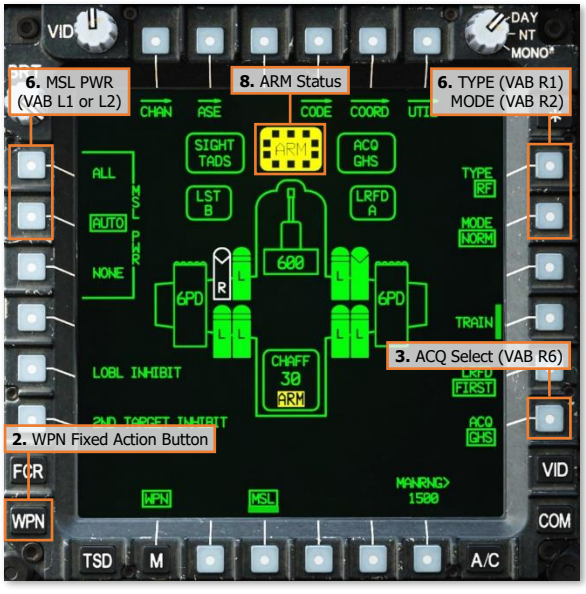
15. Weapon Status – Verify "MSL LAUNCH". (High Action Display)

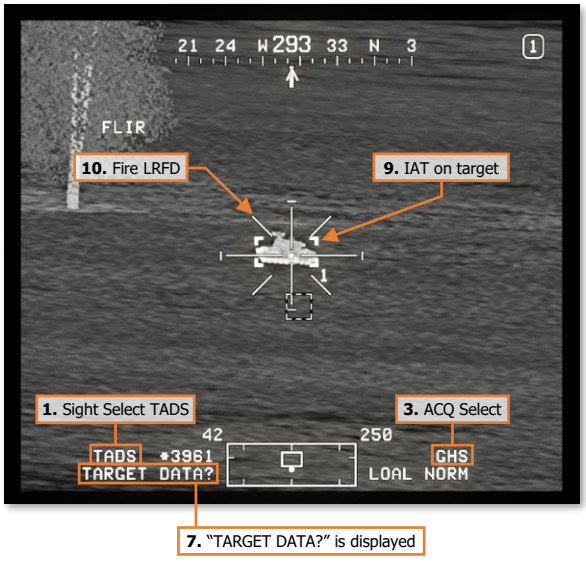
NOTE: When engaging a target with an RF missile in LOAL mode, the Pilot should align the aircraft within launch constraints and the missile should be fired as soon as possible after target handover to the missile.

Radar-guided Hellfire Engagement (TADS)

When employing an RF missile while using the TADS to generate targeting data, the target is designated by the TADS LRFD for 3 seconds prior to missile launch. TADS LMC and/or IAT targeting modes should be used to assist the CPG in stabilizing the TADS LOS Reticle on the target, which will increase the accuracy of the target data sent to the missile. When missiles are actioned in the CPG crewstation, the Missile Constraints Box will also be displayed in the Pilot crewstation to ensure the aircraft is maneuvered to within acceptable launch constraints.

To engage a target with an RF missile while using the TADS to generate a target handover:

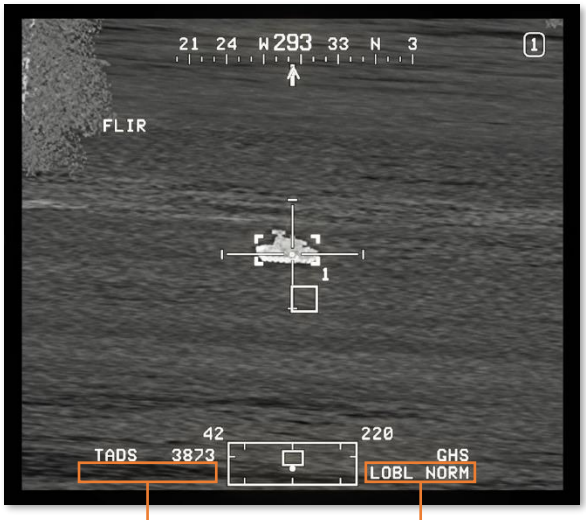




1. CPG Sight Select switch – TADS. (TEDAC Right Handgrip)
2. CPG WPN Fixed Action Button – Press.
3. CPG **(Optional)** Determine the appropriate acquisition source (ACQ) for acquiring the target.
   - If the target is visually acquired by either crewmember, set ACQ to PHS or GHS.
   - If the target is stored as a point within the navigational database, set ACQ to the corresponding point.
4. CPG **(Optional)** SLAVE button – Press, and then press again to de-slave when the TADS has finished slewing.
5. CPG Weapon Action Switch (WAS) – Right. (TEDAC Left Handgrip)
6. CPG Weapon settings – Verify or select. (WPN page)
   - TYPE (VAB R1) – RF.
   - © MODE (VAB R2) – NORM or MAN.
   - © MSL PWR (VAB L1 or L2) – ALL or AUTO.
7. CPG Sight Status – Verify "TARGET DATA?" is displayed. (High Action Display)
8. CPG A/S button – Verified in ARM. (Armament Panel)
9. CPG If the target or aircraft are moving, engage TADS targeting modes to stabilize the TADS on target.
   - Manual tracking - Engage LMC and employ the Sight Manual Tracker.
   - Automatic tracking - Engage IAT.

10. CPG LRFD Trigger – Pull and hold for 3 seconds, 2nd detent, until "TARGET DATA?" is removed from the Sight Status field. (TEDAC Right Handgrip)

NOTE: When "TARGET DATA?" is removed from the Sight Status field, the LRFD trigger may be released.



10. "TARGET DATA?" not displayed

10. "LOBL NORM" when scanning

Launch Mode Selection (LOBL/LOAL)

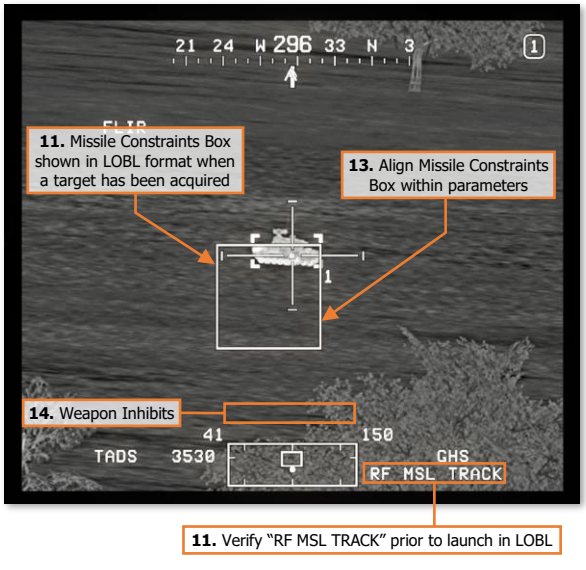
After the target data has been received, the RF missile will automatically select LOBL or LOAL mode based on the nature of the target data itself. (See RF LOBL/LOAL Selection Logic for more information.)

If the missile is attempting to lock on to a target, "LOBL NORM" or "LOBL MAN" will be displayed within the Weapon Status field of the High Action Display.

If the missile successfully acquires a target in LOBL mode, "RF MSL TRACK" will be displayed in the Weapon Status field.

If the missile fails to acquire a target that is moving or is less than 1 kilometer in range, "NO ACQUIRE" will be displayed in the Weapon Status field. The missile may still be fired in LOAL mode, but the missile may not hit the target. The missiles should be de-actioned to erase the target handover and re-actioned to attempt another target handover.

If the missile is not attempting to lock on to a target or has failed to acquire a stationary target between 1 and 2.5 kilometers in range, "LOAL NORM" or "LOAL MAN" will be displayed within the Weapon Status field.



11. CPG Weapon Status – Verify "RF MSL TRACK", "LOAL NORM", or "LOAL MAN". (High Action Display)

NOTE: "LOBL INHIBIT" may also be displayed if enabled on the WPN page.

12. CPG Instruct the Pilot to align the aircraft with the Missile Constraints Box – "Constraints."

13. PLT Missile Constraints Box – Align toward the HMD LOS Reticle.

- Running/Diving Fire – Apply cyclic inputs in the direction of the Missile Constraints Box.
- Hover Fire – Apply pedal inputs in the direction of the Missile Constraints Box.

14. CPG Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

- ACCEL LIMIT
- ALT LAUNCH
- GUN OBSTRUCT
- PYLON ERROR
- BAL LIMIT
- PYLON ANGLE
- PYLON LIMIT
- RATE LIMIT
- ROLL LIMIT
- SKR LIMIT
- YAW LIMIT

15. CPG Weapon Trigger – Pull. (TEDAC Left Handgrip)

16. CPG Weapon Status – Verify "MSL LAUNCH". (High Action Display)

NOTE: When engaging a target with an RF missile in LOAL mode, the Pilot should align the aircraft within launch constraints and the CPG should fire the missile as soon as possible after the target handover to the missile, signified by "TARGET DATA?" being removed from the Sight Status field of the High Action Display.

Radar-guided Hellfire Engagement (RF Handover)

When employing an RF missile after receiving an RFHO via the datalink, the RFHO target data is stored as the FCR Next-To-Shoot (NTS) target, even if the receiving AH-64D is not equipped with an FCR itself. When missiles are actioned, the target data is transferred to the AGM-114L. The Missile Constraints Box will also be displayed in the Pilot crewstation to ensure the aircraft is maneuvered to within acceptable launch constraints.

To engage a target with an RF missile while using an RF Handover (RFHO) to generate a target handover:

1. TSD Fixed Action Button – Press.
2. RF Handover (RFHO) – Receive (TSD page)
   - REC (VAB L2) - Select.
   - RFHO (VAB L2-L5) – Select.
3. Sight Select switch – FCR. (Collective Mission Grip or TEDAC Right Handgrip)
4. Weapon Action Switch (WAS) – Right. (Cyclic Grip or TEDAC Left Handgrip)
5. Weapon settings – Verify or select. (WPN page)
   - © MODE (VAB R2) – NORM or MAN.
   - © MSL PWR (VAB L1 or L2) – ALL or AUTO.
6. A/S button – Verified in ARM. (Armament Panel)
7. Range source – Verify Radar range is within appropriate engagement range.

Launch Mode Selection (LOBL/LOAL)

After the target data has been received, the RF missile will automatically select LOBL or LOAL mode based on the nature of the target data itself. (See RF LOBL/LOAL Selection Logic for more information.)

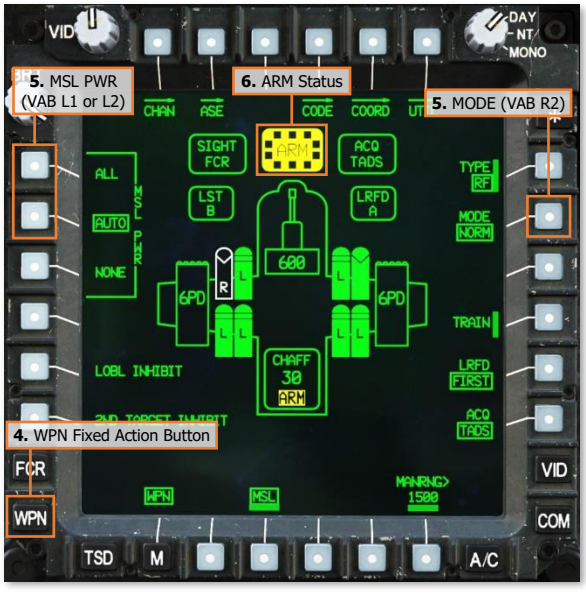
If the missile is attempting to lock on to a target, "LOBL NORM" or "LOBL MAN" will be displayed within the Weapon Status field of the High Action Display.

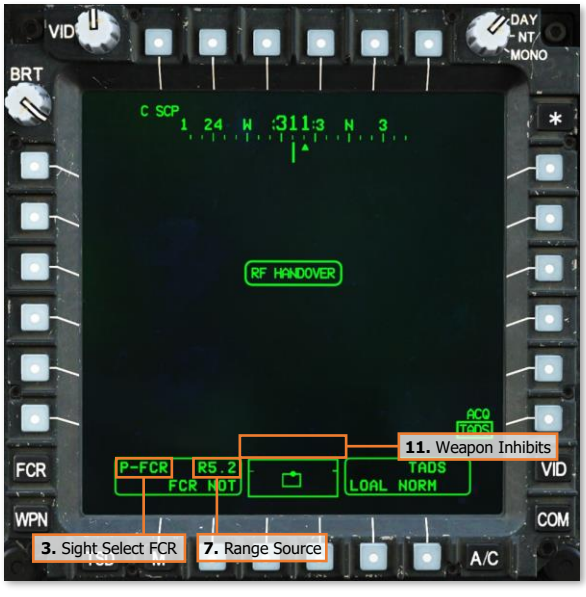
If the missile successfully acquires a target in LOBL mode, "RF MSL TRACK" will be displayed in the Weapon Status field.

If the missile fails to acquire a target that is moving or is less 1 kilometer in range, "NO ACQUIRE" will be displayed in the Weapon Status field. The missile may still be fired in LOAL mode, but the missile may not hit the

target. The missiles should be de-actioned to erase the target handover and re-actioned to attempt another target handover.

If the missile is not attempting to lock on to a target or has failed to acquire a stationary target between 1 and 2.5 kilometers in range, "LOAL NORM" or "LOAL MAN" will be displayed within the Weapon Status field.





8. Weapon Status – Verify "RF MSL TRACK", "LOAL NORM", or "LOAL MAN". (High Action Display)

   NOTE: "LOBL INHIBIT" may also be displayed if enabled on the WPN page.

9. CPG **(If CPG)** Instruct the Pilot to align the aircraft with the Missile Constraints Box – "Constraints."

10. PLT Missile Constraints Box – Align toward the HMD LOS Reticle.

    - Running/Diving Fire – Apply cyclic inputs in the direction of the Missile Constraints Box.
    - Hover Fire – Apply pedal inputs in the direction of the Missile Constraints Box.

11. Weapon Inhibit messages – Verify no Safety or Performance inhibit messages are displayed:

    - ACCEL LIMIT
    - ALT LAUNCH
    - GUN OBSTRUCT
    - PYLON ERROR
    - BAL LIMIT
    - PYLON ANGLE
    - PYLON LIMIT
    - RATE LIMIT
    - ROLL LIMIT
    - SKR LIMIT
    - YAW LIMIT

12. Weapon Trigger – Pull. (Cyclic or TEDAC Left Handgrip)

13. CPG Weapon Status – Verify "MSL LAUNCH". (High Action Display)

NOTE: When the crew receives an RF Handover, they should attempt to engage the target as soon as possible after the RFHO notification is annunciated within the cockpit. When engaging a target with an RF missile using an RF Handover, the Pilot should align the aircraft within launch constraints and the missile should be fired as soon as possible after the RFHO has been received and the missiles have been actioned.

WEAPON HAND CONTROLS

Either crewmember may employ any aircraft weapon system independently of the other crewstation. However, only the Copilot/Gunner can use the TADS to provide laser guidance for the AGM-114K Hellfire missile.

Cyclic & Collective Controls

The Pilot and Copilot/Gunner Cyclic and Collective Mission Grips include identical controls for weapons employment. However, the CPG's cyclic weapon trigger is only activated if the CPG actions a weapon using the Weapon Action Switch on the cyclic.

TEDAC Controls

The CPG's TEDAC weapon trigger is only activated if the CPG actions a weapon using the Weapon Action Switch on the TEDAC Left Handgrip.

AIRCRAFT SURVIVABILITY EQUIPMENT (ASE)

US Army photo

AIRCRAFT SURVIVABILITY EQUIPMENT

The AH-64D features a comprehensive suite of active and passive defensive systems that are designed to ensure the survival of the aircraft while operating at NOE (Nap-Of-the-Earth) altitudes in a high threat environment. The various defensive systems installed on the aircraft are known collectively as Aircraft Survivability Equipment (ASE).

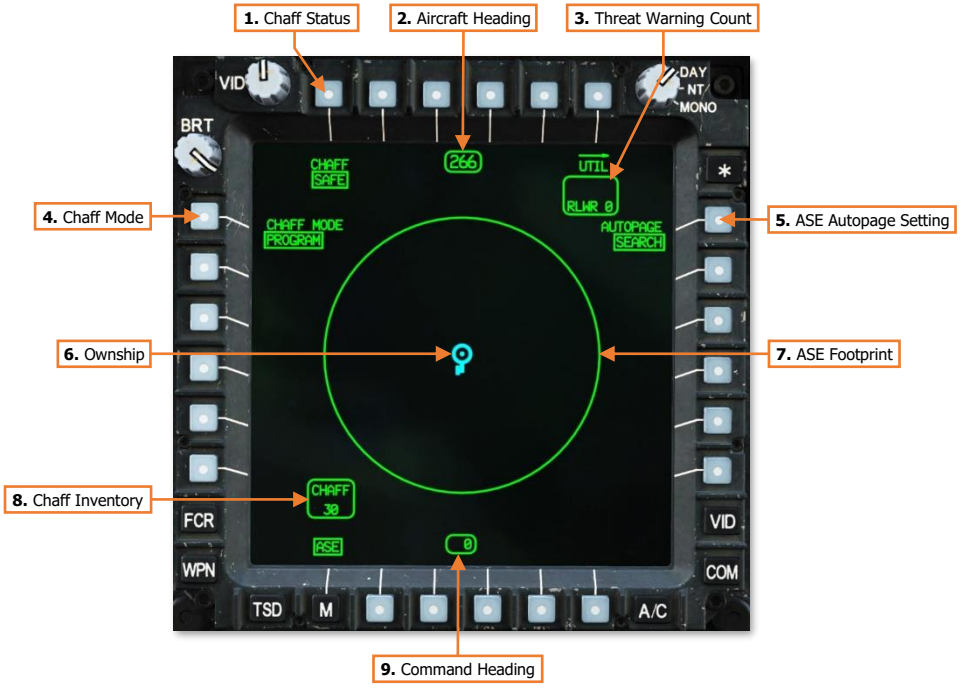
The ASE kit installed on the AH-64D includes a combined radar and laser warning receiver (RLWR), an electronic radar jamming system (ECM), a missile warning system (CMWS), chaff and flare countermeasures dispensers, infrared suppression integrated into the engine exhausts, and a Wire Strike Protection System (WSPS) installed on the forward fuselage and underside.

NOTE: *The ECM system is not implemented at this time.*

AH-64D Aircraft Survivability Equipment (ASE)

Aircraft Survivability Equipment (ASE) Page

The primary threat warning indications are integrated into the Tactical Situation Display's ASE "footprint"; however, the crew can also view the threat environment on a decluttered "footprint" on the ASE page. The ASE page also allows the crew to initialize and configure individual ASE systems.



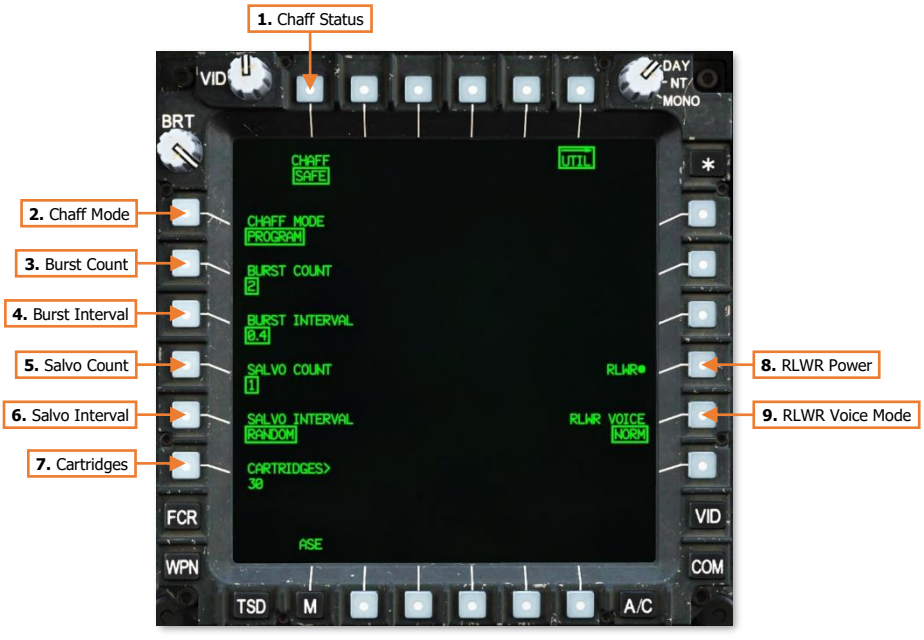
1. **Chaff Status.** Displays the state of the chaff dispenser. Pressing VAB T1 will toggle the state between SAFE and ARM.
   - **SAFE.** Chaff dispensing is inhibited. The status will default to SAFE with aircraft weight-on-wheels and inhibited from selection.
   - **ARM.** Chaff may be dispensed by either crewstation.
2. **Aircraft Heading.** Displays the current heading of the aircraft.
3. **Threat Warning Count.** Displays the total number of threats displayed around the ASE footprint.
   - **RFI.** Indicates the number of radar threats detected by the RFI and displayed on the outside of the ASE footprint, up to a maximum of 10. This field will be blank if the FCR mast-mounted assembly is not installed.
   - **RLWR.** Indicates the number of radar and/or laser threats detected by the RLWR and displayed on the inside of the ASE footprint, up to a maximum of 7.
4. **Chaff Mode.** Displays the chaff dispense mode. Pressing VAB L1 will toggle the state between PROGRAM and MANUAL.
   - **PROGRAM.** A single chaff program will be dispensed if the chaff dispenser is armed and the Chaff button is pressed on the Cyclic Grip in either crewstation. The chaff program may be edited on the ASE Utility page.

- **MANUAL.** An individual chaff cartridge will be dispensed if the chaff dispenser is armed and the Chaff button is pressed on the Cyclic Grip in either crewstation.

5. **ASE Autopage Setting.** Displays the ASE autopage setting for the crewstation. Pressing VAB R1 will display an expanded selection of autopage options.
   - **SEARCH.** If a new threat is detected, the TSD will be autopaged if the ASE or TSD pages are not already displayed within the crewstation.
   - **ACQUISITION.** If a detected threat elevates to ACQUISITION, the TSD will be autopaged if the ASE or TSD pages are not already displayed within the crewstation.
   - **TRACK.** If a detected threat elevates to TRACK, the TSD will be autopaged if the ASE or TSD pages are not already displayed within the crewstation.
   - **OFF.** ASE autopaging is disabled.
6. **Ownship.** Represents the present position of the aircraft.
7. **ASE Footprint.** Displays the relative bearings of detected radar and laser threats around the ownship. Radar and/or laser threats detected by the RLWR are displayed around the inside of the ASE footprint. Radar threats detected by the RFI (if the FCR mast-mounted assembly is installed) are displayed around the outside of the ASE footprint.
8. **Chaff Inventory.** Indicates the number of remaining chaff cartridges onboard, up to a maximum of 30.
9. **Heading to Waypoint.** Displays the heading to the next point in the route.

ASE Utility (UTIL) Sub-page

The ASE Utility page allows the crew to initialize the RLWR, set the RLWR voice mode, and configure the chaff dispenser settings.



1. **Chaff Status.** Displays the state of the chaff dispenser. Pressing VAB T1 will toggle the state between SAFE and ARM.
   - **SAFE.** Chaff dispensing is inhibited. The status will default to SAFE with aircraft weight-on-wheels and will be inhibited from selection.
   - **ARM.** Chaff may be dispensed by either crewstation.
2. **Chaff Mode.** Displays the chaff dispense mode. Pressing VAB L1 will toggle the state between PROGRAM and MANUAL.
   - **PROGRAM.** A single chaff program will be dispensed if the chaff dispenser is armed and the Chaff button is pressed on the Cyclic Grip in either crewstation.
   - **MANUAL.** An individual chaff cartridge will be dispensed if the chaff dispenser is armed and the Chaff button is pressed on the Cyclic Grip in either crewstation.
3. **Burst Count.** Sets the number of chaff cartridges dispensed within each salvo of the chaff program. Pressing VAB L2 will display an expanded selection of burst count options of 1, 2, 3, 4, 6, and 8 cartridges.
4. **Burst Interval.** Sets the time interval between individual chaff cartridges dispensed within each salvo of the chaff program. Pressing VAB L3 will display an expanded selection of burst interval options of 0.1, 0.2, 0.3, and 0.4 seconds.
5. **Salvo Count.** Sets the number of salvos dispensed within each chaff program. Pressing VAB L4 will display an expanded selection of salvo count options of 1, 2, 4, 8, and CONTINUOUS. When set to CONTINUOUS, salvos will be dispensed in accordance with the remainder of the chaff program settings until the chaff dispenser is depleted or the chaff is set to SAFE status.

6. **Salvo Interval.** Sets the time interval between each salvo dispensed within the chaff program. Pressing VAB L5 will display an expanded selection of salvo interval options of 1, 2, 3, 4, 5, 8, and RANDOM. When set to RANDOM, the interval between each salvo will be randomly selected.

7. **Cartridges Input.** Activates the KU for inputting the current chaff cartridge quantity, if necessary.

8. **RLWR Power.** Enables/Disables power to the Radar/Laser Warning System.

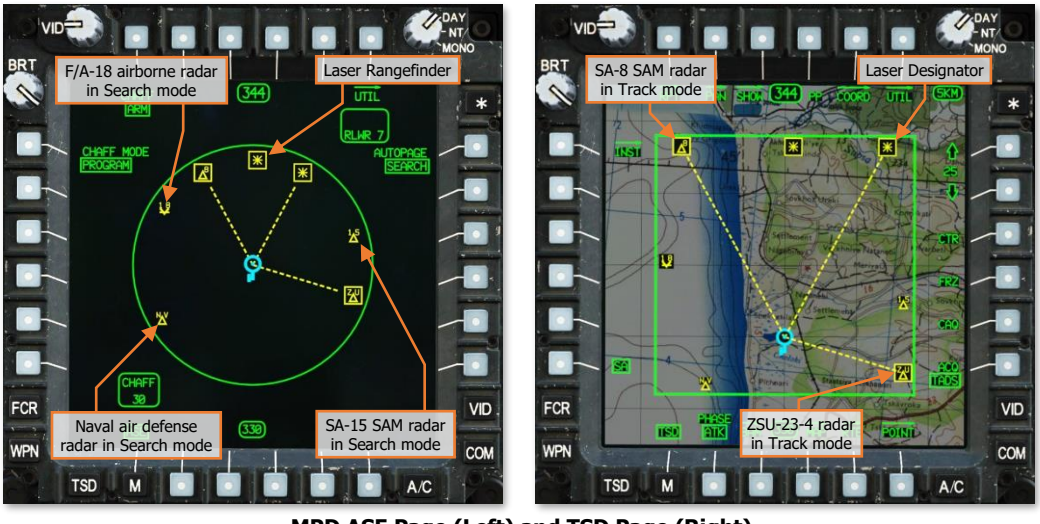
9. **RLWR Voice Mode.** Displays the voice warning mode of the Radar/Laser Warning System. Pressing VAB L5 will toggle the mode between NORM and TERSE.

   - **NORM.** The RLWR will report radar and laser threats by threat classification, clock direction, and lethality when initially detected. If any detected threat elevates in lethality, the RLWR will repeat the audio report to include the current clock direction and increased lethality.
     - **Audio report of a laser threat:** "Laser ranging, 1 o'clock."
     - **Initial audio report of an SA-8 radar:** "SA-8, 1 o'clock, searching."
     - **Updated audio report of an SA-8 radar:** "SA-8, 1 o'clock, tracking."
   - **TERSE.** The RLWR will report radar and laser threats by threat type and lethality only when initially detected. If any detected threat elevates in lethality, the RLWR will repeat the audio report to include the increased lethality.
     - **Audio report of a laser threat:** "Laser ranging."
     - **Initial audio report of an SA-8 radar:** "Radar searching."
     - **Updated audio report of an SA-8 radar:** "Radar tracking."

RADAR & LASER SIGNAL DETECTING SETS

The AN/APR-39A(V)4 provides detection of threat radar emissions by using a series of external antennas to passively detect and identify radar signals. The AN/AVR-2A provides detection of threat laser emissions by using a series of external detectors to passively detect and classify laser sources. As the combined RLWR system, the APR-39 and AVR-2 provide threat indications to the aircrew by displaying threat symbols on the TSD and ASE pages. In addition, the RLWR generates audio voice warnings describing the type of threat, threat direction, and what mode the radar or laser is operating, allowing the crew to remain focused outside for obstructions to flight or searching for enemy targets.

Like the TSD, the ASE page provides a singular footprint for the combined indications of the RLWR and RFI (if equipped with an FCR mast-mounted assembly). The display is an azimuth-only top-down display, with RLWR threat symbols displayed within the inside of the ASE footprint. The nature of the threat is indicated by the type of symbol and label, and the severity of the threat is indicated by enhancements placed around the symbol itself.



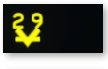
MPD ASE Page (Left) and TSD Page (Right)

New threat detected. A new radar or laser threat is displayed in a bolded symbol format for 3 seconds following initial detection.

Radar in Search mode. A radar signal in search mode.

Radar in Track mode. A radar signal in target tracking mode.

Radar in Launch mode. A radar signal in missile guidance mode.


Fixed-Wing Radar. A radar signal identified as an airborne platform.

Laser Rangefinder. A laser source emitting in a range-finding mode.

Laser Designator. A laser source emitting in a target designation mode.

Laser Beam-Rider. A laser source emitting in a beam-riding guidance mode.

Threat signal lost. A threat that is no longer detected will be displayed in partial intensity for 10 seconds before being removed from the RLWR "footprint".

COMMON MISSILE WARNING SYSTEM

The AN/AAR-57 Common Missile Warning System (CMWS) provides detection of threat missiles via a series of external detectors to passively detect missiles after launch. The system displays the threat direction to the Pilot via the Control Indicator Display, along with an audio threat alert to the crew. The AAR-57 is also capable of automatically dispensing flare countermeasures without crew interaction; however, the crew retains the ability to manually dispense flares by pressing the cyclic-mounted FLARE button in either crewstation.

As a post-production modification to the AH-64D, the CMWS utilizes the ADF audio channel to provide audio threat alerts to each crewstation. As such, the ADF knob on the Communications Panel controls the volume of CMWS threat alerts within the crewstation, independently of the RLWR volume.

The CMWS/NAV switch on the CMWS Control Panel in the Pilot crewstation is used to switch the ADF audio channel between radio signals received by the AN/ARN-149 Automatic Direction Finder and the CMWS. The Pilot should ensure this switch is set to the CMWS position if operating in a hostile area where missile threats are expected.

CMWS Control Panel (Pilot crewstation only)

1. **Control Indicator Display.** Displays the current inventory of chaff and flare countermeasures onboard the aircraft, direction of detected missile threats, and system status.
2. **Power/Test Knob.** Enables/disables power to the CMWS and initiates a Built-In-Test (BIT) sequence.
   - **OFF.** Disables power to the CMWS.
   - **ON.** Enables power to the CMWS. A BIT will automatically be performed after the CMWS initializes.
   - **TEST.** Manually initiates a BIT of the CMWS.
3. **AUDIO Knob.** No function.
4. **LAMP Knob.** Adjusts the brightness of the Control Indicator Display.
5. **ARM/SAFE Switch.** Arms flare dispensers for automatic or manual dispensing. Flare dispensing is inhibited with aircraft weight-on-wheels regardless of the switch position.
   - **SAFE.** Flare dispensing is inhibited.
   - **ARM.** Flares may be automatically dispensed upon detection of a missile threat or manually dispensed by either crewstation.

6. **CMWS/NAV Switch.** Sets the ADF audio channel in both crewstations to the CMWS or ADF receiver.
   - **CMWS.** The ADF audio channel will relay threat alert audio from the CMWS. While providing threat alert audio, the crew will be unable to monitor radio signals received by the ADF.
   - **NAV.** The ADF audio channel will relay radio audio from the ADF receiver. While providing ADF radio audio, the crew will be unable to receive threat alert audio from the CMWS.
7. **JETTISON Switch (Guarded).** Jettisons all flares from the tail-mounted flare dispensers in an emergency. The CMWS does not need to be armed to initiate a jettison of flares.
8. **BYPASS/AUTO Switch.** Enables/disables automatic flare dispensing as commanded by the CMWS. Missile threat alert audio is provided regardless of switch position.
   - **BYPASS.** Automatic dispensing commands by the CMWS are bypassed. Flare programs will only by dispensed if the FLARE button on either Cyclic Grip is pressed.
   - **AUTO.** Automatic dispensing commands by the CMWS are enabled. Flare programs may be automatically dispensed by the CMWS when missile threats are detected, or manually dispensed if the FLARE button on either Cyclic Grip is pressed.

CMWS Control Panel Indicator

9. **Flare Inventory.** Indicates the number of remaining flare cartridges onboard, up to a maximum of 60. When all flares have been depleted, the flare inventory will alternate between "0" and "OUT".
10. **Chaff Inventory.** Indicates the number of remaining chaff cartridges onboard, up to a maximum of 30. When all chaff cartridges have been depleted, the flare inventory will alternate between "0" and "OUT.
11. **Quadrant Arrows.** When illuminated, indicates the direction of threat missile detection(s).
12. **Dispense Indicator.** When illuminated, indicates dispensing of flares or chaff is in progress.
13. **Ready Indicator.** When illuminated, indicates system is in a "ready" state for flare dispensing (CMWS ARM/SAFE switch is in the ARM position and the aircraft is not weight-on-wheels).

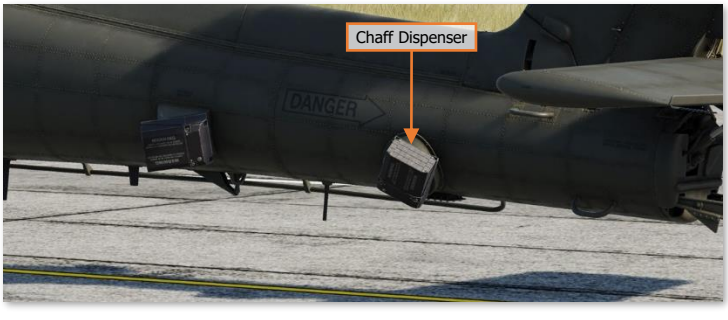
COUNTERMEASURES DISPENSERS

The AH-64D is equipped with three expendable countermeasures dispensers: a single M-141 dispenser for chaff and two Improved Countermeasure Dispensers (ICMD) for flares. Due to each dispenser's mounted location and orientation, the countermeasures loaded in each dispenser are not interchangeable between chaff and flares.

Chaff Dispenser

The M-141 chaff dispenser is mounted on the left side of the tail boom and can hold 30 chaff cartridges. Chaff cartridges may be dispensed individually in MANUAL mode, or sequentially when in PROGRAM mode. The dispenser mode is toggled between MANUAL and PROGRAM on the ASE or ASE UTIL pages, and the chaff program may be edited on the ASE UTIL page as well.

The chaff dispenser can only be set to ARM when the aircraft is airborne. If the aircraft is weight-on-wheels, the chaff dispenser is automatically set to SAFE and inhibited from dispensing.



Either crewmember may arm the chaff dispenser or configure the chaff settings, which are common between each crewstation, and either crewmember may dispense chaff by pressing the Chaff button on the Cyclic Grip.

The chaff quantity and ARM/SAFE status is also indicated on the WPN page.

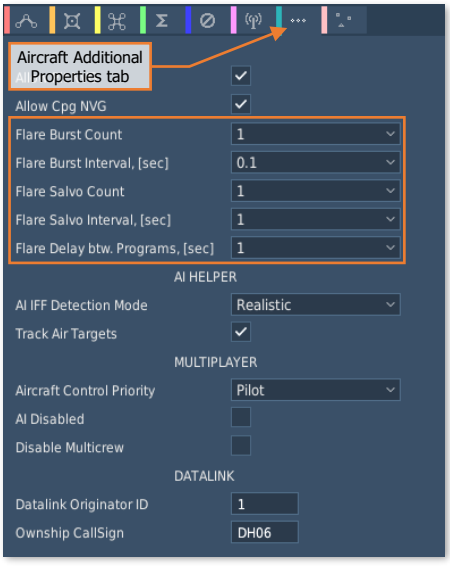
Flare Dispensers

A pair of Improved Countermeasures Dispensers (ICMD) are mounted on opposing sides of the tailboom, and each can hold 30 flare cartridges. Flares may be dispensed automatically by the CMWS itself or manually by either crewmember when the CMWS BYPASS/AUTO switch on the CMWS Control Panel is set to the AUTO position. If the switch is set to the BYPASS position, automatic flare dispensing is bypassed and may only be manually dispensed by the aircrew by pressing the Flare button on the Cyclic Grip.

The flare dispensers are only armed when the aircraft is airborne. If the aircraft is weight-on-wheels, the flare dispensers will be inhibited from dispensing, regardless of the position of the CMWS ARM/SAFE switch on the CMWS Control Panel in the Pilot crewstation.

The flare dispensers utilize a pre-set flare program, which can only be modified by an external panel by ground support crews when the engines are off. Flares are dispensed using this program regardless of whether the dispensing is commanded automatically by the CMWS or manually by the aircrew.

The flare program may be edited on the Aircraft Additional Properties tab within the Mission Editor, or from the cockpit by utilizing the player kneeboard. The available program options include Burst Count, Burst Interval, Salvo Count, Salvo Interval, and Minimum Time Between Programs.



ASE HAND CONTROLS

Either crewmember may manually dispense chaff and flares. Either crewmember may configure and arm the chaff dispenser; however, only the Pilot has access to the CMWS Control Panel to arm the flare dispensers.

Cyclic & Collective Controls

The Pilot and Copilot/Gunner Cyclic Grips include buttons for dispensing chaff and flares.

“GEORGE” AI

USAF photo
by TSgt Matt Hecht

"GEORGE" AI

The AH-64D is operated by two crewmembers: a Pilot (PLT) and a Copilot/Gunner (CPG). The DCS: AH-64D module supports multicrew capability, where two players can occupy the two seats in a multiplayer session for cooperative play. To accommodate a single-player experience, a player may utilize "George" AI, a virtual crewmember that allows players to direct and manage mission-critical tasks in the crewstation that the player is not occupying.

Unless specifically disabled in the Mission Editor options, George AI will always be present in the opposite crewstation from the player. When the player enters an AH-64D in DCS, they will be placed in the aft Pilot crewstation while George AI occupies the front CPG crewstation. If the player moves to the CPG crewstation, George will occupy the Pilot crewstation.

George may be directed by keyboard commands or a 4-way hat switch on the player's joystick. As a simulated crewmember, George is more than simply a means of interacting with the controls and systems in the crewstation that the player is not occupying. George is designed to mimic the real-life procedures used by AH-64D crewmembers, which permits players to direct and coordinate the AI crewmember actions in a similar manner to interacting with another person, albeit in a more limited capacity. When a player directs George AI via a command or control input, they are directing George to perform "tasks" rather than simple "actions". These tasks could be as basic as toggling the laser designator on and off to begin/cease target designation, or they may be as complex as engaging several targets in sequence with an assigned weapon or following a sequence of waypoints to navigate along a route at low altitude into a battle position.

As George is simulating a real crewmember, some commands may not result in an immediate or apparent reaction from George. This simulates the time needed to communicate the command over the intercom and the commanded action(s) to be performed by a real crewmember. Many commands carry several implied actions beyond what the command itself entails. These will be described throughout this chapter.

AH-64D AI Overview

George is capable of performing a wide variety of cockpit tasks, depending on the crewstation he is currently occupying. Some tasks will be performed when directed to do so by the player, some tasks will be performed based on criteria set by the player in advance, and some tasks will be performed autonomously without command.

"George" AI as Copilot/Gunner

- Search for targets along the line-of-sight of the Pilot's helmet, within a specified area or sector of the battlefield, or in proximity to a specified TSD point or FCR target location, as directed by the Pilot.
- Identify targets observed on the battlefield and discriminate between friendly and enemy units.
- Engage targets with a specified weapon and engagement method as directed by the Pilot.
- Perform start-up/shut-down procedures when directed by the Pilot.

When performing CPG duties, George cannot be directed to assume flight control of the helicopter.

"George" AI as Pilot

- Fly the helicopter at a specified speed, altitude, and heading as directed by the CPG.
- Navigate along the current route or to a specific TSD point as directed by the CPG.
- Align the heading of the helicopter to the TADS sensor azimuth when directed by the CPG.
- Configure CMWS as directed by the CPG.

When performing Pilot duties, George can be directed to transfer control of the helicopter to the player if desired. George may be configured to automatically take over the flight controls when the player switches from the Pilot seat to the Copilot/Gunner seat. (See the Special Tab in the DCS Fundamentals chapter for more information.)

AH-64D AI Controls Structure

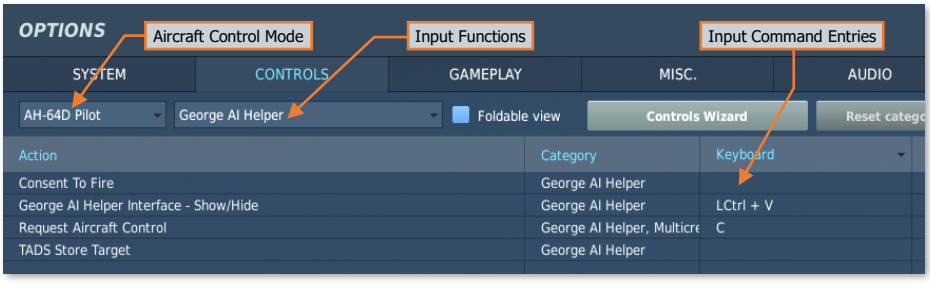
The AI controls are divided into two categories: AI Helper Commands and AI Helper Controls.

AI Helper Commands. Commands that may be given to George at any time, such as "Consent To Fire" or "Request Aircraft Control." These commands do not require the George AI Helper Interface to be displayed.

AI Helper Controls. Commands that are contextual based on the current mode of the George AI Helper Interface, such as commanding George as the CPG to search for targets in a specific area or commanding George as the Pilot to navigate along a route. These controls are only available when the AI Helper Interface is displayed.

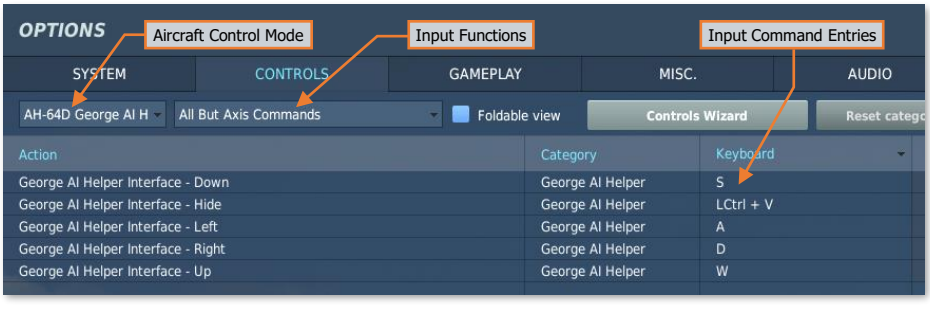
The AI Helper Interface responds to short and long presses of the interface controls to perform different functions. A short press is held down for less than 0.5 seconds, and a long press is typically held down for more than 0.5 seconds, although in some cases a long press may be required to be held down for a full second for confirmation.

Under the AH-64D Pilot and AH-64D CPG aircraft control modes, the AH-64D George AI Helper input functions category contains the input command entries for the AI Helper Commands that are available from each respective AH-64D crewstation and the input command entry for displaying the George AI Helper Interface.



Under the AH-64D George AI Helper aircraft control mode, input command entries may be programmed to navigate and utilize the George AI Helper Interface. These commands may be dual-bound to any command entries that are already bound within the AH-64D Pilot or AH-64D CPG control modes; however, these commands will take priority when the AI Helper Interface is displayed.

For example, if a 4-way hat switch is bound to the Sight Select switch under AH-64D Pilot and to the George AI Helper Interface under AH-64D George AI Helper, the 4-way hat switch will perform its function as the Sight Select switch when the AI Helper Interface is hidden, but will function as the AI Helper Controls switch when the AI Helper Interface is shown.



To control George from either crewstation, the **George AI Helper Interface Up/Down/Left/Right** and **George AI Interface Hide** commands will need to be bound under AH-64D George AI Helper aircraft control mode; as will the **George AI Helper Interface Show/Hide Menu** command entry under AH-64D Pilot and AH-64D CPG aircraft control modes.

AH-64D AI Helper Commands

The George AI Helper Interface is not required to be displayed to utilize the commands listed below.

- **Consent To Fire.** If George (as the CPG) is tracking a target and has been assigned a weapon system, this command will give George clearance to fire his assigned weapon at that target, even if his ROE is set to Hold Fire. This command is only available when the player is occupying the Pilot seat.

  If George (as the CPG) is not tracking a target or has not been assigned a weapon system, this command may be used to facilitate additional crew coordination between the player (as the Pilot) and George. The function of this command will be contextual, depending on the task George is currently performing.

  See the Player-as-Pilot AI Helper Commands within this chapter for more information.

- **George AI Helper Interface – Show/Hide.** Displays the AI Helper Interface and enables the input command entries within the AH-64D George AI Helper aircraft control mode. It is recommended that this command is bound to the same button as **George AI Helper Interface – Hide** under AH-64D George AI Helper aircraft control mode to allow the AI Helper Interface to be toggled between shown/hidden with the same input.

- **Request Aircraft Control.** When the player is occupying the CPG seat, this command transfers aircraft control to George (as the Pilot) or returns it to the player (as the CPG). George cannot accept aircraft control when performing CPG duties.

  When flying with another player in multi-crew, this command transfers the flight controls from the other player. (See the Mission Editor Options in the DCS Fundamentals chapter for more information.)

  NOTE: If George AI is disabled in the Mission Editor, the player will be required to fly the aircraft at all times, regardless of which seat the player is occupying at any point in the mission.

- **TADS Store Target.** If George (as the CPG) is tracking a target with the TADS or a Target List is displayed, this command will direct George to store a Target point (T##) using the STORE/UPDT switch on the TEDAC Left Handgrip. If George is not already lasing, he will momentarily fire the LRFD to get accurate range data before storing the location as a Target point. This command is only available when the player is occupying the Pilot seat.

AH-64D AI Helper Controls

The commands listed below will only function when the George AI Helper Interface is displayed.

- **George AI Helper Interface – Hide.** Hides the on-screen AI Helper Interface and disables the input command entries within the AH-64D George AI Helper aircraft control mode. It is recommended that this command is bound to the same button as **George AI Helper Interface – Hide** under AH-64D George AI Helper aircraft control mode to allow the AI Helper Interface to be toggled between shown/hidden with the same input.

- **George AI Helper Interface – Down.** Performs the action associated with the Down function, given the current Interface mode and duration of the button press.

- **George AI Helper Interface – Left.** Performs the action associated with the Left function, given the current Interface mode and duration of the button press.

- **George AI Helper Interface – Right.** Performs the action associated with the Right function, given the current Interface mode and duration of the button press.

- **George AI Helper Interface – Up.** Performs the action associated with the Up function, given the current Interface mode and duration of the button press.

See the command lists within the Player-as-Pilot or Player-as-CPG sections of this chapter for more information.

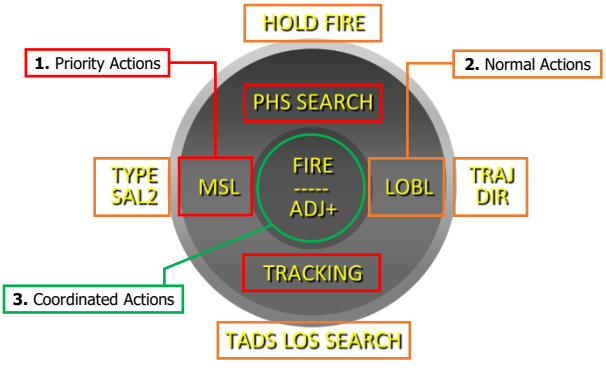
PLAYER-AS-PILOT "GEORGE" AI CONTROLS

When the player is in the Pilot crewstation, the role of George as the Copilot/Gunner (CPG) is to utilize the TADS to search, acquire, identify, and engage targets on the battlefield with the helicopter's weapon systems. However, George is also capable of using the TADS to assist the player in performing reconnaissance of specified points on the battlefield, identifying targets classified by the FCR, or performing battle damage assessment of FCR targets.

Pressing the **George AI Helper Interface – Show/Hide** command will show or hide the AI Helper Interface, a ring-shaped graphical representation for which actions may be performed by George as the CPG. The actions displayed within the AI Helper Interface are contextual, based on which commands are relevant to the current task that George is being directed to perform.

- Actions displayed inside the ring correspond with a short press (<0.5 second) of the **George AI Helper Interface Up/Down/Left/Right** control functions.
- Actions displayed outside the ring correspond with a long press (>0.5 second) of the **George AI Helper Interface Up/Down/Left/Right** control functions.
- Actions displayed within the center of the ring correspond with a short press (<0.5 second; top function) or a long press (>0.5 second; bottom function) of the **Consent To Fire** command.

These actions are grouped within 3 categories: Priority Actions, Normal Actions, and Coordinated Actions.



1. **Priority Actions.** These actions may need to be performed immediately during combat and remain available any time a Search List, Point List, or Target List are not displayed.
   - **Up-Short.** George will cease any existing tasks, including engaging targets, and immediately search for targets along the Pilot's helmet line-of-sight. (See Search Tasks for more information.)
   - **Down-Short.** George will cease any existing tasks, including engaging targets, and slave the TADS to fixed forward. The text displayed in this data field provides additional information as to how George is currently employing the TADS while performing his current task. (See the following page for more information.)
   - **Left-Short.** George will action the assigned weapon when set to GUN, MSL, or RKT; or de-action all weapons when set to NO WPN. If a Search List, Point List, or Target List are displayed, this command will exit the list without making a selection.
2. **Normal Actions.** These actions determine how George will perform his current task and are broadly contextual depending on the tasks themselves and which weapon, if any, has been assigned to George.
3. **Coordinated Actions.** These actions direct George to perform tasks in coordination with the player, such as performing reconnaissance in the vicinity of a TSD point or identifying an FCR target to which the player has linked the TADS. The AI Helper Interface is not required to be displayed to command these actions.

Whether performing an attack mission or a reconnaissance mission, the workflow of the aircrew may be outlined within four distinct phases. The key distinction being that attack missions primarily involve destroying enemy targets, whereas reconnaissance missions primarily involve reporting target locations to develop situational awareness of the battlefield or hand over target locations to other armed platforms for subsequent engagement.

Attack Mission

- Sensor Coordination
- Target Search & Detection
- Target Acquisition & Identification
- Target Tracking & Engagement

Reconnaissance Mission

- Sensor Coordination
- Target Search & Detection
- Target Acquisition & Identification
- Target Tracking & Reporting

As the CPG is the primary operator of the helicopter sensors and weapon systems, the AI Helper Interface has been designed with this workflow in mind. The available commands remain contextually applicable to the CPG's current mission task and permit the player (as the Pilot) to easily coordinate the AI CPG's workflow with the helicopter maneuvers that the player may be performing at any given moment.

Sensor Coordination

The first step is deciding where and how George should search for targets using the TADS sensor. (See Search Tasks for more information.)

Target Search & Detection

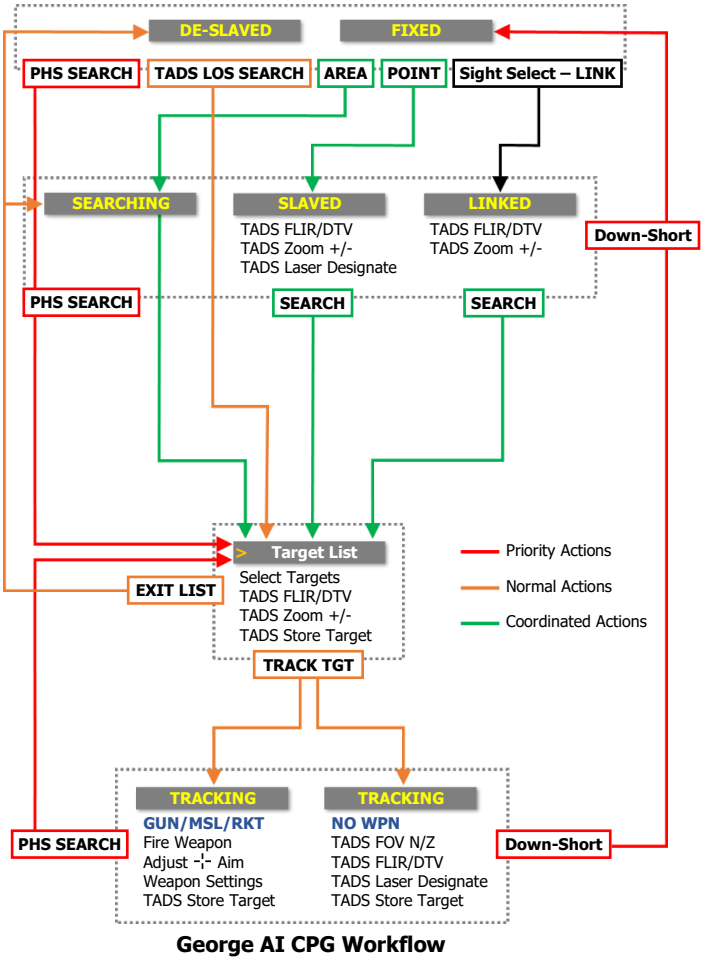
When commanded to perform a Direct or Area search, George will orient the TADS sensor as necessary and begin searching for targets. Upon initial command to perform a Point search or if the TADS is linked to the FCR, George will leave the TADS slaved/linked. George may then be commanded to change the TADS selected sensor or field-of-view, or search for targets in vicinity of that location.

Target Acquisition & Identification

George will attempt to identify and discriminate any targets that he acquires within the TADS sensor video, the results of which are presented to the player as a Target List. The player may assist with the identification process or command George to store target locations.

Target Tracking & Engagement

George will track the selected target with the TADS and engage the target with a weapon system when/if commanded. If performing reconnaissance, the player may command George to store the target location, change the TADS selected sensor or field-of-view, or laser designate the target.



George AI CPG Workflow

Search Tasks

George may be commanded to perform nine different types of searches for targets within the battlespace. Each search task varies in its tactical application and how George will prioritize targets that are detected.

"Direct" searches
Search for targets along a sensor's line-of-sight.

- **PHS SEARCH**
- **TADS LOS SEARCH**

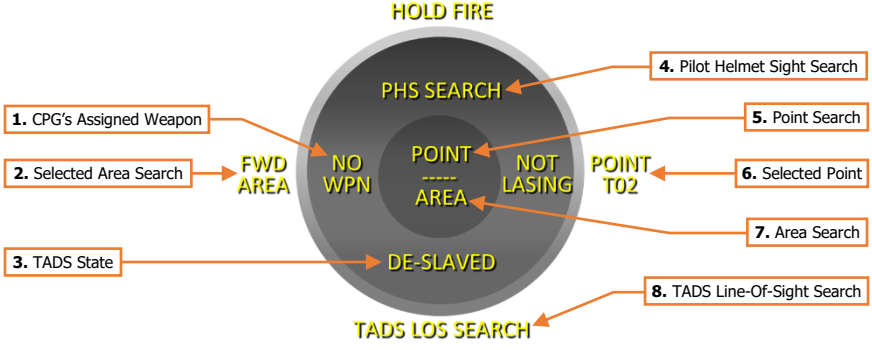
"Area" searches
Search for targets within a specified area of the battlefield.

- **FWD AREA**
- **PHS AREA**
- **FCR TGTS**
- **OWN PZF**
- **ACTV PZF**

"Point" searches
Search for targets within proximity of a specific point on the battlefield.

- **POINT**
- **LINKED**

Although the player may command George to perform an Area or Point search when the CPG's assigned weapon is set to GUN, MSL, or RKT, the Search List and Point List may only be accessed when the CPG's assigned weapon is set to NO WPN (no weapon) and the Selected Area Search and Selected Point actions are displayed.



1. **CPG's Assigned Weapon.** Displays the weapon system that has been assigned to George. Pressing Left-Short will cycle George's assigned weapon in the following sequence: NO WPN → GUN → MSL → RKT. This setting will determine which actions are displayed for the Left-Long, Right-Short, and Right-Long functions.
   - **NO WPN.** George may be commanded to fire the TADS laser rangefinder/designator (LRFD).
   - **GUN, MSL, or RKT.** The settings George will utilize may be configured for the corresponding weapon.
2. **Selected Area Search.** Displays the type of Area Search that will be performed. Pressing Left-Long will display the Search List, allowing the player to choose a different type of Area Search.
3. **TADS State.** Displays additional information as to the current state of the TADS sensor turret and how it is currently being used, or not used, by George. Pressing Down-Short will command George to cease any existing tasks, including engaging targets, and slave the TADS to fixed forward.
   - **FIXED.** The TADS is slaved to the CPG's ACQ source while set to FXD (Fixed forward).
   - **SLAVED.** The TADS is slaved to the CPG's ACQ source while set to PHS or a TSD point.
   - **DE-SLAVED.** The TADS is not slaved to the CPG's ACQ source.
   - **SEARCHING.** The TADS is being employed to continuously search for targets.
   - **TRACKING.** The TADS is being employed to track a target.
   - **LINKED.** The TADS is linked to the FCR Next-To-Shoot (NTS) target.
   - **TADS UNAVAIL.** The TADS is not powered or is being used as a crewmember's NVS sensor.

4. **Pilot Helmet Sight Search.** Pressing Up-Short will command George to search for targets along the Pilot's helmet line-of-sight.
5. **Point Search.** Pressing Consent To Fire (<0.5 second) will command George to slave the TADS to the TSD point selected for performing a Point Search. The AI Helper Interface is not required to be displayed to command this action.
6. **Selected Point.** Displays the TSD point that is selected for performing a Point Search. Pressing Right-Long will display the Point List, allowing the player to choose a different TSD point from the TSD point database.
7. **Area Search.** Pressing Consent To Fire (>0.5 second) will command George to begin performing the selected Area Search. The AI Helper Interface is not required to be displayed to command this action.
8. **TADS Line-Of-Sight Search.** Pressing Down-Long will command George to search for targets along the current line-of-sight (LOS) of the TADS sensor turret.

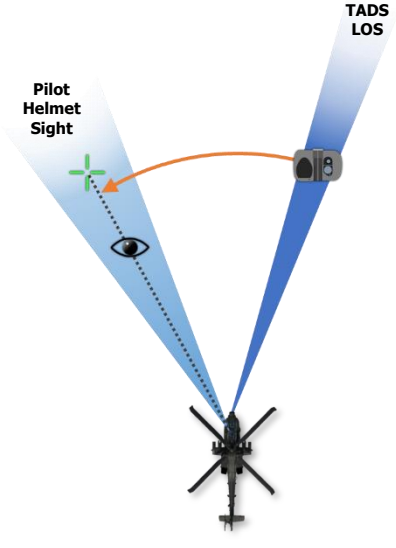
Direct Searches

George will perform a search for targets within the TADS field-of-view (FOV) and prioritize targets based on their threat level (i.e., air defense systems will be listed at the top of the list).

PHS SEARCH

George will slave the TADS to the Pilot's helmet line-of-sight and perform a momentary search for targets along that vector. George will set his Acquisition (ACQ) source to PHS and announce when he has enabled SLAVE. The player must maintain the HMD LOS Reticle at the desired search vector until George has announced that he has de-slaved the TADS.

This may be used to rapidly hand over a target to the CPG for engagement using the TADS after being visually acquired by the Pilot through the HMD.



Pilot Helmet Sight (PHS) Search

TADS LOS SEARCH

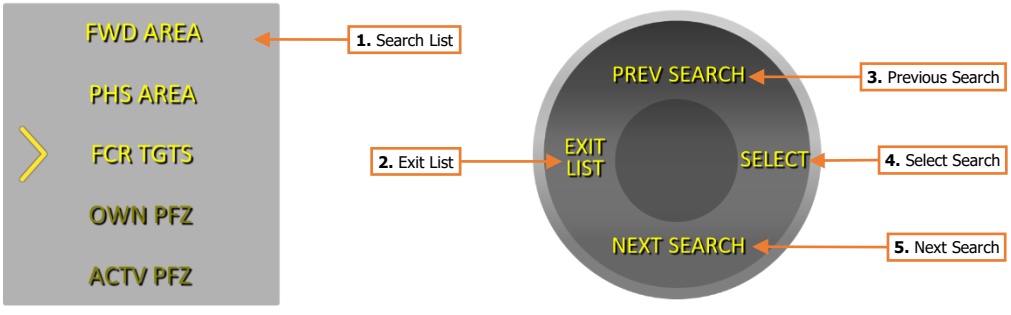
George will perform a momentary search for targets along the line-of-sight (LOS) of the TADS sensor itself.

This may be used to perform another search for targets along the same vector as the previous search.

Area Searches

George will search for targets within a specified area or sector of the battlefield and prioritize targets based on their threat level (i.e., air defense systems will be listed at the top of the list).

If the CPG's assigned weapon is set to NO WPN (no weapon) and a Point List and Target List are not displayed, pressing Left-Long will display the Search List. The Search List allows the player to select which type of Area Search George should perform when directed to do so. When the Search List is displayed, the AI Helper Interface will change format as shown below to facilitate interaction with the list itself.



1. **Search List.** Displays each type of Area Search that may be selected. If a search type requires specific criteria in order to perform the search but that criteria has not yet been met, the entry label will be displayed as "partial-intensity". These entries may still be selected from the list, but George will not be able to perform the search if commanded to do so before the corresponding criteria for the search has been met.
2. **Exit List.** Pressing Left-Short removes the Search List without changing the selected Area Search type and returns the AI Helper Interface to the normal command format.
3. **Previous Search.** Pressing Up-Short increments the list upwards to the previous entry in the Search List.
4. **Select Search.** Pressing Right-Short selects the current entry in the Search List as the selected Area Search type, removes the Search List, and returns the AI Helper Interface to the normal command format.
5. **Next Search.** Pressing Down-Short decrements the list downwards to the next entry in the Search List.

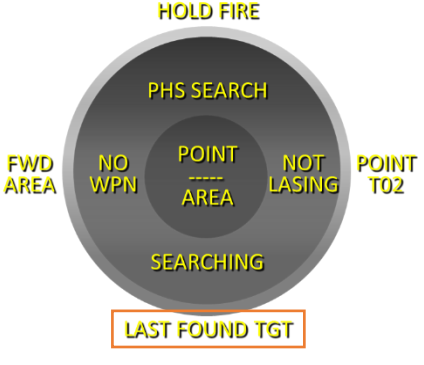
FWD AREA

George will continuously search for targets within a 90° sector (±45°) centered on the helicopter nose. George will announce when targets are detected but will continue to search for targets within the forward 90° sector until the AI Helper Interface is displayed.

This may be used when contact with enemy forces is possible while moving through the battlespace or when unmasking the helicopter from behind cover to observe the battlefield.

If 3 seconds have elapsed between George announcing a target detection and the AI Helper Interface being displayed, George will continue to search for targets but the player may press Down-Long to command George to slew the TADS back to the most recently detected target(s) and generate a Target List.

NOTE: If the helicopter attitude exceeds ±30° in pitch or roll, George will assume the Pilot is maneuvering the helicopter to evade enemy weapons fire or rapidly orient the helicopter toward an observed target. George will terminate the FWD AREA search and slave the TADS forward in preparation for the command to perform a PHS SEARCH, or any other search task, as directed.



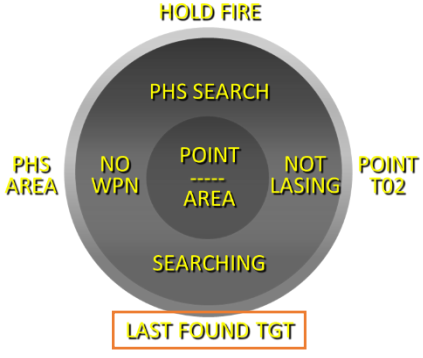
PHS AREA

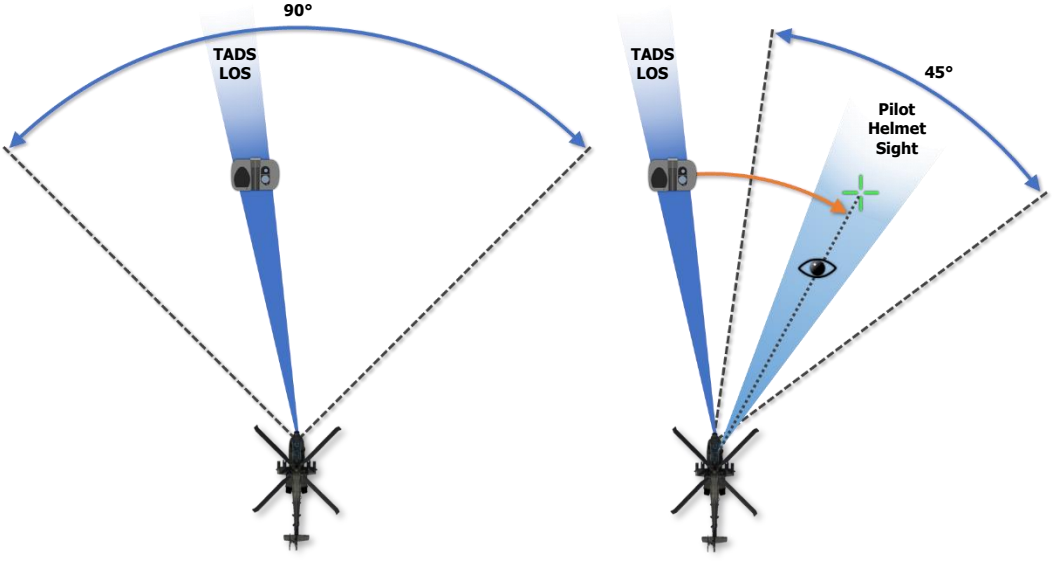
George will slave the TADS to the Pilot's helmet line-of-sight and will continuously search for targets within a 45° sector (±22.5°) centered on that vector. George will set his Acquisition (ACQ) source to PHS and announce when he has enabled SLAVE. The player must maintain the HMD LOS Reticle at the desired search vector until George has announced that he has de-slaved the TADS. George will announce when targets are detected but will continue to search for targets within the assigned 45° sector until the AI Helper Interface is displayed.

This may be used when contact with enemy forces is possible while moving through the battlespace or when unmasking the helicopter from behind cover to observe the battlefield.

If 3 seconds have elapsed between George announcing a target detection and the AI Helper Interface being displayed, George will continue to search for targets but the player may press Down-Long to command George to slew the TADS back to the most recently detected target(s) and generate a Target List.

NOTE: If the helicopter attitude exceeds ±30° in pitch or roll, George will assume the Pilot is maneuvering the helicopter to evade enemy weapons fire or rapidly orient the helicopter toward an observed target. George will terminate the PHS AREA search and slave the TADS forward in preparation for the command to perform a PHS SEARCH, or any other search task, as directed.





Forward Area Search (Left) and PHS Area Search (Right)

FCR TGTS

George will attempt to acquire and identify FCR targets detected by the ownship FCR or received via the datalink from an FCR-equipped AH-64D. George will enable C-Scope and use the FCR target symbols overlaid within the TADS sensor video to aid in locating targets at the corresponding locations that match the FCR symbol classification. George will announce if the targets can be observed or are obscured by terrain or other obstacles. If the targets can be observed, George will attempt to identify the targets themselves.

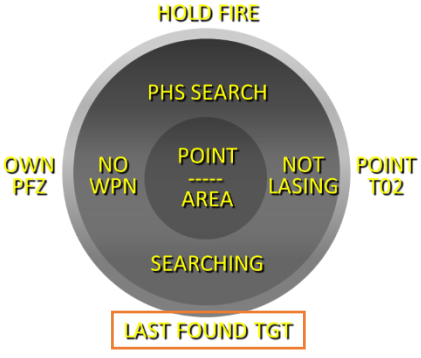
This may be used to perform Combat Identification (CID) or battle damage assessment of high priority FCR targets. If no FCR target data is present or the FCR is still scanning for targets, this search cannot be performed.

OWN PFZ

George will continuously search for targets within the Priority Fire Zone (PFZ) that is assigned to the ownship. George will announce when targets are detected but will continue to search for targets within the PFZ until the AI Helper Interface is displayed.

This may be used to focus the TADS within the ownship's assigned PFZ when unmasking the helicopter from behind cover to observe the battlefield. If no PFZ is assigned to the ownship, this search cannot be performed.

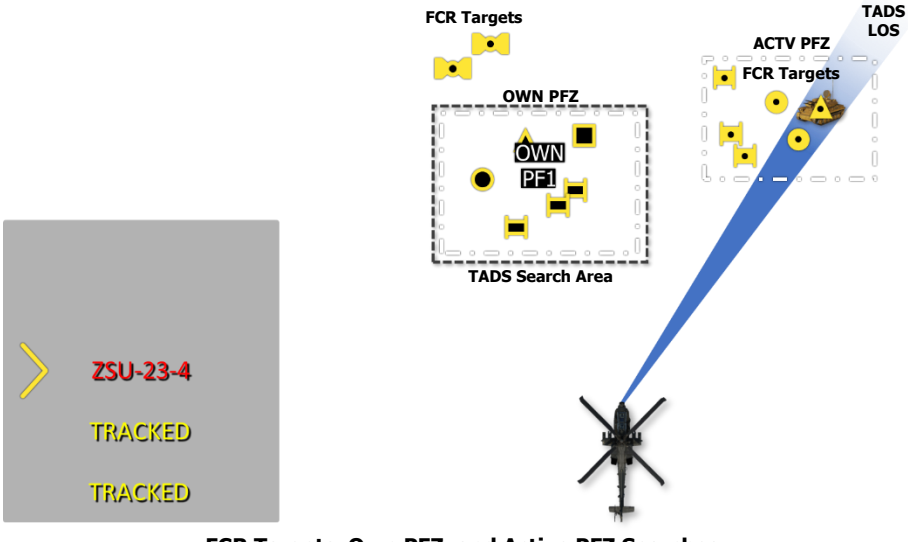
If 3 seconds have elapsed between George announcing a target detection and the AI Helper Interface being displayed, George will continue to search for targets but the player may press Down-Long to command George to slew the TADS back to the most recently detected target(s) and generate a Target List.



ACTV PFZ

George will attempt to acquire and identify FCR targets within the activated Priority Fire Zone (PFZ). George will enable C-Scope and use the FCR target symbols overlaid within the TADS sensor video to aid in locating targets at the corresponding locations that match the FCR symbol classification. George will announce if the targets can be observed or are obscured by terrain or other obstacles. If the targets can be observed, George will attempt to identify the targets themselves.

This may be used to perform Combat Identification (CID) or battle damage assessment of high priority FCR targets within the activated PFZ. If no FCR target data is present, the FCR is still scanning for targets, or no PFZ is activated, this search cannot be performed.



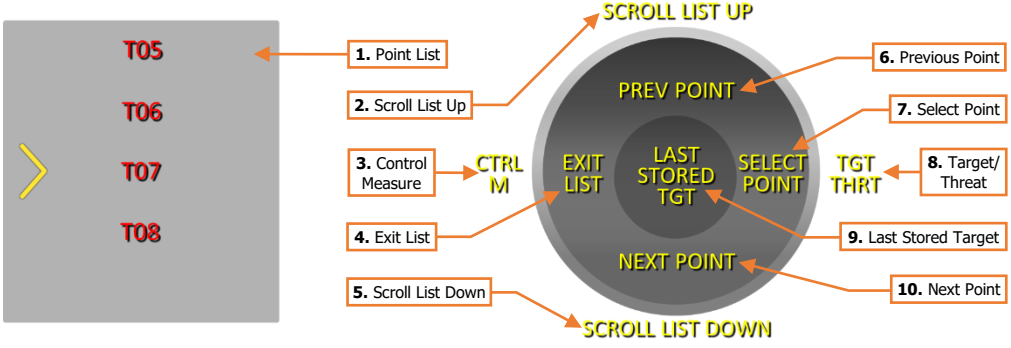
FCR Targets, Own PFZ, and Active PFZ Searches

If directed to perform an FCR TGTS or ACTV PFZ search, George will generate a Target List based on the most recent FCR target data and the initial classification of each FCR target symbol. As the player scrolls up or down through the Target List, George will slew the TADS sensor to the corresponding target symbol and attempt to identify the target itself. If able to identify the target, George will update the corresponding entry within the Target List. (See Target Acquisition for more information.)

Point Searches

George will perform a search for targets within the vicinity of a specified TSD point or the FCR Next-To-Shoot (NTS) Target and prioritize targets based on their geographic proximity.

If the CPG's assigned weapon is set to NO WPN (no weapon) and a Search List and Target List are not displayed, pressing Right-Long will display the Point List. The Point List allows the player to select a TSD point from the TSD point database to which George should slave the TADS when directed to do so. When the Point List is displayed, the AI Helper Interface will change format as shown below to facilitate interaction with the list itself.



1. **Point List.** Displays a list of TSD points that may be selected. When the Point List is displayed, the list will automatically display the most recently added or received TGT/THRT point. This allows the player to rapidly select the most recent target point that has been added to the TSD database via manual entry of coordinates, added directly on the TSD itself using the MPD cursor, stored using the TADS, or received via the datalink.
2. **Scroll List Up.** Scrolls the Target List upward while Up-Long is pressed and held.
3. **Control Measure or Waypoint/Hazard.** Changes the Point List format to display Control Measure points or Waypoint/Hazard points. The displayed action will be contextual depending on the displayed list format.
   - **CTRL M.** If Target/Threat or Waypoint/Hazard points are displayed, pressing Left-Long will change the Point List format to display a list of Control Measure points residing within the TSD point database.
   - **WPT HZ.** If Control Measure points are displayed, pressing Left-Long will change the Point List format to display a list of Waypoint/Hazard points residing within the TSD point database.
4. **Exit List.** Pressing Left-Short removes the Point List without changing the selected point and returns the AI Helper Interface to the normal command format.
5. **Scroll List Down.** Scrolls the Target List downward while Down-Long is pressed and held.
6. **Previous Point.** Pressing Up-Short increments the list upwards to the previous entry in the Point List.
7. **Select Point.** Pressing Right-Short selects the current entry in the Point List as the selected point, removes the Point List, and returns the AI Helper Interface to the normal command format.
8. **Target/Threat.** Pressing Right-Long changes the Point List format to display Target/Threat points.
9. **Last Stored Target.** Pressing Consent To Fire commands George to select the most recent target point that has been stored within the CPG crewstation using the TADS. This allows the player to immediately select the last target that George was commanded to store.

   NOTE: This command only applies to target points stored using the TADS and ignores any TGT/THRT point that has been added to the TSD database using any other method or received via the datalink.
10. **Next Point.** Pressing Down-Short decrements the list downwards to the next entry in the Point List.

POINT

Upon initial command to perform a Point search George will set his Acquisition (ACQ) source to the selected TSD point and slave the TADS. George will keep his TADS slaved to that point until the player commands him to perform a search for targets, but he may be commanded to manually adjust the TADS field-of-view or toggle the TADS sensor between FLIR and DTV while the TADS remains slaved. (See the following page for more information.)

When subsequently commanded to perform a search for targets, George will de-slave the TADS and perform a momentary search for targets within the vicinity of the TSD point.

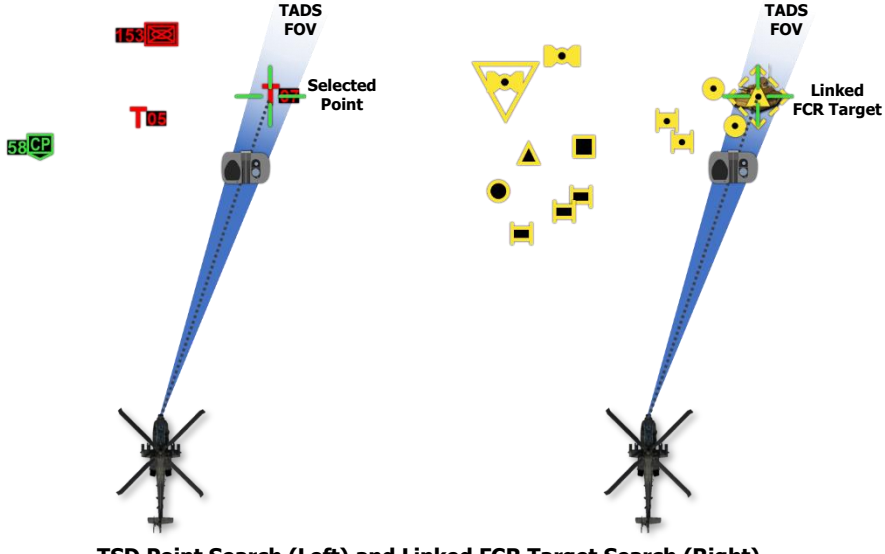
This may be used to perform reconnaissance of a specific target location or Named Area of Interest (NAI), orient the TADS to a known or suspected target location prior to unmasking the helicopter from behind cover, or to slave the TADS to a known target location in preparation for employing indirect rocket fire in Cooperative mode.

LINKED

If the player links the TADS to the FCR NTS target, George will lose primary control over the TADS as his sight but will retain control over the TADS sensor selection and field-of-view controls on the TEDAC handgrips. George will leave the TADS linked to the FCR until the player commands him to perform a search for targets, but he may be commanded to manually adjust the TADS field-of-view or toggle the TADS sensor between FLIR and DTV while the TADS remains linked. (See the following page for more information.)

When subsequently commanded to perform a search for targets, George will assume control of the TADS as his sight and perform a momentary search for targets within the vicinity of the FCR NTS target.

This may be used to rapidly hand over an FCR target to the CPG for engagement using the TADS, observe or identify the FCR NTS target from the Pilot crewstation, or to perform battle damage assessment of the FCR NTS target from the Pilot crewstation.

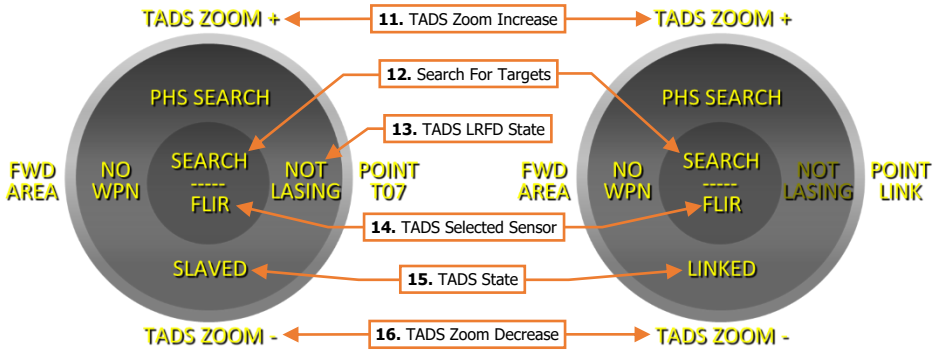


TSD Point Search (Left) and Linked FCR Target Search (Right)

Regardless of whether the TADS is slaved to a TSD point or linked to the FCR NTS target, George may still be commanded to perform a PHS SEARCH by pressing Up-Short if the need arises to rapidly hand over a target to the CPG for engagement using the TADS after being visually acquired by the Pilot through the HMD.

Pressing Down-Short while the TADS is slaved to a TSD point or linked to the FCR NTS target will command George to take control of the TADS if necessary and slave the TADS to fixed forward.

When the TADS is slaved to a TSD point or linked to the FCR NTS target, George may be commanded to manually adjust the TADS field-of-view, toggle the TADS sensor between FLIR and DTV, or (when slaved to a TSD point) employ the TADS LRFD to designate the location to which the TADS is slaved.



11. **TADS Zoom Increase.** Pressing Up-Long will command George to select the next TADS field-of-view in the following sequence: Wide → Medium → Narrow → Zoom. If the TADS field-of-view is set to Zoom, this action will not be displayed.

12. **Search For Targets.** Pressing Consent To Fire (<0.5 second) will command George to de-slave the TADS and perform a search for targets around the selected TSD point or the FCR NTS target.

    If the TADS was slaved to a TSD point, George will prioritize targets based on their geographic proximity to that point.

    If the TADS was linked to the FCR, George will prioritize the closest target that matches the classification of the NTS target symbol, and then prioritize any remaining targets based on their geographic proximity to the FCR NTS target.

13. **TADS LRFD State.** Displays the state of the TADS Laser Rangefinder/Designator (LRFD) when George has not been assigned a weapon. Pressing Right-Short will command George to start lasing or terminate lasing.

    - **NOT LASING.** George is not firing the LRFD.
    - **LASING.** George is firing the LRFD to range and/or designate the location to which the TADS is slaved.

    NOTE: If the TADS is linked to the FCR, the TADS LRFD is disabled and this action will not be available.

14. **TADS Selected Sensor.** Displays the selected TADS sensor. Pressing Consent To Fire (>0.5 second) will command George to toggle the selected sensor between FLIR and DTV.

15. **TADS State.** Displays additional information as to the current state of the TADS sensor turret and how it is currently being used, or not used, by George.

    - **SLAVED.** The TADS is slaved to the CPG's ACQ source while set to PHS or a TSD point.
    - **LINKED.** The TADS is linked to the FCR Next-To-Shoot (NTS) target.

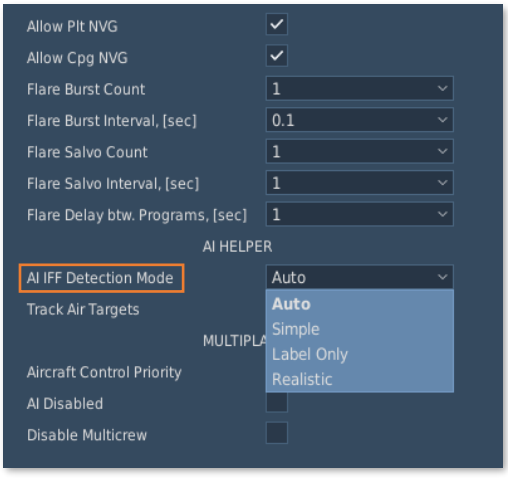
16. **TADS Zoom Decrease.** Pressing Down-Long will command George to select the previous TADS field-of-view in the following sequence: Zoom → Narrow → Medium → Wide. If the TADS field-of-view is set to Wide, this action will not be displayed.

Combat Identification (CID)

While occupying the Copilot/Gunner crewstation, George is capable of identifying military units and equipment on the battlefield and whether they are friend or foe. This process is known as Combat Identification, or CID. The speed and accuracy at which George performs CID may vary based on the DCS mission settings, the distance to the target, the target aspect, and whether the type of equipment is exclusive to one or multiple coalitions.

As is the case with many gameplay options within DCS, George's CID ability level may be forced to adhere to a specific type of behavior within the AH-64D Additional Properties tab of the Mission Editor, or it may be configured based on a combination of F10 View Options and Label settings.

AI IFF Detection Mode. Sets the level of Identification-Friend-or-Foe (IFF) that George will utilize when detecting and identifying potential targets.



Mission Editor – Additional Properties tab

- **Auto.** The ability of George to determine the type of target and its coalition affiliation will be derived from the combination of F10 View Options and Labels settings. These settings themselves may be enforced by the mission or may be determined by the player's personal preferences set on the Gameplay tab within the DCS Options.
- **Simple.** No factors affect George's ability to determine the type of target or its coalition affiliation. Upon detection of a target, George will instantly determine (without error) the type of target and whether the target is friendly or hostile.
- **Label Only.** Identification logic factors affect George's ability to determine the type of target, but they do not affect his ability to determine the coalition affiliation. Upon detection of a target, George will attempt to determine the type of target, which is affected by the aspect and angular size of the target within the sensor field-of-view; and will then instantly determine (without error) whether the target is friendly or hostile.
- **Realistic.** Identification logic factors affect George's ability to determine the type of target and the coalition affiliation. Upon detection of a target, George will attempt to correctly determine the type of target, which is affected by the aspect and angular size of the target within the sensor field-of-view; and will then attempt to determine whether the target is friendly or hostile, with the potential for a false identification.

When the AI IFF Detection Mode is set to **Auto**, George will use **Simple**, **Label Only**, or **Realistic** IFF modes based on the matrix logic shown below.

		F10 VIEW OPTIONS	
		All / Allies Only / Fog of War	My A/C / Map Only
LABELS SETTINGS	Full Abbreviated	Simple	Simple
	Symbol Only	Simple	Label Only
	Dot Neutral No Labels	Simple	Realistic

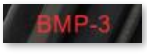
Combat Identification Process

George will perform the Combat Identification process in four steps. As each step is performed for a given contact, the level of detail displayed within the Target List will be updated accordingly.

1. **Contact Detection**. A contact is detected and initially classified as either GROUND, AIR, or NAVAL.

2. **Type Classification.** A contact is further classified by the general type of unit, such as ARMORED, AAA, HELICOPTER, etc.

3. **Equipment Identification.** A contact is identified by recognizing the type of equipment, such as BMP-3, ZSU-23-4, Mi-24, etc.



4. **Target Discrimination.** The recognized type of equipment is compared to the list of equipment used by each coalition to discriminate by coalition affiliation.

If **Simple** IFF mode is used, all four steps are performed instantly and without error.

If **Label Only** IFF mode is used, identification factors will affect George's ability in performing steps 1-3, but step 4 will be performed instantly and without error after steps 1-3 have been performed.

If **Realistic** IFF mode is used, identification factors will affect George's ability in performing each step.

Combat Identification Factors

The following factors may affect George's ability to identify a contact's type or its coalition affiliation, depending on the AI IFF Detection Mode.

Angular Size. Angular size of the contact is measured from the point of view of the CPG through the TADS. As the range to the contact decreases, the greater the angular size of the contact within the TADS sensor, and the easier it is for George to identify the equipment type.

Aspect. Angular size automatically includes aspect dependence. Vehicles that are head-on within the TADS sensor will have a smaller angular size, hindering the ability for George to identify the contact compared to a contact that is being viewed from the side at the same range.

Coalition Order Of Battle. When the type of equipment is determined (e.g., a BMP-2 vs an M113), the equipment type is compared to the equipment known to be employed by either coalition, also known as the Order Of Battle. If only one coalition uses the type of equipment, the contact is identified as friendly or enemy based on the corresponding coalition. If multiple coalitions use the type of equipment, there is a chance that the final identification may be incorrectly identified as friendly or enemy.

Sensors

George will prefer to use the TADS Forward-Looking Infrared (FLIR) camera, which aids in initial target detection and acquisition, particularly during missions at night. Any contacts of the required angular size within the TADS sensor video will be detected by George AI when he is directed to search an area of the battlefield for targets.

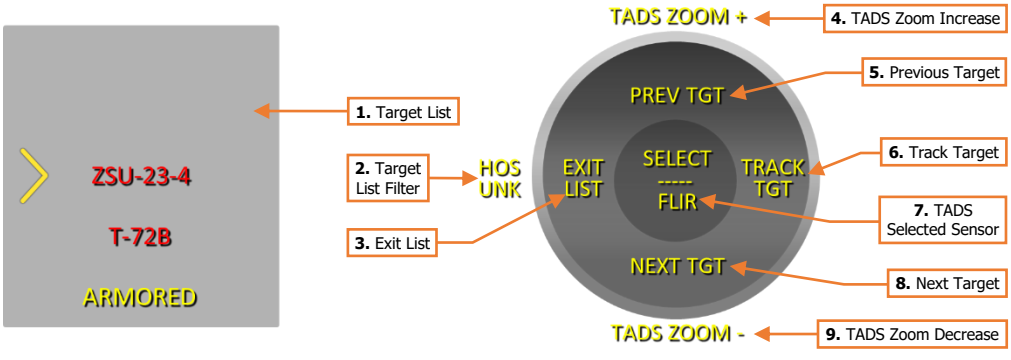
George will utilize multiple zoom levels as appropriate in an attempt to recognize each detected contact within a reasonable amount of time. However, if there are many contacts within the sensor field-of-view, George may not be able to identify each of them before presenting the Target List to the player.

When the Target List is displayed, the player may select specific Target List entries to direct George to focus the TADS at that contact. During this time, George will continue to perform Combat Identification and update the Target List accordingly as he works through each step of the identification process, which may be further enhanced by directing George to increase the TADS sensor magnification or change the TADS sensor to DTV (during daylight hours) while focused on a given contact. See the following page for more information.

Target Acquisition

If George detects any targets with the TADS after being commanded to search within a specified area, sector, or location of the battlefield, he will generate a Target List and display detected units based on the following logic.

- If a Direct or Area search was performed, the list will be sorted according to target type, with the highest priority targets such as air defenses shown at the top of the list, and the lowest priority targets such as unarmed vehicles and support equipment shown at the bottom of the list.
- If a Point search was performed in the vicinity of a TSD point, the list will be sorted according to geographic proximity, with the unit closest to the TSD point shown at the top of the list and the unit furthest from the TSD point shown at the bottom of the list.
- If a Point search was performed after linking the TADS to the FCR Next-To-Shoot (NTS) target, the highest priority target at the top of the list will be the target closest to the FCR NTS target location that matches the classification of the FCR NTS target symbol, and any remaining targets will be sorted based on their geographic proximity in the same manner as a Point search in the vicinity of a TSD point.



1. **Target List.** Displays targets that George has acquired during the target search. If desired, multiple targets may be selected for sequential engagement. (See Multi-Target Selection for more information.)
2. **Target List Filter.** Displays which coalition affiliations are displayed within the Target List. Pressing Left-Long will toggle the filter setting.
   - **HOS UNK.** The Target List will only display targets that have been discriminated as enemy or unknown affiliation. If any unknown targets are subsequently discriminated as friendly or neutral affiliation, these targets will be removed from the Target List.
   - **ALL TGTS.** The Target List displays all targets regardless of coalition affiliation, to include friendly and neutral units.

   By default, the Target List Filter will be set to HOS UNK if any enemy or unknown targets are detected. However, if no enemy or unknown targets are detected, the Target List Filter will automatically be set to ALL TGTS and display all friendly and/or neutral units to aid in preventing fratricide (friendly fire).

   NOTE: The player may command George to engage a target that has been identified as a friendly or neutral unit. Care should be taken when operating areas near the frontline in which friendly and enemy positions are not well known, as George has the potential to incorrectly identify a friendly unit as enemy or an enemy unit as a friendly. See Combat Identification (CID) for more information regarding how George AI identifies and discriminates targets.
3. **Exit List.** Pressing Left-Short removes the Target List without selecting a target to track and returns the AI Helper Interface to the normal command format. If any targets have been selected for sequential engagements, these selections will be cancelled.

4. **TADS Zoom Increase.** Pressing Up-Long will command George to select the next TADS field-of-view in the following sequence: Wide → Medium → Narrow → Zoom. If the TADS field-of-view is set to Zoom, this action will not be displayed.
5. **Previous Target.** Pressing Up-Short increments the list upwards to the previous target in the Target List.
6. **Track Target.** Pressing Right-Short selects the current target in the Target List for George to begin tracking, removes the Target List, and returns the AI Helper Interface to the normal command format.
7. **TADS Selected Sensor.** Displays the selected TADS sensor. Pressing Consent To Fire (>0.5 second) will command George to toggle the selected sensor between FLIR and DTV.
8. **Next Target.** Pressing Down-Short decrements the list downwards to the next target in the Target List.
9. **TADS Zoom Decrease.** Pressing Down-Long will command George to select the previous TADS field-of-view in the following sequence: Zoom → Narrow → Medium → Wide. If the TADS field-of-view is set to Wide, this action will not be displayed.

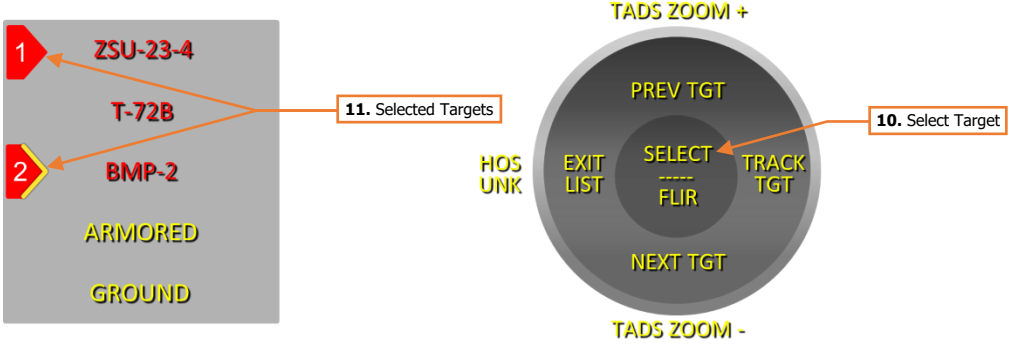
As the player scrolls up or down through the Target List, George will slew the TADS sensor to the corresponding target location. If the Combat Identification process has not been completed for the current target, George will resume the process when the target is within the sensor field-of-view and, if able, update the corresponding entry within the Target List. The player may monitor and even assist with this process via the AI Helper Controls, by commanding George to zoom in or out by pressing Up-Long or Down-Long, respectively, or pressing Consent To Fire (>0.5 second) to toggle the TADS sensor between FLIR and DTV.

When a Target List is presented to the player, targets will be displayed using the AI IFF Color Scheme that is chosen on the Special tab within the DCS Options, unless the AI Interface Color Scheme has been set to Monochrome White or Monochrome Yellow.

- **NATO.** Targets will be colored based on their hostility status, regardless of their coalition color.
  - Unit belongs to Hostile Coalition
  - Unit belongs to Friendly Coalition
  - Unit belongs to Neutral Coalition
  - Coalition affiliation is unknown.
- **Coalition color.** The Target List will display all targets in accordance with their assigned coalition.
  - Unit belongs to Red Coalition
  - Unit belongs to Blue Coalition
  - Unit belongs to Neutral Coalition
  - Coalition affiliation is unknown.

Multi-Target Selection

When a Target List is presented to the player, multiple targets may be selected for sequential engagement. If multiple targets are selected from the Target List, George will engage each selected target in sequence until his assigned weapon is depleted or is commanded by the player to cease fire or search for a new target.



10. Select Target. Pressing Consent To Fire (<0.5 second) will command George to add the current target entry within the Target List to a "shoot list" for sequential engagement. A subsequent press of Consent To Fire (<0.5 second) will command George to remove the current target entry from the "shoot list".

11. Selected Targets. Targets that are selected for sequential engagement. When a target is selected for engagement, a numbered symbol will be displayed within the Target List to indicate which targets will be engaged and the order of engagement.

If Left-Short is pressed to exit the Target List, the "shoot list" will be canceled.

If Right-Short is pressed while the Target List is set to a non-selected target, George will begin tracking that target and the "shoot list" will be canceled.

If Right-Short is pressed while the Target List is set to a selected target that has been added to the "shoot list", George will slew to the first target on the "shoot list", begin tracking that target, and initiate the multi-target engagement sequence, in accordance with his Rules Of Engagement (ROE). As each target is destroyed, George will autonomously shift the TADS to the next target on the "shoot list" in sequence without player intervention.

- When ROE is set to HOLD FIRE, George will wait for a Consent To Fire command from the player before engaging each target with his assigned weapon.
    - If the target that George is tracking is destroyed, George will autonomously shift to the next target on the "shoot list" and wait for a Consent To Fire command from the player before engaging.
    - If the target that George is tracking is not destroyed, George will maintain track on the current target and wait for a Consent To Fire command from the player before re-engaging.
- When ROE is set to FREE FIRE, George will immediately engage each target with his assigned weapon.
    - If the target that George is tracking is destroyed, George will autonomously shift to the next target on the "shoot list" and immediately engage.
    - If the target that George is tracking is not destroyed, George will maintain track on the current target and immediately re-engage.

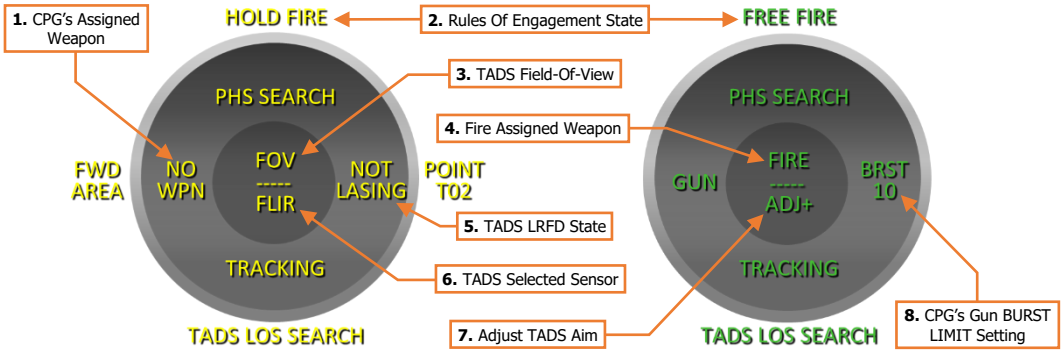
See Target Tracking & Engagement on the following page for more information.

Target Tracking & Engagement

If commanded to track a target, George will attempt to keep the TADS sensor oriented on the target itself until commanded to cease tracking of the target or perform another search for targets, the target is destroyed, or George loses sight of the target for a period of time and is unable to re-acquire it.

Upon initial acquisition of his assigned target, George will attempt to establish automatic tracking on the target using the Image Auto-Track (IAT) function of the TADS, which will maintain the TADS LOS Reticle on the target and provide a stable targeting solution. However, if the helicopter is being maneuvered while George attempts to establish IAT on the target, he may not be able to attain an optimal aiming solution on the center mass of the target. If necessary, the player may press and hold Consent To Fire when the CPG's assigned weapon is set to GUN, MSL, or RKT to command George to drop the IAT and adjust the TADS LOS Reticle to the center mass of the target itself to optimize the aiming solution prior to, or during, an engagement against that target.

The player may direct George to engage targets when the CPG's assigned weapon is set to GUN or MSL; or observe and/or laser designate targets when the CPG's assigned weapon is set to RKT or NO WPN (no weapon).



1. **CPG's Assigned Weapon.** Displays the weapon system that has been assigned to George. Pressing Left-Short will cycle George's assigned weapon in the following sequence: NO WPN → GUN → MSL → RKT. This setting will determine which actions are displayed for the Left-Long, Right-Short, and Right-Long functions.
   - **NO WPN.** George may be commanded to fire the TADS laser rangefinder/designator (LRFD).
   - **GUN, MSL, or RKT.** The settings George will utilize may be configured for the corresponding weapon.
2. **Rules Of Engagement (ROE) Status.** Displays the ROE to which George will adhere. The color of the text within the AI Helper Interface will correspond to the ROE setting, unless the AI Interface Color Scheme has been set to Monochrome White or Monochrome Yellow on the Special tab within the DCS Options.
   - **HOLD FIRE (yellow text).** If George is assigned a weapon and is tracking a target, George will prepare to engage that target with his assigned weapon but will not fire until commanded to do so by the player. After firing one missile or one burst from the gun, George will not fire again until commanded to do so by the player.
   - **FREE FIRE (green text).** If George is assigned a weapon and is tracking a target, George will engage that target until the target is destroyed, his assigned weapon is depleted, his ROE is switched to HOLD FIRE, or is commanded by the player to cease fire or search for a new target.
3. **TADS Field-Of-View.** If tracking a target and NO WPN (no weapon) or RKT has been assigned, George may be commanded to select a different sensor field-of-view (FOV) for performing reconnaissance if no weapon is assigned or observing for rocket impacts when employing rockets in a Cooperative mode. Pressing Consent To Fire (<0.5 second) will command George to toggle the TADS field-of-view between Narrow and Zoom.

4. **Fire Assigned Weapon.** If tracking a target and GUN or MSL has been assigned, pressing Consent To Fire (<0.5 second) will command George to fire the gun or launch a missile of the selected type if engagement parameters have been met and the target is within range.

   NOTE: If a Performance inhibit is displayed, George will not launch a missile if ROE is set to FREE FIRE. However, the player may order George to override Performance inhibits using the Consent To Fire command.

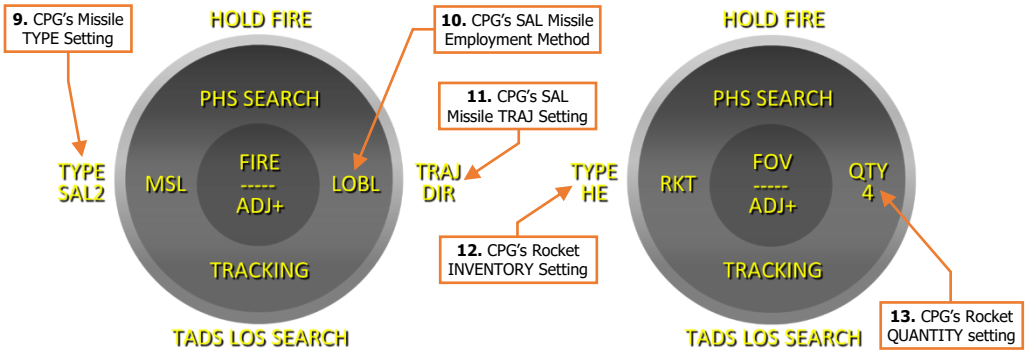
5. **TADS LRFD State.** Displays the state of the TADS Laser Rangefinder/Designator (LRFD) when George has not been assigned a weapon. Pressing Right-Short will command George to start lasing or terminate lasing.

   - **NOT LASING.** George is not firing the LRFD.
   - **LASING.** George is firing the LRFD to range and/or designate a target or location on the battlefield.

6. **TADS Selected Sensor.** If tracking a target and no weapon has been assigned (NO WPN), George may be commanded to select a different sensor for performing reconnaissance. Pressing Consent To Fire (>0.5 second) will command George to toggle the TADS selected sensor between FLIR and DTV.

7. **Adjust TADS Aim.** If tracking a target and a weapon has been assigned (GUN, MSL, or RKT), pressing Consent To Fire (>1.0 second and hold) will command George to drop the Image Auto-Track (IAT) on the target and adjust the TADS LOS Reticle to the center mass of the target for the duration that Consent To Fire remains held. Upon release of Consent To Fire, George will re-establish IAT on the target.

8. **CPG's Gun BURST LIMIT Setting.** Displays the burst limit George will select if his assigned weapon is set to GUN. Pressing Right-Short will cycle the gun BURST LIMIT setting in the following sequence: 10 → 20 → 50 → 100 → ALL. (See Area Weapon System for more information.)



9. **CPG's Missile TYPE Setting.** Displays the type of missile George will select if his assigned weapon is set to MSL. Pressing Left-Long will toggle the selected TYPE between SAL2 and RF. (See Hellfire Modular Missile System for more information.)

   - **SAL2.** George will select semi-active laser-homing (SAL) AGM-114K missiles.
   - **RF.** George will select fire-and-forget radio frequency (RF) AGM-114L missiles.

10. **CPG's SAL Missile Employment Method.** Displays the employment method George will utilize if his assigned weapon is set to MSL and his assigned missile type is SAL (AGM-114K Semi-Active Laser-homing missiles). Pressing Right-Short will toggle the method between LOBL and LOAL.

    - **LOBL.** George will employ a Lock-On-Before-Launch method.
    - **LOAL.** George will employ a Lock-On-After-Launch method.

    NOTE: The SAL missile employment method may only be toggled between LOBL and LOAL if the CPG's SAL missile TRAJ setting is set to DIR. If the TRAJ setting is set to LO or HI after the SAL missile employment method is set to LOAL, the employment method cannot be changed.

11. **CPG's SAL Missile TRAJ Setting.** Displays the trajectory setting George will select if his assigned weapon is set to MSL and his assigned missile type is SAL (AGM-114K Semi-Active Laser-homing missiles). Pressing Right-Long will cycle the TRAJ setting in the following sequence: DIR → LO → HI.
    - **DIR.** George will set the SAL missile trajectory to DIR.
    - **LO.** George will set the SAL missile trajectory to LO.
    - **HI.** George will set the SAL missile trajectory to HI.

    NOTE: The SAL missile TRAJ setting may only be set to LO or HI if the SAL missile employment method is set to LOAL. If the employment method is set to LOBL, the TRAJ setting cannot be changed from DIR.
12. **CPG's Rocket INVENTORY Setting.** Displays the rocket type that George will select if his assigned weapon is set to RKT. Pressing Left-Long will cycle the rocket INVENTORY setting in the following sequence: HE → ILL → SMK. (See Aerial Rocket Sub-system for more information.)
    - **HE.** George will select M151 or M229 high explosive rockets.
    - **ILL.** George will select M257 battlefield illumination rockets.
    - **SMK.** George will select M274 target practice smoke rockets.
13. **CPG's Rocket QTY Setting.** Displays the rocket salvo quantity that George will select if his assigned weapon is set to RKT. Pressing Right-Short will cycle the rocket QTY setting in the following sequence: 1 → 2 → 4 → 8 → 12 → 24 → ALL.

Pilot Commanded Laser Designation

When George is tracking a target or the TADS is slaved to a TSD point, if no weapon has been assigned (NO WPN), the player may command George to designate the target or TSD point location with the TADS LRFD. Pressing Right-Short while the AI interface is displayed will command George to start lasing or terminate lasing.

This may be used when the player intends to employ AGM-114K laser-guided missiles from the Pilot crewstation while George provides laser guidance, if designating the target or TSD point location for another aircraft to acquire or engage, or if simply intending to gain accurate range data to the target or TSD point location.

Target Engagement using Gun

When George is tracking a target and the CPG's assigned weapon is set to GUN, George will prepare for engagement against the current target in accordance with the directed gun settings, and will begin designating the target with the TADS LRFD to gain accurate range data and initiate Target State Estimator (TSE) ballistic compensation.

When George is ready to fire the weapon, he will either wait for a Consent To Fire command from the player if ROE is set to HOLD FIRE, or he will immediately begin engaging the target if ROE is set to FREE FIRE and acceptable engagement parameters have been met.

If George is engaging a target with the gun while his ROE is set to FREE FIRE, George will continue to engage until the target is destroyed but will pause between bursts to observe for weapon effects. If the target is not destroyed after the previous burst impacts, George will fire another burst. However, if desired, the player may order George to fire another burst before the previous burst impacts using the Consent To Fire command.

If George is tracking a target, the CPG's assigned weapon is set to GUN, and his ROE is set to FREE FIRE, George will only engage targets within a range of 2,500 meters. However, if desired, the player may order George to engage from a longer range, to a maximum range of 4,200 meters, using the Consent To Fire command.

When all gun ammunition is expended, George will de-action the gun.

Target Engagement using Laser-guided Missiles

When George is tracking a target, the CPG's assigned weapon is set to MSL, and the missile type is set to SAL2, George will prepare for engagement against the current target in accordance with the directed missile settings.

If directed to employ the Lock-On-Before-Launch (LOBL) method, George will begin lasing the target and either wait for a Consent To Fire command from the player if ROE is set to HOLD FIRE, or will immediately fire a missile if ROE is set to FREE FIRE and acceptable launch parameters have been met.

If directed to employ the Lock-On-After-Launch (LOAL) method, George will wait for a Consent To Fire command from the player if ROE is set to HOLD FIRE, or will immediately fire a missile if ROE is set to FREE FIRE and acceptable launch parameters have been met. After the missile has been launched, he will begin lasing the target.

If the target is not destroyed after the first missile impacts the target, or misses altogether, George will wait for another Consent To Fire command from the player before firing another missile if ROE is set to HOLD FIRE, or will immediately fire another missile if ROE is set to FREE FIRE and acceptable launch parameters have been met.

If both missile types are loaded but all SAL missiles are expended, George will subsequently select RF missiles. If all missiles are expended, George will de-action missiles after the final missile time-of-flight has expired.

Target Engagement using Radar-guided Missiles

When George is tracking a target, the CPG's assigned weapon is set to MSL, and the missile type is set to RF, George will prepare for engagement against the current target.

George will designate the target with the TADS LRFD to perform a target handover to the missile and either wait for a Consent To Fire command from the player if ROE is set to HOLD FIRE, or will immediately fire the missile if ROE is set to FREE FIRE and acceptable launch parameters have been met.

If the target is not destroyed after the missile impacts the target, or misses altogether, George will designate the target with the TADS LRFD to perform a target handover to the next missile and wait for another Consent To Fire command from the player before firing the next missile if ROE is set to HOLD FIRE, or will immediately fire the next missile if ROE is set to FREE FIRE and acceptable launch parameters have been met.

If both missile types are loaded but all RF missiles are expended, George will subsequently select SAL missiles. If all missiles are expended, George will de-action missiles after the final missile's time-of-flight has expired.

Target Engagement using Rockets

When George is tracking a target and the CPG's assigned weapon is set to RKT, George will prepare for engagement against the current target in accordance with the directed rocket settings. George will assume the Pilot is intending to engage using Cooperative (COOP) mode and will provide the targeting solution using the TADS but will not fire rockets himself. The player (as the Pilot) must also action rockets to enter COOP.

If George is tracking a target with the TADS, he will begin designating the target with the TADS LRFD to gain accurate range data and initiate Target State Estimator (TSE) ballistic compensation. After actioning rockets in the Pilot seat, the player must maneuver the helicopter to align the HMD LOS Reticle with the Rocket Steering Cursor and fire. See Rocket Engagement using TADS (Direct Fire in COOP Mode) for more information.

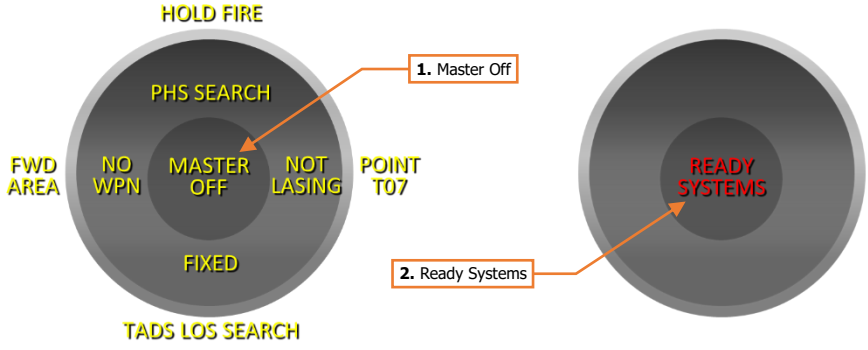
If George has slaved the TADS to a TSD point after an initial command to perform a Point search, he will not fire the TADS LRFD but will rely on the Navigation range to the TSD point for range data. After actioning rockets in the Pilot seat, the player must maneuver the helicopter to align the HMD LOS Reticle with the Rocket Steering Cursor and fire. See Rocket Engagement using TADS (Indirect Fire in COOP Mode) for more information.

If multiple rocket types are loaded but all rockets of the selected type are subsequently expended, George will select the next type. If all rockets are expended, George will de-action rockets after the final rocket salvo's time-of-flight has expired.

Start-Up & Shutdown

When the helicopter is landed with weight-on-wheels, George may be commanded to perform the relevant procedures in the CPG crewstation for start-up and/or shutdown. If NO POWER is displayed in the center of the AI Interface, George cannot perform start-up procedures.

If George is in the process of performing start-up procedures, START UP IN PROG will be displayed in the center of the AI Interface until George announces the start-up is complete. If George is in the process of performing shutdown procedures, SHUT DOWN IN PROG will be displayed in the center of the AI Interface until George announces the shutdown is complete.



1. **Master Off.** If the helicopter is landed and systems are initialized, pressing Consent To Fire (>1.0 second) will command George to perform the necessary shutdown procedures within the CPG crewstation.
   - Sight Select switch – HMD (TEDAC Right Handgrip).
   - NVS Mode switch – OFF.
   - ACM button – Disable ACM.
   - TDU Display knob – OFF.
   - RLWR Power – Disable. (ASE Utility page)
   - MASTER OFF – Select. (DMS Shutdown page)
   - INTR LT panel – All interior lighting to OFF.
2. **Ready Systems.** If the aircraft is operating on generator power and the systems are not initialized, pressing Consent To Fire (>1.0 second) will command George to perform the necessary start-up procedures within the CPG crewstation.
   - INTR LT panel – Set as appropriate.
   - TADS Power – Enable. (WPN Utility page)
   - LASER Power – Enable. (WPN Utility page)
   - TDU Display knob – Set to DAY or NT, as appropriate.
   - IHADSS – Perform BORESIGHT procedure.
   - MMA State – NORM, if FCR is installed. (FCR Utility page)
   - RLWR Power – Enable. (ASE Utility page)

Player-as-Pilot AI Helper Commands

The AI Helper Commands are broadly contextual based on whether the AI CPG is tracking a target, which weapon is assigned to the AI CPG, and whether a Search List, Point List, or Target List is displayed.

MODE CONDITIONS	COMMAND		ACTION
POINT SEARCH/ AREA SEARCH **NOT TRACKING ANY TARGET**	Consent To Fire	Short	Commands George to slave the TADS to the selected TSD point.
		Long	Commands George to perform the selected Area Search.
	TADS Store Target		(No function)
POINT RECON/ LINKED TO FCR **NOT TRACKING ANY TARGET** **TADS SLAVED TO TSD POINT OR LINKED**	Consent To Fire	Short	Commands George to perform a Point Search within the vicinity of the selected TSD point or FCR NTS target.
		Long	Commands George to toggle the TADS selected sensor between FLIR and DTV.
	TADS Store Target		(No function)
TARGET RECON **TRACKING TARGET** **NO WPN ASSIGNED**	Consent To Fire	Short	Commands George to toggle the TADS field-of-view between Narrow and Zoom.
		Long	Commands George to toggle the TADS selected sensor between FLIR and DTV.
	TADS Store Target		Commands George to store a Target point.
GUN/MISSILE ENGAGEMENT **TRACKING TARGET** **GUN/MSL ASSIGNED**	Consent To Fire	Short	Commands George to fire the assigned weapon.
		Long	Commands George to adjust the TADS aim on target.
	TADS Store Target		Commands George to store a Target point.
ROCKET ENGAGEMENT **TRACKING TARGET** **RKT ASSIGNED**	Consent To Fire	Short	Commands George to toggle the TADS field-of-view between Narrow and Zoom.
		Long	Commands George to adjust the TADS aim on target.
	TADS Store Target		Commands George to store a Target point.
SEARCH LIST	Consent To Fire	Short	(No function)
		Long	(No function)
	TADS Store Target		Commands George to store a Target point if tracking a target.
POINT LIST	Consent To Fire	Short	Selects the last Target point that has been stored by George as the selected TSD point.
		Long	(No function)
	TADS Store Target		Commands George to store a Target point if tracking a target.
TARGET LIST	Consent To Fire	Short	Select/de-select target for multi-target engagement.
		Long	Commands George to toggle the TADS selected sensor between FLIR and DTV.
	TADS Store Target		Commands George to store a Target point.
START-UP/ SHUTDOWN **WEIGHT-ON-WHEELS**	Consent To Fire	Short	(No function)
		Long	Commands George to perform start-up or shutdown procedures within the CPG crewstation.
	TADS Store Target		Commands George to store a Target point if tracking a target.

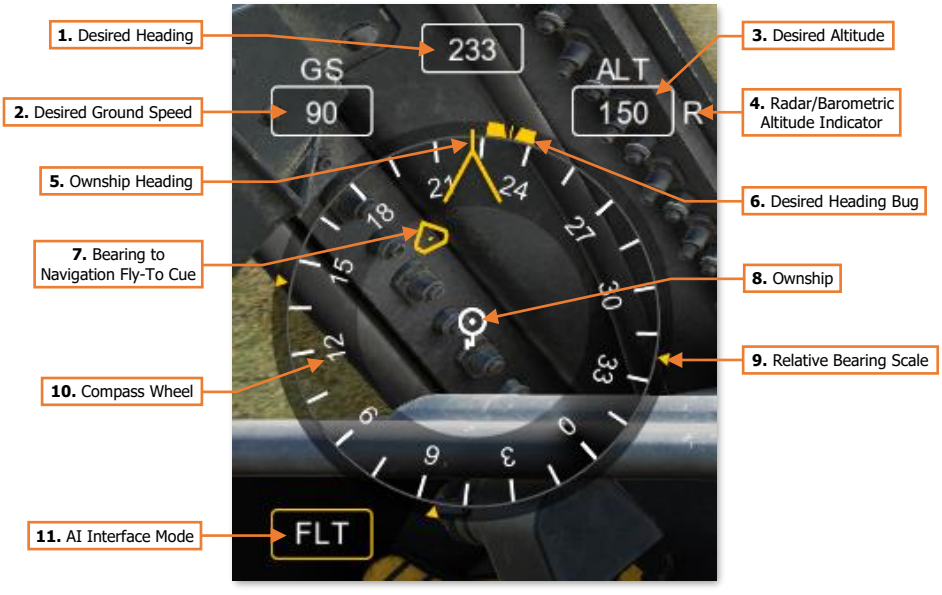
Player-as-Pilot AI Helper Controls

The AI Helper Controls are broadly contextual based on which weapon is assigned to the AI CPG, whether the TADS is Slaved or Linked, and whether a Search List, Point List, or Target List is displayed.

MODE	COMMAND		ACTION
DIRECT SEARCH/ WEAPON CONTROL	Left	Short	Cycles George's assigned weapon **NO WPN→GUN→MSL→RKT**
		Long	**NO WPN:** Displays the Search List for selecting an Area Search. **MSL**: Toggles missile TYPE between SAL2 and RF. **RKT:** Cycles rocket TYPE HE→ILL→SMK. (Only missile/rocket types that are loaded will be displayed.)
	Right	Short	**NO WPN:** Toggles TADS laser between NOT LASING and LASING. **GUN:** Cycles gun BURST LIMIT 10→20→50→100→ALL. **MSL:** Toggles between LOBL and LOAL if DIR is selected TRAJ. **RKT:** Cycles rocket QTY 1→2→4→8→12→24→ALL.
		Long	**NO WPN:** Displays the Point List for selecting a TSD point. **MSL:** Cycles missile TRAJ DIR→LO→HI if LOAL is selected.
	Up	Short	Commands George to slave the TADS to Pilot Helmet Sight (PHS) and search along the designated line-of-sight for targets.
		Long	Toggles George's Rules Of Engagement (ROE) between HOLD FIRE and FREE FIRE. HOLD FIRE is the default ROE state. **SLAVED/LINKED:** Commands George to increase sensor magnification to the next TADS field-of-view setting.
	Down	Short	Commands George to cease any existing tasks, including engaging targets, and slave the TADS to fixed forward.
		Long	Commands George to search along the current TADS line-of-sight for targets. **SLAVED/LINKED:** Commands George to decrease sensor magnification to the previous TADS field-of-view setting.
SEARCH LIST/ POINT LIST/ TARGET LIST	Left	Short	Exits list and cancels any list selections.
		Long	**Target List:** Enables/Disables Target List filtering. (By default, friendly and neutral units are excluded if enemy or unknown targets are detected.) **Point List:** Selects CTRLM or WPTHZ Point List filtering.
	Right	Short	**Search List:** Selects current Area Search. **Point List:** Selects current TSD Point. **Target List:** Commands George to track the current target or the first target added to the multi-target "shoot list".
		Long	**Point List:** Selects TGT/THRT Point List filtering.
	Up	Short	Scrolls list upwards.
		Long	**Target List:** Commands George to increase sensor magnification to the next TADS field-of-view setting.
	Down	Short	Scrolls list downwards.
		Long	**Target List:** Commands George to decrease sensor magnification to the previous TADS field-of-view setting.

PLAYER-AS-CPG "GEORGE" AI CONTROLS

When the player is in the Copilot/Gunner (CPG) crewstation, pressing the **George AI Helper Interface – Show/Hide** command will display a horizontal situation indicator that can be used as a directional reference for giving commands to George (as the Pilot).



Player-as-CPG AI Interface

1. **Desired Heading.** Displays the heading that George has been commanded to maintain.
2. **Desired Ground Speed.** Displays the ground speed that George has been commanded to maintain.
3. **Desired Altitude.** Displays the altitude that George has been commanded to maintain.
4. **Radar/Barometric Altitude Indicator.** Displays the altitude reference that George will use to maintain the desired altitude.
   - **R.** George will maintain the desired radar altitude above ground level (AGL).
   - **B.** George will maintain the desired barometric altitude above mean sea level (MSL).
5. **Ownship Heading.** Displays the current heading of the ownship on the compass wheel.
6. **Desired Heading Bug.** Displays the heading that George has been commanded to maintain relative to the ownship heading on the compass wheel.
7. **Bearing to Navigation Fly-To Cue.** Displays the bearing to the Navigation Fly-To Cue relative to the ownship heading on the compass wheel.
8. **Ownship.** Indicates the aircraft orientation relative to the compass wheel and associated bearing indicators.
9. **Relative Bearing Scale.** Displays bearings relative to the desired heading bug at the 3 o'clock, 6 o'clock, and 9 o'clock positions.
10. **Compass Wheel.** Displays the magnetic heading reference around the ownship.

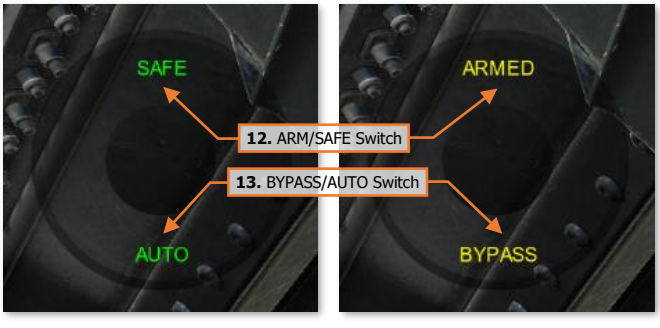
11. AI Interface Mode. Displays the current mode of the George AI Helper Interface.

- **FLT.** The AI Interface is set to "Flight" mode, which is used to direct specific flight parameters for George to fly.
  - Assign a ground speed to achieve and maintain.
  - Assign a heading to turn toward and maintain.
  - Assign an altitude to achieve and maintain.
  - Turn the aircraft toward the direction the player (as the CPG) is looking.
- **H-B.** The AI Interface is set to "Hover/Bob-up" mode, which is used to direct George to maneuver the aircraft while in a stationary hover, such as when occupying a battle position.
  - Translate the aircraft forward/backward/left/right across the surface at low speed.
  - Assign a hover altitude to achieve and maintain.
  - Turn the aircraft toward the direction the player (as the CPG) is looking.

  NOTE: H-B mode is only available when the aircraft is below 30 knots ground speed. When above 30 knots ground speed, this mode will be skipped, and the AI Interface Mode will proceed from FLT directly to CMBT.
- **CMBT.** The AI Interface is set to "Combat" mode, which is used to direct George in performing combat mission-related tasks.
  - Perform an immediate break turn to the 3 o'clock, 6 o'clock, or 9 o'clock directions.
  - Align the aircraft heading to the azimuth of the TADS sensor turret.
  - Navigate along the current route and come to a hover at the final waypoint.
- **CMWS.** The AI Interface is set to "Common Missile Warning System" mode. This mode directs George to change the settings on the CMWS control panel in the Pilot crewstation.
  - Arm/Safe the flare dispensers.
  - Enable/disable automatic dispensing of flares.

When **CMWS** mode is entered, an additional circular interface element will be displayed to the player as a directional reference for giving commands, showing the current settings of the CMWS control panel.

The text color of the AI Helper Interface text corresponds with the Arm/Safe status of the CMWS in the same color pattern as the A/S button on the Armament Panel.



Player-as-CPG AI Interface - CMWS mode

12. ARM/SAFE Switch. Displays the position of the ARM/SAFE switch on the CMWS control panel.

- **SAFE** Flare dispensers are safed.
- **ARMED** Flare dispensers are armed.

13. BYPASS/AUTO Switch. Displays the position of the BYPASS/AUTO switch on the CMWS control panel.

- **AUTO.** Flares will be dispensed automatically when threats are detected by the CMWS.
- **BYPASS.** Flares will not be dispensed when threats are detected by the CMWS.

Player-as-CPG AI Helper Controls

The AI Helper Controls are contextual based on the current mode of the AI Helper Interface. The actions listed below correspond with the commands issued by the player when occupying the Copilot/Gunner crewstation.

MODE	COMMAND		ACTION
FLT FLIGHT PARAMETERS	Left	Short	If >30 knots, changes the AI Interface mode to **CMBT**. If <30 knots, changes the AI Interface mode to **H-B**.
		Long	Moves desired heading bug left. After the button is released, commands George to turn the helicopter to the new heading.
	Right	Short	Commands George to turn the helicopter toward the direction you are looking.
		Long	Moves desired heading bug right. After the button is released, commands George to turn the helicopter to the new heading.
	Up	Short	Increases the desired speed in the GS window. After a short delay, George will accelerate the helicopter to the new speed.
		Long	Increases the desired altitude in the ALT window. After the button is released, George will increase the helicopter's altitude. If set to <1,420 feet AGL, George will hold the radar altitude. If set ≥1,420 feet AGL, George will hold the barometric altitude.
	Down	Short	Decreases the desired speed in the GS window. After a short delay, George will decelerate the helicopter to the new speed. (**H-B** Interface mode becomes available if speed decreases below 30 knots.)
		Long	Decreases the desired radar altitude in the ALT window. After the button is released, George will decrease the helicopter's altitude. If set to <1,420 feet AGL, George will hold the radar altitude. If set ≥1,420 feet AGL, George will hold the barometric altitude.
H-B HOVER/BOB-UP MANEUVERS	Left	Short	Changes the AI Interface mode to **CMBT**.
		Long	George translates the helicopter to the left while the button is held.
	Right	Short	Same function as FLT mode.
		Long	George translates the helicopter to the right while the button is held.
	Up	Short	George increases hover altitude by 10 feet.
		Long	George translates the helicopter forward while the button is held.
	Down	Short	George decreases hover altitude by 10 feet.
		Long	George translates the helicopter backward while the button is held.
CMBT COMBAT TASKS	Left	Short	Changes the AI Interface mode to **CMWS**.
		Long	Commands George to perform a 90° turn to the left to evade or more quickly re-attack.
	Right	Short	Commands George to fly a direct path to the current Navigation Direct-To Cue. If the point is part of a route, George will continue along that route in sequence. If the point is not part of a route, or is the final point in the route, George will come to a hover at that location.
		Long	Commands George to perform a 90° turn to the right to evade or more quickly re-attack.

	Up	Short	Commands George to turn the aircraft to the heading of the TADS LOS reticle. This is useful for starting an attack run, bringing the helicopter into Hellfire launch constraints, or aligning the Rocket Steering Cursor.
		Long	No Function.
	Down	Short	No Function.
		Long	Commands George to perform a 180° turn to evade or turn away after an attack.
CMWS CMWS PANEL SETTINGS	Left	Short	Changes the AI Interface mode to **FLT**.
		Long	No Function.
	Right	Short	No Function.
		Long	No Function.
	Up	Short	Toggles flare dispensers arming state between ARM and SAFE.
		Long	No Function.
	Down	Short	Toggles flare dispense mode between AUTO and BYPASS.
		Long	No Function.

ADDITIONAL "GEORGE" AI FEATURES

Some additional features and important notes regarding George are listed below.

- During a cold start, George will close his cockpit canopy when the player closes theirs, or after the APU is powered on, whichever comes first.
- George may be configured to automatically take over the flight controls when the player switches from the Pilot seat to the Copilot/Gunner seat. (See the DCS Fundamentals chapter for more information.)
- When George assumes control of the aircraft, he will attempt to maintain the current flight parameters until ordered to do otherwise.
- George will not ground taxi. When the player is occupying the Copilot/Gunner seat, George may be directed to takeoff by increasing the Desired Altitude above zero or order him to land by decreasing the Desired Altitude to zero. Once airborne, the **H-B** mode may be used to direct George to hover or translate in any direction to hover taxi around a FARP or airfield or maneuver the aircraft within a battle position.
- Any time George is directed to perform a search for targets while the A/S button on the Armament Panel is set to SAFE, he will set the button to ARM to permit the TADS LRFD to be fired for gaining accurate range to target. When subsequently commanded to cease any existing tasks and slave the TADS to fixed forward via Down-Short, he will set the A/S button back to SAFE.
- George is not immortal. If George "dies", the player cannot occupy George's position to continue the mission. The seat that George occupies at the moment of his incapacitation will be locked out from use by the player.

AI Mission Editor Options

Mission creators may configure several additional options that affect the behavior of George during a mission. These options are displayed within the Aircraft Additional Properties tab for the AH-64D BLK.II.

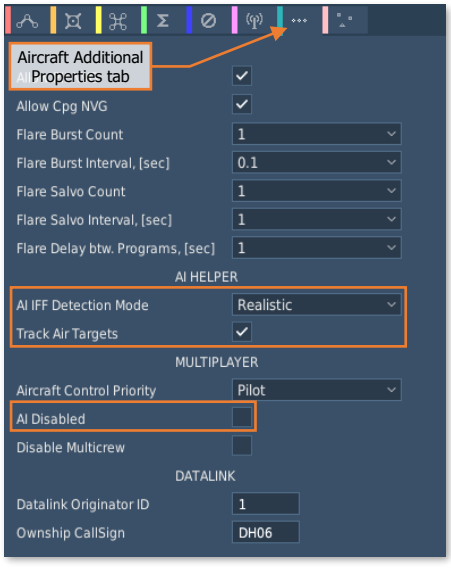
AI IFF Detection Mode. Sets the level of Identification-Friend-or-Foe that George will utilize when detecting, acquiring, and identifying potential targets. Depending on the selection, F10 View Options and Labels selections will affect the level George is able to identify whether a contact is friendly or enemy, and what type of target it is. (See Combat Identification for more information)

Track Air Targets. When checked, George (as the CPG) will include aircraft as potential targets when generating the Target List. If this option is un-checked, George will ignore helicopter and fixed-wing aircraft when performing sensor scans of the battlefield.

AI Disabled. When checked, this option will disable all George AI Interface functions.

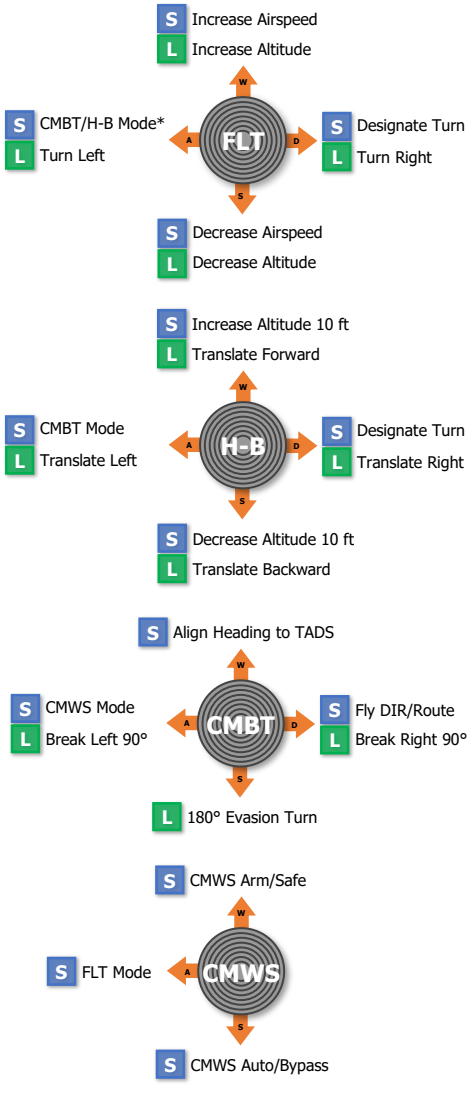
- As the CPG, George will not scan for targets, will not use the TADS laser rangefinder/designator, and will not action any weapons.
- As the Pilot, George will not fly the aircraft.

If the player is flying the DCS AH-64D by himself or herself in single-player, they will need to perform all duties as necessary, which will usually require switching between seats.

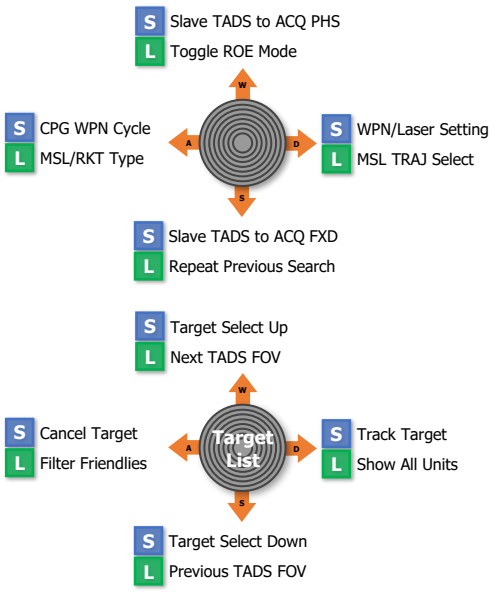


AI HELPER CONTROLS

Player-as-CPG



Player-as-PLT



S Short press (<0.5 sec)
L Long press (>0.5 sec)

* H-B **mode is not available >30 knots**

WEAPONS TIGHT (Default ROE; Player consent required)
WEAPONS FREE (CPG will engage tracked target at will)

APPENDICES

US Army photo
by SGT Richard Wrigley

APPENDIX A – ABBREVIATED CHECKLISTS

Procedures

Aircraft Start
Ground Taxi
Before Takeoff
Before Landing
After Landing
Aircraft Shutdown
Rapid Refueling/Rearming

Navigation

Adding a Point on the TSD
Editing a Point on the TSD
Deleting a Point on the TSD
Storing a Point on the TSD
Creating a Route on the TSD
Editing a Route on the TSD
Selecting a New Route
Deleting a Route
Tuning the ADF to a Manual Frequency
Tuning the ADF to a Preset Frequency
Editing an ADF Preset

Radio Communications

Editing a Communications Preset
Tuning a Radio to a Preset frequency/network
Tuning a Radio to a Manual frequency

Datalink Communications

Editing Ownship network settings
Editing a Preset network settings
Building a Datalink network
Editing a Datalink network
Drawing/Assigning Fire Zones
Sending Fire Zones
Receiving Fire Zones
Sending a TSD Point
Receiving a TSD Point
Sending a BDA Report
Sending a TGT Report
Sending a PP Report
Sending a FARM Report
Receiving BDA/TGT/PP/FARM Reports
Sending a Text message
Receiving a Text message
Sending a Misson File
Receiving a Mission File
Sending an RF Handover
Receiving an RF Handover

Combat Employment

Performing Pre-Combat Checks
Engaging targets with AGM-114K Laser-guided Missiles
Engaging targets with AGM-114L Radar-guided Missiles
Performing Post-Engagement Procedures
Selecting an Acquisition Source
Engaging targets with 2.75-inch Unguided Rockets
Engaging targets with 30mm Area Weapon System

Return to Checklist index

Procedures

Abbreviated checklists for performing start-up, ground taxi, takeoff, landing, and shutdown procedures.

Aircraft Start

Once the interior checks are complete, perform the following:

1	PLT	MSTR IGN switch – BATT (or EXT PWR if external power is to be used).
2	PLT	TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
3	PLT & CPG	ICS system – Check to verify communications between crewstations.
4	PLT & CPG	INTR LT PRESS-TO-TEST button – Press and hold; verify all signal lights illuminate.
5	PLT / CPG	MSTR WARN, MSTR CAUT, and EUFD – Check for any malfunction indications.
6	PLT	FIRE DET/EXTG TEST switch held to position 1 – Both crewmembers check for correct indications.
7	CPG	FIRE DET/EXTG TEST switch held to position 2 – Both crewmembers check for correct indications.
8	PLT	APU button – Press and release to initiate APU start sequence.
9	PLT	EUFD advisory column – Verify "APU ON" message is displayed.
10	PLT	MSTR IGN – BATT (if external power was used prior to APU start).

Once the APU has been started and the MPDs have initialized, perform the following:

11	PLT & CPG	Canopy door – Close.
12	PLT / CPG	DTU page – Select MASTER LOAD to upload DTC data to the aircraft systems. (N/I)
13	PLT & CPG	Aircraft systems – Initialize and configure remaining options as appropriate for mission
14	PLT	Standby Attitude Indicator – Uncage.
15	PLT	RTR BRK switch – OFF (or LOCK if performing a Rotor Lock start).
16	PLT	EXT LT ANTI-COL switch – WHT for day, or RED for night.
17	PLT	First engine – Start as follows: • ENG START switch – START. • POWER lever – IDLE, at first indication of N_G increase and if TGT is less than 80° C.
18	PLT	Second Engine – Repeat the steps above after first engine start sequence is complete.
19	PLT	RTR BRK switch – OFF.
20	PLT	POWER levers – Advance both POWER levers smoothly to FLY.
21	PLT	N_P and N_R – Verify 101%.
22	PLT	MSTR WARN, MSTR CAUT, and EUFD – Monitor for any malfunction indications.
23	PLT	APU button – Press and release to initiate APU shutdown sequence.

Return to Checklist index

Ground Taxi

Prior to initiating ground taxi, perform the following:

1	PLT / CPG	Chocks removed – Verify.
2	PLT / CPG	Bleed Air – On.
3	PLT / CPG	ANTI-ICE – As required.
4	PLT	EXT LT/INTR LT panel – Set exterior lighting in accordance with local procedures.
5	PLT & CPG	Searchlight – As required.
6	PLT	PARK BRAKE – Release by applying wheel brake pressure; ensure PARK BRAKE handle is inward.

During ground taxi, perform the following:

7	PLT / CPG	TAIL WHEEL button – Unlock; "UNLOCK" light is illuminated.
8	PLT & CPG	Wheel brakes – Check in each crew station.
9	PLT / CPG	ENG page – Check; ensure N_P and N_R 101%, all indications green.
10	PLT / CPG	FLT page – Check; update altimeter if necessary.
11	PLT	Pilot standby instruments – Check; update standby altimeter if necessary

Before Takeoff

Perform the following prior to lifting up to a hover or initiating takeoff from the ground:

1	PLT & CPG	Weapons systems – Check the following: • A/S button – "SAFE" light is illuminated. • GND ORIDE button – Off; "ON" light is not illuminated. • Weapons not actioned – Verify.
2	PLT / CPG	TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
3	PLT	PARK BRAKE – As desired (Ensure released unless operating on uneven or sloped terrain).
4	PLT & CPG	POWER levers – Ensure both POWER levers are set to FLY.
5	PLT / CPG	Systems – Check as follows: • FUEL page – Verify options set as appropriate. • Fuel quantity – Check; verify sufficient fuel is onboard the aircraft for the mission. • EUFD – Check; clear of Warnings and Cautions. • Engine and flight instruments – Check. • ASE – As required. • Avionics – As desired (Transponder/Radios on COM page; Navigation on TSD page).
6	PLT	Hover Power Check – Perform. (see Hover Power Check for more information.)

Return to Checklist index

Before Landing

Prior to landing, perform the following:

1	PLT & CPG	Weapons systems – Check the following: • A/S button – "SAFE" light is illuminated. • GND ORIDE button – Off; "ON" light is not illuminated. • Weapons not actioned – Verify.
2	PLT / CPG	ASE – As required.
3	PLT / CPG	TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
4	PLT	PARK BRAKE – Ensure brakes are released, PARK BRAKE handle is inward.

After Landing

After landing, perform the following:

1	PLT / CPG	TAIL WHEEL button – Unlock as necessary for ground taxi.
2	PLT	EXT LT/INTR LT panel – Set exterior lighting in accordance with local procedures.
3	PLT / CPG	Avionics – As desired (COM/TSD pages). • Transponder – STBY. • Communications – As appropriate; verify on EUFD.

Return to Checklist index

Aircraft Shutdown

Once stationary in designated parking location, perform the following:

1	PLT	APU button – Press and release to initiate APU start sequence.
2	PLT / CPG	TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
3	PLT	PARK BRAKE – Brakes set; PARK BRAKE handle is pulled outward.

Prior to retarding the POWER levers to IDLE, verify the "APU ON" advisory message is displayed on the EUFD:

4	PLT	POWER levers – Retard both POWER levers to IDLE; press EUFD Stopwatch button to start a timer for a 2-minute engine cooldown.
5	PLT	Standby Attitude Indicator – Cage.
6	PLT	CMWS Power/Test knob – OFF.
7	PLT & CPG	NVS Mode switch – OFF.
8	PLT	ACM switch – OFF.
9	CPG	ACM button – Disable ACM.
10	CPG	TDU Mode knob – OFF.
11	PLT / CPG	DMS SHUT DOWN page – MASTER OFF.
12	PLT	POWER levers – OFF after 2 minutes have elapsed on EUFD stopwatch.
13	PLT	RTR BRK switch – BRK after N_R has decreased below 50%.
14	PLT	Stabilator – Manually set the stabilator angle to 0°.
15	PLT	Searchlight – STOW.
16	PLT	RTR BRK switch – OFF after main rotor has stopped.
17	PLT	EXT LT/INTR LT panel – All interior and exterior lighting to OFF.
18	CPG	INTR LT panel – All interior lighting to OFF.
19	PLT	APU button – Press and release to initiate APU shutdown sequence.
20	PLT	MSTR IGN – OFF.

Return to Checklist index

Rapid Refueling/Rearming

Once stationary at the designated refueling/rearming location, perform the following:

1	PLT / CPG TAIL WHEEL button – Verify locked; "UNLOCK" light is not illuminated.
2	PLT PARK BRAKE – Brakes set; PARK BRAKE handle is pulled outward.
3	PLT & CPG Weapons systems – Check the following: • A/S button – "SAFE" light is illuminated. • GND ORIDE button – Off; "ON" light is not illuminated.
4	PLT **(If refueling)** POWER lever NO 2 – IDLE.
5	PLT / CPG **(If refueling)** XFER (VAB L4) – OFF (FUEL page).
6	PLT / CPG **(If rearming)** Weapon systems – Power off (WPN UTIL page): • GUN Power (VAB B2) – Press. • MSL Power (VAB B3) – Press. • RKT Power (VAB B5) – Press.
7	PLT / CPG Datalink transmissions – Inhibit: • DL INHBT (VAB B3) – Select (DL page).
8	PLT EXT LT ANTI-COL switch – OFF.
9	PLT & CPG Refueling/rearming – Perform.

When refueling/rearming is complete, perform the following:

10	PLT / CPG **(If rearming)** Weapon systems – Power on (WPN UTIL page): • GUN Power (VAB B2) – Press. • MSL Power (VAB B3) – Press. • RKT Power (VAB B5) – Press.
11	PLT / CPG **(If rearming)** Missile launchers – Verify ARM status (WPN page). • LNCHR ARM (VAB R2) – Select, if necessary (WPN UTIL page).
12	PLT EXT LT ANTI-COL switch – WHT for day, or RED for night.
13	PLT / CPG Datalink transmissions – Enable: • DL INHBT (VAB B3) – Select (DL page).
14	PLT **(If refueling)** POWER lever NO 2 – FLY.
15	PLT / CPG **(If refueling)** XFER (VAB L4) – AUTO (FUEL page).

Return to Checklist index

Navigation

Abbreviated checklists for adding/editing/deleting/storing points, selecting a point for direct navigation, selecting/editing/deleting a route, tuning the ADF to an NDB, or editing an NDB preset.

Adding a Point on the TSD

To quickly add a point using the "cursor drop" method, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**POINT** (VAB B6) – Select.
3	**ADD** (VAB L2) – Select.
4	Point Type (VAB L3-L6) – Select **WP**, **HZ**, **CM**, or **TG** as desired.
5	**MPD Cursor** Controller/Enter – Slew to desired location on TSD.
6	**MPD Cursor** Controller/Enter – Press.

To add a point using the Keyboard Unit, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**POINT** (VAB B6) – Select.
3	**ADD** (VAB L2) – Select.
4	ABR (T4) – Select, as required to review point abbreviations.
5	Point Type (VAB L3-L6) – Select **WP**, **HZ**, **CM**, or **TG** as desired.
6	**IDENT>** (VAB L1) – Select.
7	Input identifier data using the KU, and press ENTER on the KU.
8	Input free text data using the KU, and press ENTER on the KU.
9	Input location data using the KU, and press ENTER on the KU.
10	Input altitude data using the KU, and press ENTER on the KU.

Return to Checklist index

Editing a Point on the TSD

To edit a point using the Keyboard Unit, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**POINT** (VAB B6) – Select.
3	**POINT>** (VAB L1) – Select and input the point index of the point to be edited into the KU. *or* **MPD Cursor** Controller/Enter – Select the point to be edited on TSD.
4	**EDIT** (VAB L3) – Select.
5	**FREE>** (VAB L1) – Select.
6	If the existing free text is desired, simply press ENTER on the KU. If different free text data is desired, input new free text, and press ENTER on the KU.
7	If the existing location is desired, simply press ENTER on the KU. If different location data is desired, input new location, and press ENTER on the KU.
8	If the existing altitude is desired, simply press ENTER on the KU. If different altitude data is desired, input new altitude, and press ENTER on the KU.

Deleting a Point on the TSD

To delete a point, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**POINT** (VAB B6) – Select.
3	**POINT>** (VAB L1) – Select and input the point index of the point to be edited into the KU. *or* **MPD Cursor** Controller/Enter – Select the point to be edited on TSD.
4	**DEL** (VAB L4) – Select.
5	**YES** (VAB L3) – Select to confirm deletion. *or* **NO** (VAB L4) – Select to abort deletion.

Storing a Point on the TSD

To store a point at the current aircraft position, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**POINT** (VAB B6) – Select.
3	**STO** (VAB L5) – Select.
4	**TYPE** (VAB L6) – Select **WP** or **TG** as desired.
5	**NOW** (VAB L1) - Select.

Return to Checklist index

To store a point at the CPG's HMD line-of-sight using an Automatic range, perform the following:

1	Sight Select switch – **HMD**.
2	**WPN** Fixed Action Button – Press.
3	**MANRNG** (VAB B6) – Select, enter "**A**" on the KU, and press **ENTER**.
4	**TSD** Fixed Action Button – Press.
5	**POINT** (VAB B6) – Select.
6	**STO** (VAB L5) – Select.
7	**TYPE** (VAB L6) – Select **WP** or **TG** as desired.
8	Position the HMD LOS Reticle over the desired location.
9	STORE/UPDT switch – **STORE**.

To store a point at the CPG TADS line-of-sight using a laser range, perform the following:

1	**NVS** Mode switch – **OFF**, if applicable.
2	**Sight Select** switch – **TADS**.
3	Sight Manual Tracker – Position the TADS LOS Reticle over the desired location.
4	**TSD** Fixed Action Button – Press.
5	**POINT** (VAB B6) – Select.
6	**STO** (VAB L5) – Select.
7	**TYPE** (VAB L6) – Select **WP** or **TG** as desired.
8	ARM/SAFE button – **ARM**.
9	LRFD trigger – 1st detent for ranging.
10	STORE/UPDT switch – **STORE**.

To store a point at the CPG TADS line-of-sight using an Automatic range, perform the following:

1	**NVS** Mode switch – **OFF**, if applicable.
2	**Sight Select** switch – **TADS**.
3	**WPN** Fixed Action Button – Press.
4	**MANRNG** (VAB B6) – Select, enter "**A**" on the KU, and press **ENTER**.
5	Sight Manual Tracker – Position the TADS LOS Reticle over the desired location.
6	**TSD** Fixed Action Button – Press.
7	**POINT** (VAB B6) – Select.
8	**STO** (VAB L5) – Select.
9	**TYPE** (VAB L6) – Select WP or TG as desired.
10	STORE/UPDT switch – **STORE**.

Return to Checklist index

Creating a Route on the TSD

To add points to a new route, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**RTE** (VAB B5) – Select.
3	**ADD** (VAB L2) – Select.
4	**POINT>** (VAB L1) – Select and input the point index of the point to be added into the KU. *or* **MPD Cursor** Controller/Enter – Select the point to be added on TSD.
5	Route Point (VAB R5) – Select the button adjacent to the route "END" identifier to place the point at the start of the route.
6	**POINT>** (VAB L1) – Select and input the point index of the next point to be added into the KU. *or* **MPD Cursor** Controller/Enter – Select the next point to be added on TSD.
7	Route Point (VAB R2-R5) – Select the button adjacent to the route "END" identifier to place the next point at the end of the route.

To create a direct route to a point, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**RTE** (VAB B5) – Select.
3	**DIR** (VAB L5) – Select.
4	**POINT>** (VAB L1) – Select and input the point index of the point to be added into the KU. *or* **MPD Cursor** Controller/Enter – Select the point to be removed on TSD. *or, if the point is part of the current route,* Route Scroll (VAB R1/R6) – Select, as necessary.
5	Route Points (VAB R2-R5) – Select the button that corresponds with the point desired for creating a direct route.

Return to Checklist index

Editing a Route on the TSD

To insert a point into the current route, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**RTE** (VAB B5) – Select.
3	**ADD** (VAB L2) – Select.
4	**POINT>** (VAB L1) – Select and input the point index of the point to be added into the KU. *or* **MPD Cursor** Controller/Enter – Select the point to be added on TSD.
5	Route Points (VAB R2-R5) – Select the button that corresponds with the desired location within the route to which the point will be inserted.

To remove a point from the current route, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**RTE** (VAB B5) – Select.
3	**DEL** (VAB L4) – Select.
4	**MPD Cursor** Controller/Enter – Select the point to be removed on TSD. *or* Route Scroll (VAB R1/R6) – Select, as necessary.
5	Route Points (VAB R2-R5) – Select the button that corresponds with the point that to be removed.

Return to Checklist index

Selecting a New Route

To select a new route for navigation, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**RTE** (VAB B5) – Select.
3	**RTM** (VAB B6) – Select.
4	**NEW** (VAB L4) – Verify boxed.
5	Paging Controls (VAB B2/B3) – Select as necessary to view the available route sequences.
6	Route Select (VAB T1-T5) – Select the desired route sequence.
7	REVERSE ROUTE (VAB R5) – Select as necessary, depending on the direction the route is intended to be flown.

Deleting a Route

To select a route for deletion, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**RTE** (VAB B5) – Select.
3	**RTM** (VAB B6) – Select.
4	**DEL** (VAB L4) – Verify boxed.
5	Paging Controls (VAB B2/B3) – Select as necessary to view the available route sequences.
6	Route Select (VAB T1-T5) – Select the route sequence that is intended for deletion.
7	**YES** (VAB L4) – Select to confirm deletion. *or* **NO** (VAB L5) – Select to abort deletion.

Return to Checklist index

Tuning the ADF to a Manual Frequency

To tune the ADF to a manual frequency, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**INST** (VAB L1) – Select.
3	**FREQ>** (VAB L3) – Select and input the manual frequency using the KU.

Tuning the ADF to a Preset Frequency

To tune the ADF to a preset frequency, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**INST** (VAB L1) – Select.
3	**UTIL** (VAB T6) – Select.
4	Preset (VAB L2-L6, R2-R6) – Select as desired.
5	**TUNE** (VAB T5) – Select.

Editing an ADF Preset

To edit an ADF preset using the KU, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**INST** (VAB L1) – Select.
3	**UTIL** (VAB T6) – Select.
4	Preset (VAB L2-L6, R2-R6) – Select as desired.
5	**ID>** (VAB B4) – Select and input the desired 3-character identifier on the KU.
6	**FREQ>** (VAB B5) – Select and input the desired preset frequency on the KU.

Return to Checklist index

Radio Communications

Abbreviated checklists for editing COM Presets on the MPD COM page, assigning a preset frequency/network to a radio using the MPD COM page or EUFD, or manually tuning a radio frequency using the MPD COM page.

NOTE: Configuring the datalink network associated with a COM Preset is performed using the NET and MODEM pages after selecting the PRESET EDIT page. (See the Datalink Communications checklists below.)

Editing a Communications Preset

To edit a COM Preset's Unit ID, Call Sign, and radio frequencies, perform the following:

1	**COM** Fixed Action Button – Press.
2	Preset (VAB L1-L5, R1-R3) – Select as desired.
3	**PRESET EDIT** (VAB B6) – Select.
4	**EDIT – UNIT** (VAB T2) – Select.
5	**UNIT ID>** (VAB L1) – Select and input the preset's 8-character unit identification on the KU.
6	**CALL SIGN>** (VAB L2) – Select and input the preset's 5-character callsign on the KU.
7	**PRIMARY** (VAB L4) – Select the preset's primary frequency and radio as desired.
8	**EDIT – V/UHF** (VAB T3) – Select.
9	**VHF FREQ>** (VAB L1) – Select and input the preset's VHF frequency on the KU if necessary.
10	**FREQ>** (VAB R4) – Select and input the preset's UHF frequency on the KU if necessary.
11	**EDIT – FM** (VAB T4) – Select.
12	**FREQ>** (VAB L4) – Select and input the preset's FM1 frequency on the KU if necessary.
13	**FREQ>** (VAB R4) – Select and input the preset's FM2 frequency on the KU if necessary.
14	**DATA SWAP** (VAB L5) – Select to swap the FM1 and FM2 frequencies if desired.
15	**EDIT – HF** (VAB T5) – Select.
16	**HF RECV – FREQ>** (VAB R1) – Select and input the preset's HF receive frequency on the KU.
17	**HF XMIT – FREQ>** (VAB R3) – Select and input the preset's HF transmit frequency on the KU.

Return to Checklist index

Tuning a Radio to a Preset frequency/network

To assign a preset frequency/network to a radio using an MPD, perform the following:

1	**COM** Fixed Action Button – Press.
2	Preset (VAB L1-L5, R1-R5) – Select as desired.
3	**RADIO** (VAB T1-T5) – Select as desired.
4	**TUNE** Mode (VAB B2) – Set as **PRI** or **STBY** as desired.
5	**TUNE** Select (VAB B6) – Select **SC**.

To assign a preset frequency/network to a radio using the EUFD, perform the following:

1	EUFD **Preset** button – Press to display the preset list
2	EUFD **RTS** rocker switch – Select radio to tune.
3	EUFD **WCA** rocker switch – Select preset frequency from preset list.
4	EUFD **Enter** button – Press.

Tuning a Radio to a Manual frequency

To manually tune a VHF, UHF, or FM frequency, perform the following:

1	**COM** Fixed Action Button – Press.
2	**MAN** (VAB B2) – Select.
3	**VHF>** (VAB L1) – Select and input the frequency on the KU. *or* **UHF>** (VAB L1) – Select and input the frequency on the KU. *or* **FM1>** (VAB L1) – Select and input the frequency on the KU *or* **FM2>** (VAB L1) – Select and input the frequency on the KU

To manually tune an HF frequency, perform the following:

1	**COM** Fixed Action Button – Press.
2	**MAN** (VAB B2) – Select.
3	**HF RECV – FREQ>** (VAB R1) – Select and input the receive frequency on the KU.
4	**HF XMIT – FREQ>** (VAB R3) – Select and input the transmit frequency on the KU.

Return to Checklist index

Datalink Communications

Abbreviated checklists for configuring datalink networks and transmitting/receiving/reviewing datalink messages.

NOTE: Tuning a datalink network is performed by tuning the COM Preset to which the network is associated, using the MPD COM page or the EUFD. (See the Radio Communications checklists above.)

Editing the Ownship network settings

To edit the ownship Originator Identification using the Member Directory, perform the following:

1	**COM** Fixed Action Button – Press.
2	**ORIG ID** (VAB B4) – Select.
3	**ORIG DIR** (VAB L6) – Select.
4	Directory Member (VAB L1-L4, R1-R4) – Select as desired.
5	**REPLACE** (VAB T5) – Select to replace the existing ownship originator information with the selected directory member.

To edit the ownship Originator Identification using the Keyboard Unit, perform the following:

1	**COM** Fixed Action Button – Press.
2	**ORIG ID** (VAB B4) – Select.
3	**DATALINK ORIG ID>** (VAB R1) – Select and input the ownship's originator ID number on the KU.

Editing a Preset network settings

To enable a COM Preset to use a Datalink network, perform the following:

1	**COM** Fixed Action Button – Press.
2	Preset (VAB L1-L5, R1-R3) – Select as desired.
3	**PRESET EDIT** (VAB B6) – Select.
4	**MODEM** (VAB R6) – Select.
5	**PROTOCOL** (VAB L1) – Select.
6	**DATALINK** (VAB L1) – Select.

Return to Checklist index

Building a Datalink network

To build a COM Preset's network of Subscribers from the Member Directory, perform the following:

1	**COM** Fixed Action Button – Press.
2	Preset (VAB L1-L5, R1-R3) – Select as desired.
3	**NET** (VAB B4) – Select.
4	**MBR DIR** (VAB L6) – Select.
5	Directory Member (VAB L1-L4, R1-R4) – Select as desired.
6	**ADD** (VAB T6) – Select to add the selected directory member into the first available subscriber entry. *or* **REPLACE** (VAB T5) – Select to replace an existing subscriber entry with the selected directory member.
7	Network Member (VAB L1-L5, R1-R5) – Select the network member to replace with the selected directory member.

Editing a Datalink network

To edit a COM Preset's network of Subscribers using the Keyboard Unit, perform the following:

1	**COM** Fixed Action Button – Press.
2	Preset (VAB L1-L5, R1-R3) – Select as desired.
3	**NET** (VAB B4) – Select.
4	Network Member (VAB L1-L5, R1-R5) – Select.
5	**C/S>** (VAB T5) – Select and input the network member's callsign on the KU.
6	**SUB>** (VAB T6) – Select and input the network member's subscriber ID on the KU.
7	**TEAM** (VAB T3) – Set to enable the network member to receive Team datalink messages.
8	**PRI** (VAB T4) – Set to enable the network member to receive Primary datalink messages.

Return to Checklist index

Sending a Text message

To send a pre-composed Text message to all Team members within a datalink network, perform the following:

1	**DL** rocker switch – Select radio with the corresponding datalink network.
2	**COM** Fixed Action Button – Press.
3	**MSG – SEND** (VAB T6) – Select.
4	**TEXT** (VAB T6) – Select.
5	**TEXT MSG – MPS** (VAB T3) – Select.
6	Message Select (VAB L1-L5, R1-R5) – Select as desired.
7	**SEND** (VAB R6) – Press.

To send a custom Text message to all Team members within a datalink network, perform the following:

1	**DL** rocker switch – Select radio with the corresponding datalink network.
2	**COM** Fixed Action Button – Press.
3	**MSG – SEND** (VAB T6) – Select.
4	**TEXT** (VAB T6) – Select.
5	**TEXT MSG – FREE** (VAB T4) – Select.
6	**CLEAR** (VAB T5) – Select to clear existing text entries if necessary.
7	**TEXT 1>** (VAB L1) – Select and input the first line of text on the KU.
8	**TEXT 2>** (VAB L1) – Select and input the second line of text on the KU, if desired.
9	**TEXT 3>** (VAB L1) – Select and input the third line of text on the KU, if desired.
10	**TEXT 4>** (VAB L1) – Select and input the fourth line of text on the KU, if desired.
11	**SEND** (VAB R6) – Press.

Receiving a Text message

To review a text message received through the datalink, perform the following:

1	**COM** Fixed Action Button – Press.
2	**MSG – REC** (VAB B5) – Select.
3	Message Select (VAB L1-L6, R1-R6) – Select the **FREE TEXT** message to be reviewed.
4	**RVW** (VAB T2) – Select.

Return to Checklist index

Sending a Mission File

To send a Mission File, or all Mission Files, to all Team members within a datalink network, perform the following:

1	**DL** rocker switch – Select radio with the corresponding datalink network.
2	**COM** Fixed Action Button – Press.
3	**MSG – SEND** (VAB T6) – Select.
4	**CURRENT MISSION** (VAB R1) – Select.
5	Mission File Select (VAB L1-L3, L4, L5, or R2) – Select as desired to send an individual mission file. *or* **ALL** (VAB B4) – Select to send all mission files in the aircraft memory.
6	**SEND** (VAB R6) – Press.

To send a Route, or the Route file, to all Team members within a datalink network, perform the following:

1	**DL** rocker switch – Select radio with the corresponding datalink network.
2	**COM** Fixed Action Button – Press.
3	**MSG – SEND** (VAB T6) – Select.
4	**CURRENT MISSION** (VAB R1) – Select.
5	**ROUTE** (VAB B3) – Select.
6	Route Select (VAB L1-L6, R2-R5) – Select as desired to send a single route. *or* **ALL** (VAB B4) – Select to send all routes within the Route file.
7	**SEND** (VAB R6) – Press.

Receiving a Mission File

To store a Mission File received through the datalink, perform the following:

1	**COM** Fixed Action Button – Press.
2	**MSG – REC** (VAB B5) – Select.
3	Message Select (VAB L1-L6, R1-R6) – Select the **WPT/HZD FILE**, **CLTRM FILE**, **TGT/THRT FILE**, **LASER CODES**, **ROUTE**, or **ROUTE FILE** to be stored.
4	**STORE** (VAB T2) – Press.

Return to Checklist index

Sending a TSD Point

To send an individual TSD Point to selected Primary members, perform the following:

1	**DL** rocker switch – Select radio with the corresponding datalink network.
2	**TSD** Fixed Action Button – Press.
3	**POINT** (VAB B6) – Select.
4	**XMIT** (VAB L6) – Select.
5	**POINT>** (VAB L1) – Select and input the point index of the point to be transmitted into the KU. *or* **MPD Cursor** Controller/Enter – Select the point to be transmitted on TSD.
6	Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.
7	**SEND** (VAB R6) – Press.

Receiving a TSD Point

To store a TSD Point received through the datalink from the TSD page, perform the following::

1	**TSD** Fixed Action Button – Press.
2	**REC** (VAB L2) – Select.
3	Message Select (VAB L2-L5) – Select **WPT/HZD**, **CTRLM**, or **TGT/THRT**.

To store a TSD Point received through the datalink from the COM page, perform the following:

1	**COM** Fixed Action Button – Press.
2	**MSG – REC** (VAB B5) – Select.
3	Message Select (VAB L1-L6, R1-R6) – Select the **WPT/HZD**, **CLTRM**, or **TGT/THRT** to be stored.
4	**STORE** (VAB T2) – Press.

Return to Checklist index

Sending a BDA Report

To send/request a Battle Damage Assessment Report to selected Primary members, perform the following:

1	**DL** rocker switch – Select radio with the corresponding datalink network.
2	**TSD** Fixed Action Button – Press.
3	**RPT** (VAB T1) – Select.
4	**BDA** (VAB L1) – Select.
5	**MSG** (VAB B2) – Set to **SEND** to send a BDA Report. *or* **MSG** (VAB B2) – Set to **RQST** to request a BDA Report.
6	**OWN** (VAB L4) – Select to include ownship SHOT file in the BDA report. *or* **ALL** (VAB L5) – Select to include ownship and datalink-received SHOT files in the BDA report.
7	Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.
8	**SEND** (VAB R6) – Press.

Sending a TGT Report

To send an FCR Target Report to selected Primary members, perform the following:

1	**DL** rocker switch – Select radio with the corresponding datalink network.
2	**TSD** Fixed Action Button – Press.
3	**RPT** (VAB T1) – Select.
4	**ALL** (VAB L4) – Select to include all FCR targets in the TGT report. *or* **PRI** (VAB L5) – Select to include 16 high-priority FCR targets in the TGT report. *or* **MPD Cursor** Controller/Enter – Select individual FCR targets to be transmitted within the TGT report.
5	Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.
6	**SEND** (VAB R6) – Press.

Return to Checklist index

Sending a PP Report

To send/request a Present Position Report to selected Primary members, perform the following:

1	**DL** rocker switch – Select radio with the corresponding datalink network.
2	**TSD** Fixed Action Button – Press.
3	**RPT** (VAB T1) – Select.
4	**PP** (VAB L3) – Select.
5	**MSG** (VAB B2) – Set to **SEND** to send a PP Report. *or* **MSG** (VAB B2) – Set to **RQST** to request a PP Report.
6	Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.
7	**SEND** (VAB R6) – Press.

Sending a FARM Report

To send/request a Fuel/Ammunition/Rockets/Missiles Report to selected Primary members, perform the following:

1	**DL** rocker switch – Select radio with the corresponding datalink network.
2	**TSD** Fixed Action Button – Press.
3	**RPT** (VAB T1) – Select.
4	**FARM** (VAB L4) – Select.
5	**MSG** (VAB B2) – Set to **SEND** to send a FARM Report. *or* **MSG** (VAB B2) – Set to **RQST** to request a FARM Report.
6	Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.
7	**SEND** (VAB R6) – Press.

Return to Checklist index

Receiving BDA/TGT/PP/FARM Reports

To store BDA, TGT, PP, or FARM Reports received through the datalink from the TSD page, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**REC** (VAB L2) – Select.
3	Message Select (VAB L2-L5) – Select **BDA REPORT**, **FCR TGT RPT**, **PP REPORT**, or **FARM REPORT**.

To store BDA, TGT, PP, or FARM Reports received through the datalink from the COM page, perform the following:

1	**COM** Fixed Action Button – Press.
2	**MSG – REC** (VAB B5) – Select.
3	Message Select (VAB L1-L6, R1-R6) – Select the **BDA REPORT**, **FCR TGT RPT**, **PP REPORT**, or **FARM REPORT** to be stored.
4	**STORE** (VAB T2) – Press.

Return to Checklist index

Drawing/Assigning Fire Zones

To draw Priority Fire Zones on the TSD page, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**BAM** (VAB B3) – Select.
3	**TYPE** (VAB L1) – Set to **PF**.
4	**OPT** (VAB L2) – Select **AUTO**, **MAN**, or **TRP** as desired.
5	**#Z** (VAB L5) – Select desired number of zones if OPT is set to AUTO or MAN. *or* **KM** (VAB L5) – Select zone size (in kilometers) if OPT is set to TRP.
6	**DR** (VAB L6) – Select **BX** or **LN** as desired.
7	**MPD Cursor** Controller/Enter – Draw each zone in sequence as necessary.

To assign Priority Fire Zones to selected Primary members on the TSD page, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**BAM** (VAB B3) – Select.
3	**TYPE** (VAB L1) – Set to **PF** to draw Priority Fire Zones.
4	**ASN** (VAB T4) – Select.
5	Primary Member(s) (VAB T5, T6, R1-R5) – Select for each zone in sequence as desired. *or* **OWN** (VAB B6) – Select to assign ownship to the selected zone.

To draw No Fire Zones on the TSD page, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**BAM** (VAB B3) – Select.
3	**TYPE** (VAB L1) – Set to **NF**.
4	**SEL** (VAB L2) – Select as desired.
5	Zone Select (VAB T1, T2, L1-L6) – Select an empty (white) zone as desired.
6	**DR** (VAB L6) – Select **BX** or **LN** as desired.
7	**MPD Cursor** Controller/Enter – Draw each zone in sequence as necessary.
8	**ACT** (VAB L3) – Select to accept and activate the NFZ. *or* **ACCEPT** (VAB L4) – Select to accept but *not* activate the NFZ.

Return to Checklist index

Sending Fire Zones

To send Priority Fire Zones and/or No Fire Zones to selected Primary members, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**BAM** (VAB B3) – Select.
3	**TYPE** (VAB L1) – Set to **PF** or **NF**, if intending to send only one type of zones *or* **XMIT BOTH** (VAB B5) – Select, if intending to send both types of zones.
4	Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.
5	**SEND** (VAB R6) – Press.

Receiving Fire Zones

To store Fire Zones received through the datalink from the TSD page, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**REC** (VAB L2) – Select.
3	Message Select (VAB L2-L5) – Select **PF ZONE** or **NF ZONE**.

To store Fire Zones received through the datalink from the COM page, perform the following:

1	**COM** Fixed Action Button – Press.
2	**MSG – REC** (VAB B5) – Select.
3	Message Select (VAB L1-L6, R1-R6) – Select the **PF ZONE** or **NF ZONE** to be stored.
4	**STORE** (VAB T2) – Press.

Return to Checklist index

Sending an RF Handover

To send an RFHO to selected Primary members, perform the following:

1	**Sight Select** switch – **FCR**, if FCR is not the selected sight. *or* **FCR** Fixed Action Button – Press, if FCR is the selected sight.
2	**NTS** (VAB L1) – Select NTS target for RF Handover. *or* **MPD Cursor** Controller/Enter – Select NTS target for RF Handover.
3	**RFHO** (VAB R4) – Select.
4	Primary Member(s) (VAB T5, T6, R1-R5) – Select as desired.
5	**SEND** (VAB R6) – Press.

Receiving an RF Handover

To store an RFHO received through the datalink from the TSD page, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**REC** (VAB L2) – Select.
3	Message Select (VAB L2-L5) – Select **RFHO**.

To store an RFHO received through the datalink from the COM page, perform the following:

1	**COM** Fixed Action Button – Press.
2	**MSG – REC** (VAB B5) – Select.
3	Message Select (VAB L1-L6, R1-R6) – Select the **RFHO** to be stored.
4	**STORE** (VAB T2) – Press.

Return to Checklist index

Combat Employment

Abbreviated checklists for performing pre-combat checks, selecting acquisition sources, engaging targets with each weapon system, and post-engagement procedures.

Performing Pre-Combat Checks

When approaching the Forward Edge of Battle Area (FEBA), the following should be considered:

1	Weapons – Set Armament panel to ARM and ensure weapons are properly configured for the mission.
2	ASE – Arm defensive systems on the ASE page and CMWS control panel.
3	IFF (N/I) – Ensure Identification Friend-or-Foe transponder settings are configured.
4	Lights – Off (or set Formation lighting as appropriate).
5	Recorder (N/I) – Configure and set appropriately.
6	MPDs – Select TSD phase and pages as desired.

Selecting an Acquisition Source

To select an Acquisition source from the ACQ expanded menu, perform the following:

1	**TSD**, **FCR**, or **WPN** Fixed Action Button – Press.
2	**ACQ** (VAB R6) – Select.
3	Select desired ACQ source from expanded menu options.

To select a TSD Point as an Acquisition source directly from the TSD page, perform the following:

1	**TSD** Fixed Action Button – Press.
2	**CAQ** (VAB R5) – Select.
3	**MPD Cursor** Controller/Enter – Select the desired point on TSD.

To select a TSD point as an Acquisition source from the COORD page database, perform the following:

1	**TSD** or **WPN** Fixed Action Button – Press.
2	**COORD** (VAB T5) – Select.
3	WPTHZ (VAB T1) or CTRLM (VAB T2) – Select if necessary.
4	Use paging controls (VAB B2/B3) – Select. *or* **SRCH>** (VAB B4) – Select and enter desired point index on the KU.
5	Point select (VAB L1-L6) – Select the desired point.

Return to Checklist index

Engaging a Target with 30mm Area Weapon System

To engage a target with the 30mm Area Weapon System (AWS), perform the following:

1	**Sight** select – **TADS**, **FCR**, or **HMD** as desired and verify in HAD Sight Select Status field.
2	**Weapon** Action Switch (WAS) – Forward to **GUN**.
3	ARM/SAFE button – **ARM** (Performed by crewmember not on the controls).
4	**Range** – Set as desired or verify in the HAD Range/Range Source field.
5	**Messages** – Verify no Weapon Inhibit messages are displayed. Verify "ROUNDS ####" is displayed in the HAD Weapon Status field.
6	**Fire** – Squeeze weapon trigger to 1st detent (2nd detent to override performance inhibits).

Engaging a Target with 2.75-inch Unguided Rockets

To independently (HMD) engage a target with 2.75-inch unguided rockets, perform the following:

1	**Sight** select – **TADS**, **FCR**, or **HMD** as desired and verify in HAD Sight Select Status field.
2	**Weapon** Action Switch (WAS) – Left to **RKT**.
3	ARM/SAFE button – **ARM** (Performed by crewmember not on the controls).
4	**Range** – Set as desired or verify in the HAD Range/Range Source field.
5	**Messages** – Verify no Weapon Inhibit messages are displayed. Verify "RKT NORM" is displayed in the HAD Weapon Status field.
6	**Fire** – Squeeze weapon trigger to 1st detent (2nd detent to override performance inhibits).

To cooperatively (COOP) engage a target with 2.75-inch unguided rockets, perform the following:

1	PLT **Sight** select – **HMD** and verify in HAD Sight Select Status field.
2	CPG **Sight** select – **TADS** or **FCR** and verify in HAD Sight Select Status field.
3	PLT **Weapon** Action Switch (WAS) on **Cyclic** – Left to **RKT**.
4	CPG **Weapon** Action Switch (WAS) on **TEDAC Left Handgrip** – Left to **RKT**.
5	PLT / CPG ARM/SAFE button – **ARM** (Performed by crewmember not on the controls).
6	CPG **Range** – Set as desired or verify in the HAD Range/Range Source field.
7	PLT & CPG **Messages** – Verify no inhibit messages are displayed. Verify "COOP" is displayed in HAD Weapon Control field and "RKT NORM" is displayed in the HAD Weapon Status field.
8	PLT **Fire** – Squeeze weapon trigger to 1st detent (2nd detent to override performance inhibits).

Return to Checklist index

Engaging a Target with AGM-114K Laser-Guided Missile

To engage a target with an AGM-114K laser-guided missile, perform the following:

1	CPG **Sight** select – **TADS** and verify in HAD Sight Select Status field.
2	CPG **Weapon** Action Switch (WAS) – Right to **MSL**.
3	CPG ARM/SAFE button – **ARM**.
4	CPG **Range** – Set as desired or verify in the HAD Range/Range Source field.
5	CPG (If launching **LOBL**) Designate – Pull and hold LRFD trigger, 2nd detent.
6	CPG **Messages** – Verify no Weapon Inhibits are displayed. (If launching **LOBL**) Verify "**PRI CHAN TRK**" is displayed in the HAD Weapon Status field. (If launching **LOAL**) Verify trajectory and mode is displayed as desired in HAD Weapon Status field.
7	PLT Maneuver as necessary to ensure aircraft is within missile launch constraints).
8	CPG **Fire** – Pull weapon trigger to 1st detent (2nd detent to override performance inhibits).

Engaging a Target with AGM-114L Radar-Guided Missile

To engage a target with an AGM-114L radar-guided missile, perform the following:

1	(PLT/CPG) **Sight** select – **FCR** and verify in HAD Sight Select Status field. *or* (CPG only) **Sight** select – **TADS** and verify in HAD Sight Select Status field.
2	**Weapon** Action Switch (WAS) – Right to **MSL** (set TYPE to **RF** on WPN page, if TADS is selected sight).
3	ARM/SAFE button – **ARM** (Performed by crewmember not on the controls).
4	**Range** – Verify in the HAD Range/Range Source field.
5	(CPG only, if TADS is selected sight) Designate – Pull and hold LRFD trigger, 2nd detent, until "**TARGET DATA?"** is removed from HAD Sight Status field.
6	**Messages** – Verify no Weapon Inhibits are displayed. (If launching **LOBL**) Verify "**RF MSL TRACK**" is displayed in the HAD Weapon Status field.
7	(PLT only) Maneuver as necessary to ensure aircraft is within missile launch constraints.
8	**Fire** – Pull weapon trigger to 1st detent (2nd detent to override performance inhibits).

Performing Post-Engagement Procedures

Following an engagement, the crewmember engaging the target with a weapon system should:

1	Ensure finger is off the weapon trigger.
2	Ensure weapon is de-actioned.
3	ARM/SAFE button – As desired (Performed by crewmember not on the controls).

APPENDIX B – ASE THREAT SYMBOLS

The Tactical Situation Display (TSD) and Aircraft Survivability Equipment (ASE) pages provide the crew with warning indications of radar and laser threats in azimuth, accompanied by audio alerts.

The threat symbols under the "ASE" column correspond with how the radar or laser threat will appear on the Tactical Situation Display (TSD) and Aircraft Survivability Equipment (ASE) pages.

The quoted words or phrases under the "AUDIO" column correspond with the associated audio alert that will be heard over the ICS when the radar or laser threat is detected.

Air defense radar systems are further identified by their type in small font under the "RADAR SYSTEMS" column. The table below lists the definition of each type abbreviation following the radar system's designation/name to identify the radar's function within their respective air defense units.

TYPE	DESCRIPTION	TYPE	DESCRIPTION
CWAR	Continuous-Wave Acquisition Radar	**STR**	Search and Tracking Radar
EWR	Early Warning Radar	**TAR**	Target Acquisition Radar
FCR	Fire Control Radar	**TI**	Target Illumination
RR	Ranging Radar	**TTR**	Target Tracking Radar
SR	Surveillance Radar		

Air Defense Radar Systems

ASE	AUDIO	THREAT TYPE	AIR DEFENSE SYSTEM	RADAR SYSTEMS
S R	**"Radar"**	Surveillance radar		1L13 "BOX SPRING" SR/EWR 5G66 "TALL RACK" SR/EWR AN/FPS-117 "SEEK IGLOO" SR/EWR
T R	**"Radar"**	Target acquisition radar	S-200 S-75, S-125, S-200 S-200, S-300 PPRU-M1	P-14 "TALL KING C" SR/TAR P-19 "FLAT FACE B" SR/TAR ST-68U "TIN SHIELD" TAR 9S80M1 "DOG EAR" TAR
2	**"SA-2"**	SA-2 air defense battery	S-75	SNR-75 "FAN SONG" TTR RD-75 Amazonka RR
3	**"SA-3"**	SA-3 air defense battery	S-125	SNR-125 "LOW BLOW" TTR
5	**"SA-5"**	SA-5 air defense battery	S-200	5N62 "SQUARE PAIR" TTR/TI
6	**"SA-6"**	SA-6 air defense battery	2K12 Kub	1S91 "STRAIGHT FLUSH" TAR/TI
7	**"HQ-7"**	CSA-5/HQ-7B air defense unit	Hóng Qí-7	HQ-7 ACU TAR Type 345 TTR
8	**"SA-8"**	SA-8 air defense unit	9K33 Osa	"LAND ROLL" TAR/TTR
1 0	**"SA-10"**	SA-10 air defense battery	S-300PS	64N6E "BIG BIRD" TAR 5N66M "CLAM SHELL" TAR 30N6E "FLAP LID" TTR
1 1	**"SA-11"**	SA-11 air defense battery	9K37M Buk-M1	9S18M1 "SNOW DRIFT" TAR 9S35 "FIRE DOME" TTR

1 3	"SA-13"	SA-13 air defense unit	9K35 Strela-10M3	9S86 "SNAP SHOT" RR
1 5	"SA-15"	SA-15 air defense unit	9K331 Tor-M1 9K332 Tor-M2	"SCRUM HALF" TAR/TTR
S 6	"2S6"	SA-19 air defense unit	2S6M Tunguska	1RL144 "HOT SHOT" TAR/TTR
2 2	"SA-22"	SA-22 air defense unit	Pantsir-S1	2RL80 TAR / 1RS2-1 TTR "TRICK SHOT"
Z U	"ZSU"	ZSU-23-4 air defense gun unit	ZSU-23-4 Shilka	RPK-2 "GUN DISH" FCR
A A	"Gun"	Air defense gun battery	S-60, KS-19	SON-9 "FIRE CAN" FCR
G S	"Gun"	Self-propelled air defense gun unit	Flakpanzer Gepard LPWS C-RAM M163 Vulcan ADS	MPDR-12 TAR / Albis FCR AN/TPQ-36 FCR AN/VPS-2 RR
R A	"Rapier"	Rapier air defense unit	Rapier FSA	Rapier PU SR DN 181 Blindfire TTR
R O	"Roland"	Roland air defense unit	Roland TÜR Marder Roland	MPDR-3002S SR MPDR-16 TAR / DOMINO-30 TTR
H K	"Hawk"	Hawk air defense battery	MIM-23B I-Hawk	AN/MPQ-50 TAR AN/MPQ-46 TTR AN/MPQ-55 CWAR
P T	"Patriot"	Patriot air defense battery	MIM-104C Patriot PAC-2	AN/MPQ-53 STR
S A	"SAM"	NASAMS air defense battery	NASAMS 2	AN/MPQ-64F1 Sentinel STR
S P	"SAM"	IRIS-T air defense battery	IRIS-T SLM	TRML-4D STR
N V	"Radar"	Naval air defense system		

Airborne Radar Systems

ASE	AUDIO	AIRCRAFT	ASE	AUDIO	AIRCRAFT	ASE	AUDIO	AIRCRAFT
1 9	"Fixed Wing"	MiG-19	J F	"Fixed Wing"	JF-17	F 4	"Fixed Wing"	F-4
2 1	"Fixed Wing"	MiG-21	2 9	"Fixed Wing"	J-11	F 5	"Fixed Wing"	F-5
2 3	"Fixed Wing"	MiG-23	5 0	"Fixed Wing"	KJ-2000	1 4	"Fixed Wing"	F-14
2 4	"Fixed Wing"	Su-24				1 5	"Fixed Wing"	F-15
2 5	"Fixed Wing"	MiG-25	F 1	"Fixed Wing"	Mirage F1	1 6	"Fixed Wing"	F-16
2 9	"Fixed Wing"	MiG-29	M 2	"Fixed Wing"	Mirage 2000	1 8	"Fixed Wing"	F/A-18
2 9	"Fixed Wing"	Su-27	F 2	"Fixed Wing"	Tornado GR4	E 2	"Fixed Wing"	E-2
2 9	"Fixed Wing"	Su-33	U	"Fixed Wing"	Tornado IDS	E 3	"Fixed Wing"	E-3
3 0	"Fixed Wing"	Su-30	3 7	"Fixed Wing"	AJS37			
3 1	"Fixed Wing"	MiG-31						
3 4	"Fixed Wing"	Su-34						
5 0	"Fixed Wing"	A-50						

Other Threat Symbols

ASE	AUDIO	TYPE	THREATS
	"Fixed Wing, Launch"	Air-to-air missile radar detected	Active radar-homing (ARH) air-to-air missiles
	"Unknown"	Unknown radar detected	Unrecognized radar signal
	"Laser Ranging"	Laser rangefinder detected	Tank/IFV guns, electro-optical fire control sensors
	"Laser Designating"	Laser designator detected	ATGMs, electro-optical fire control sensors
	"Laser Beaming"	Laser beam-rider guidance detected	ATGMs, electro-optical missile guidance sensors

APPENDIX C – ABR PAGE POINT TABLES

The Abbreviation (ABR) sub-page provides the crew a library of aircraft point symbols that can be added to the TSD for the purposes of navigation, increasing situational awareness, or as a method of cueing sensors. This page can be accessed via the TSD Point or TSD Utility sub-pages and can provide a quick look-up of required IDENT codes for inputting new points.

In the tables below, icons with "AAA" associated with the point symbol will display the three-character free text of that point directly on the TSD itself; whereas other points will only display the point's index within the database.

Waypoints (WPTHZ)

SYMBOL	IDENT	NAME	DESCRIPTION
	CC	Communications Check Point	A radio message should be sent upon arrival/crossing
	LZ	Landing Zone	Helicopter landing or pickup location of ground troops
	PP	Passage Point	Passage across friendly front line positions
	RP	Release Point	Final point of navigation route
	SP	Start Point	First point of navigation route
	WP	Waypoint	Point used for navigation or routing

Hazards (WPTHZ)

SYMBOL	IDENT	NAME	DESCRIPTION
	TO	Tower, Over 1000'	Vertical tower hazard >1000 feet AGL
	TU	Tower, Under 1000'	Vertical tower hazard <1000 feet AGL
	WL	Wires, Power	Tall linear wire hazard
	WS	Wires, Telephone/Electric	Short linear wire hazard

General Control Measures (CTRLM)

SYMBOL	IDENT	NAME	DESCRIPTION
	AP	Air Control Point	Point used for control or timing of aircraft movement
	AG	Airfield, General	Large airfield without navigational aids
	AI	Airfield, Instrumented	Large airfield with navigational aids
	AL	Lighted Airport	Small lighted airfield
	F1	Artillery Firing Point 1	1st portion of Artillery Firing Point (i.e., AB1___)
	F2	Artillery Firing Point 2	2nd portion of Artillery Firing Point (i.e., ___234)

	AA	Assembly Area	Rear area for assembly of friendly forces
	BN	Battalion	Battalion echelon, below Brigade but above Company
	BP	Battle Position	Position used for engaging enemy forces
	BR	Bridge/Gap	Bridge across an obstacle or a passable gap in terrain
	BD	Brigade	Brigade echelon, below Division but above Battalion
	CP	Checkpoint	Reference point used for maneuver and orientation
	CO	Company	Company echelon, below Battalion but above Platoon
	CR	Corps	Corps echelon, above Division but below U.S. Army
	DI	Division	Division echelon, above Brigade but below Corps
	FF	FARP, Fuel only	Forward Arming & Refueling Point with fuel
	FM	FARP, Ammo only	Forward Arming & Refueling Point with munitions
	FC	FARP, Fuel and Ammo	Forward Arming & Refueling Point with fuel/munitions
	FA	Forward Assembly Area	Forward area for assembly of friendly forces
	GL	Ground Light/Small Town	Visual reference point used for navigation/orientation
	HA	Holding Area	Brief holding area while enroute to/from mission area
	NB	NBC Area	Nuclear, Biological, or Chemical contaminated area
	ID	Datalink Subscriber	ID and position of datalink network subscriber
	BE	NDB Symbol	Non-Directional Beacon navigational aid
	RH	Railhead Point	Location for loading/unloading cargo from trains
	GP	Regiment/Group	Regiment echelon, above Battalion but below Division
	US	U.S. Army	U.S. Army echelon, above Corps

Friendly Control Measures (CTRLM)

SYMBOL	IDENT	NAME	DESCRIPTION
	AD	Friendly Air Defense	Friendly air defense unit/command position
	AS	Friendly Air Assault	Friendly helicopter-borne infantry unit position
	AV	Friendly Air Cavalry	Friendly scout/cavalry helicopter position
	AB	Friendly Airborne	Friendly paratrooper unit position
	AM	Friendly Armor	Friendly armor unit position
	CA	Friendly Armored Cavalry	Friendly recon/cavalry ground unit position

	MA	Friendly Aviation Maintenance	Friendly helicopter maintenance unit position
	CF	Friendly Chemical	Friendly chemical unit position
	DF	Friendly Decontamination	Friendly decontamination site
	EN	Friendly Engineers	Friendly engineer unit position
	FW	Friendly Electronic Warfare	Friendly electronic warfare unit position
	WF	Friendly Fixed Wing	Friendly fixed-wing airbase/staging area
	FL	Friendly Field Artillery	Friendly artillery/MLRS firing position
	AH	Friendly Attack Helicopter	Friendly attack helicopter position
	FG	Friendly Helicopter, General	Friendly cargo/utility helicopter position
	HO	Friendly Hospital	Friendly medical facility/trauma care station
	FI	Friendly Infantry	Friendly infantry unit position
	MI	Friendly Mechanized Infantry	Friendly mechanized infantry/motor rifle unit position
	MD	Friendly Medical	Friendly medical unit position/aid station
	TF	Friendly Tactical Operations Center	Friendly headquarters/command unit position
	FU	Friendly Unit	Generic friendly unit position/marker

Enemy Control Measures (CTRLM)

SYMBOL	IDENT	NAME	DESCRIPTION
	ES	Enemy Air Assault	Enemy helicopter-borne infantry unit position
	EV	Enemy Air Cavalry	Enemy scout/cavalry helicopter position
	ED	Enemy Air Defense	Enemy air defense unit/command position
	EB	Enemy Airborne	Enemy paratrooper unit position
	EC	Enemy Armored Cavalry	Enemy recon/cavalry ground unit position
	AE	Enemy Armor	Enemy armor unit position
	ME	Enemy Aviation Maintenance	Enemy helicopter maintenance unit position
	CE	Enemy Chemical	Enemy chemical unit position
	DE	Enemy Decontamination	Enemy decontamination site
	EE	Enemy Engineers	Enemy engineer unit position
	WR	Enemy Electronic Warfare	Enemy electronic warfare unit position
	EF	Enemy Field Artillery	Enemy artillery/MLRS firing position

	WE	Enemy Fixed Wing	Enemy fixed-wing airbase/staging area
	EK	Enemy Attack Helicopter	Enemy attack helicopter position
	HG	Enemy Helicopter, General	Enemy cargo/utility helicopter position
	EH	Enemy Hospital	Enemy medical facility/trauma care station
	EI	Enemy Infantry	Enemy infantry unit position
	EM	Enemy Mechanized Infantry	Enemy mechanized infantry/motor rifle unit position
	EX	Enemy Medical	Enemy medical unit position/aid station
	ET	Enemy Tactical Operations Center	Enemy headquarters/command unit position
	EU	Enemy Unit	Generic enemy unit position/marker

Target (TGT/THRT)

SYMBOL	IDENT	NAME	DESCRIPTION
	TG	Target Point	Target reference point

Threats (TGT/THRT)

SYMBOL	IDENT	NAME	DESCRIPTION
	AX	AMX-13 Air Defense Gun	
	AS	Aspide SAM System	
	AD	Friendly Air Defense Unit	Generic 8 km threat ring
	GP	Gepard Air Defense Gun	Flakpanzer Gepard 30mm SPAAA vehicle
	G1	Growth 1	Generic 1 km threat ring
	G2	Growth 2	Generic 2 km threat ring
	G3	Growth 3	Generic 3 km threat ring
	G4	Growth 4	Generic 4 km threat ring
	SD	Spada SAM System	
	83	M1983 Air Defense Gun	
	U	Unknown Air Defense Unit	Insurgent technical vehicle w/ 23mm AA gun
	S6	2S6/SA-19 Air Defense Unit	2S6M Tunguska SAM/SPAAA vehicle
	AA	Air Defense Gun	S-60 57mm AA battery w/ SON-9 fire control radar
	GU	Generic Air Defense Unit	Generic 5 km threat ring

	MK	Marksman Air Defense Gun	
	SB	Sabre Air Defense Gun	
	GS	Self-Propelled Air Defense Gun	ZSU-57-2 57mm SPAAA vehicle
	GT	Towed Air Defense Gun	ZU-23-2 23mm AA emplacement
	ZU	ZSU-23-4 Air Defense Gun	ZSU-23-4 23mm SPAAA vehicle
	NV	Naval Air Defense System	
	SR	Battlefield Surveillance Radar	Early warning/search radar, 100km threat ring
	TR	Target Acquisition Radar	PPRU-M1 Sborka air defense coordination radar
	70	RBS-70 SAM System	
	BP	Blowpipe SAM System	
	BH	Bloodhound SAM System	
	CH	Chapparal SAM System	M48 SAM vehicle
	CT	Crotale SAM System	HQ-7 SAM battery
	C2	CSA-2/1/X SAM System	
	HK	Hawk SAM System	MIM-23B SAM battery
	JA	Javelin SAM System	
	PT	Patriot SAM System	MIM-104C SAM battery
	RE	Redeye SAM System	
	RA	Rapier SAM System	Rapier FSA SAM battery
	RO	Roland SAM System	Marder Roland SAM vehicle
	1	SA-1 SAM System	
	2	SA-2 SAM System	S-75 SAM battery
	3	SA-3 SAM System	S-125 SAM battery
	4	SA-4 SAM System	
	5	SA-5 SAM System	S-200 SAM battery
	6	SA-6 SAM System	2K12 Kub SAM battery
	7	SA-7 SAM System	
	8	SA-8 SAM System	9K33 Osa SAM vehicle
	9	SA-9 SAM System	9K31 Strela-1 SAM vehicle

	10	SA-10 SAM System	S-300PS SAM battery
	11	SA-11 SAM System	9K37M Buk-M1 battery
	12	SA-12 SAM System	
	13	SA-13 SAM System	9K13 Strela-10M3 SAM vehicle
	14	SA-14 SAM System	
	15	SA-15 SAM System	9K331 Tor-M1 SAM vehicle
	16	SA-16 SAM System	Igla/Igla-S MANPADS position [used for SA-18 threat]
	17	SA-17 SAM System	
	SM	SAMP SAM System	
	SC	SATCP SAM System	
	SP	Self-Propelled SAM System	IRIS-T SAM battery
	SH	Shahine/R440 SAM System	
	SS	Starstreak SAM System	
	TC	Tigercat SAM System	
	ST	Stinger SAM System	Avenger SAM vehicle/Stinger MANPADS position
	SA	Towed SAM System	NASAMS 2 SAM battery
	VU	Vulcan Air Defense Gun	M163 Vulcan SPAAA vehicle

APPENDIX D – FREQUENTLY ASKED QUESTIONS (FAQ)

What version of the AH-64D does the DCS: AH-64D simulate?

DCS: AH-64D simulates an AH-64D Block 2 in service with the United States Army between the years of 2005-2010, with a specific equipment configuration that was common (but not exclusive) within that time period. The specific avionics version that is modeled in DCS is Lot 9.1, which was fielded to U.S. Army AH-64D Block 2 aircraft in 2005, along with additional equipment that was fielded to the U.S Army fleet between 2005 and 2007.

What is the difference between an AH-64D equipped with a mast-mounted Fire Control Radar and an AH-64D without the FCR?

There is very little difference between these aircraft configurations. The presence, or absence, of the FCR mast-mounted assembly does not denote a different model of AH-64 but is simply a removeable sensor system (much like a targeting pod on a strike fighter). When the FCR system is removed, the AH-64D will still perform and operate the same, albeit with less overall gross weight and more limited sensor/targeting options to the crew. Further, while the U.S. Army has operated AH-64Ds with a mixed fleet of FCR and non-FCR aircraft, some countries have operated exclusively FCR-equipped AH-64D variants, such as the United Kingdom's Army Air Corps, or exclusively non-FCR-equipped variants, such as the Royal Netherlands Air Force.

What is the difference between the Pilot Night Vision System (PNVS) and the Target Acquisition Designation Sight (TADS)?

The PNVS is a *FLIR-only* turret that is intended to aid the Pilot in the back seat while flying in total darkness. The TADS is a *multi-sensor* turret that is intended to allow the Copilot/Gunner in the front seat to target and designate enemy locations and vehicles for the AH-64D's weapon systems. The TADS may also be used to fly in total darkness and serves as a backup to the PNVS in this regard. Either crewmember may select either the PNVS or the TADS FLIR sensors for flying, but neither sensor can be used by both crewmembers at the same time.

(See Night Vision Systems for more information.)

Can the PNVS be used to aim weapons?

The PNVS is simply a Forward-Looking Infrared (FLIR) sensor that provides a video underlay to the crewmember using it for flying at night; it is not a sight and it does not perform targeting nor aim any weapon systems. In such an instance where the Pilot is using the PNVS during operations at night, the Pilot's selected sight may be HMD, and the HMD *does* aim weapon systems while the PNVS provides video imagery of the surroundings.

Can the TADS be used by the Pilot in the backseat?

The TADS can be used in one of two ways: as a sight for targeting or as a sensor for flying. In the case of the former, only the Copilot/Gunner in the front seat can directly control the TADS for the purposes of targeting and aiming of weapon systems. In the case of the latter, the TADS FLIR may be used as a night-flying sensor using the NVS Sensor Select switch on the Collective Flight Grip. Therefore, either crewmember may select the TADS as their NVS sensor, but only the Copilot/Gunner can select the TADS as their sight for targeting.

(See Night Vision Systems for more information.)

What is the difference between the Pilot Night Vision System (PNVS) and night vision goggles?

The PNVS is a steerable Forward-Looking Infrared (FLIR) turret that follows the helmet movements of the Pilot and transmits a thermal-based video of the environment to the Pilot's Helmet Display Unit (HDU). This system displays the thermal environment through various shades of brightness to distinguish varying levels of heat emissions from objects within the FLIR's field of view. Night vision goggles on the other hand amplify light sources and reflected light from the environment to allow a human eye to distinguish detail and contrast.

Why can I see IR pointers when using night vision goggles, but I cannot see them when using the TADS or PNVS?

Typical night vision goggles (such as the AN/AVS-6 goggles simulated in the DCS: AH-64D) amplify visible and near-infrared light to a level that can be used by the human eye to distinguish detail and contrast. Therefore, devices that transmit light in the near-infrared spectrum (such as IR beacons or IR pointers) can be seen by individuals wearing NVG's; whereas some FLIR systems that operate on different portions of the IR spectrum, such as the AH-64D PNVS and TADS FLIR sensors, cannot be used to view such sources of IR energy.

Why can't night vision goggles be used at the same time as the Helmet Display Unit?

The Helmet Display Unit (HDU) itself physically interferes with the proper wear of the AN/AVS-6 night-vision goggles. However, more importantly, the use of NVG's and the HDU simultaneously can often present circumstances where the two devices are not properly aligned and can incur aiming errors when employing the helicopter sensors or weapon systems. For this reason, use of the two devices in such a manner is a prohibited practice for U.S. Army AH-64D aircrews.

Is an IR pointer and a laser designator the same?

No, an IR pointer is a tightly focused beam of light that continuously emits in the near-infrared spectrum, whereas a laser designator employs a coded pulse of laser energy that can be detected by compatible sensors or weapon systems that are scanning for that precise laser pulse sequence.

Why does the horizon line in the IHADSS symbology not coincide with the real horizon?

The IHADSS allows the crewmembers to maintain situational awareness of the majority of the AH-64D's flight state, sensors, and weapon systems, regardless of where the crewmember is looking at any given time. Either crewmember can look independently of the helicopter's flight path or nose direction without losing key pieces of data necessary to fly and fight. This allows the Pilot on the controls to be looking back over his/her shoulder while in a steep pitch-back turn and still have full awareness of the aircraft's attitude and flight state; or be scanning out to either side of the aircraft for threats or obstacles while flying slowly at nap-of-the-earth altitudes just feet over the treetops.

When viewing the horizon line (and/or pitch ladder in Cruise mode), the Line-Of-Sight (LOS) Reticle – or central crosshairs – within the symbology represents the nose of the aircraft, much like the watermark on a cockpit attitude indicator. If the artificial horizon line bisects the LOS reticle, the helicopter's pitch attitude is level with the horizon.

(See Symbology Elements for more information.)

Why is the AH-64D's gun called the Area Weapon System?

The AWS was designed primarily as a close-in defensive weapon system when directed by a crewmember's helmet sight to provide suppression against immediate threats to the aircraft or the team. However, the AWS can also be effectively used as an offensive weapon against light armor, soft-skinned vehicles, or personnel; especially when directed by the TADS as the sight.

Why does my range source keep switching to a Manual range when I action the gun?

As described above, the gun is designed to be used as a close-in defensive weapon system when employed by the aircrew's helmet sights. As such, when a crewmember's selected sight is HMD (Helmet Mounted Display), the range source will automatically revert to the Manual range (as set on the WPN page) whenever that crewmember actions the gun. This prevents an un-intended ranging value from being used when hasty, close-in fires are needed. As an example, if the crewmember had been employing a Navigation range to a target 4.0 kilometers away, and then needed to hastily aim the gun at a close-range threat using their HMD, the gun would attempt to elevate for a ballistic solution of 4,000 meters, and the rounds would impact a location much further than anticipated. For this reason, during start-up or during pre-combat checks, it is wise to set a Manual range value on the WPN page that you are proficient with in engaging targets at close range.

However, this does not prevent the crewmember from setting a different range source such as an Automatic or Navigation range *after* the gun is actioned.

Why does the Rocket Steering Cursor not behave as a conventional Continuously Computed Impact Point (CCIP) reticle?

The Aerial Rocket Sub-system on the AH-64D was designed to be employed as "aerial rocket artillery", making a team of AH-64Ds akin to a hovering MLRS battery. Since unguided rockets can only be employed using ballistic trajectories (like bullets), the accuracy of any ballistic munition is heavily determined by the sighting method that is used to generate a targeting solution. With CCIP targeting methods, the target must not only be visible to the naked eye, but any adjustments made to the aimpoint must also be precise enough and distinguishable to the crew in order for such corrections to ballistic trajectories to be effective. At longer ranges, the very thickness of any symbology elements of a CCIP reticle itself on a HUD or helmet display may be the difference of several hundred meters. For this reason, CCIP reticles are only effective at relatively close ranges, and within visual range of the naked eye.

In order to engage ground targets with unguided rockets beyond normal visual ranges on the battlefield, or to engage targets from behind cover without having a direct line-of-sight (LOS) to the target area, the Rocket Steering Cursor is employed to enable the crew in aligning the helicopter with the required targeting solution for rocket delivery. While used in Cooperative mode, a secondary advantage to the Rocket Steering Cursor is that the Pilot can use the symbology to align the helicopter with the required targeting solution provided by the Copilot/Gunner while the Pilot continues to scan the surrounding terrain for immediate threats, without ever looking in the direction the aircraft nose is pointed for rocket delivery.

Why doesn't the DCS: AH-64D have Stinger or Sidewinder air-to-air missiles?

The DCS: AH-64D is simulating a U.S. Army AH-64D. U.S. Army AH-64s have never been equipped or capable of firing Stinger or Sidewinder missiles, despite a small number of weapons tests conducted with such missiles. There are several "growth" provisions within the AH-64D cockpit controls (such as an Air-To-Air weapon select position and a missile Cage button) to support future additions of such capability to the AH-64D, however the avionics of AH-64Ds in the U.S. Army fleet have never supported such weapon systems.

What is a "sight" and how do I determine which one I should use in a tactical situation?

There are three possible "sights" that can be selected to directly aim a weapon or generate a targeting solution in the AH-64D. These selections are the Helmet-Mounted Display (HMD), the Target Acquisition Designation Sight (TADS), or the optionally-mounted Fire Control Radar (FCR). Any of these three sight selections may be used by the Copilot/Gunner, but only HMD and FCR are available to the Pilot. The sight currently selected by the crewmember will be displayed in the bottom-left corner of the IHADSS symbology.

Each sight used by the AH-64D has both advantages and disadvantages that must be known and evaluated for any given tactical situation. For example, the TADS is very useful for long-range target identification and designation for Hellfire missiles, however it may not be the quickest method for engaging a target that is at close-range. On the other hand, the HMD is very useful for rapidly engaging targets at close-range simply by using the crewmember's helmet-tracking capabilities, but the HMD is less accurate than the TADS and cannot designate targets for missile engagement.

(See Sights and Sensors for more information.)

What is an "acquisition source" or "ACQ" and how do I determine which one I should use in a tactical situation?

An acquisition source can quickly orient a crewmember's selected sight to either a point in space relative to the aircraft nose or a set of three-dimensional coordinates on the battlefield. The purpose of the acquisition source is to reduce the time needed to manually search and acquire a target with any given sight. In the case of the TADS or FCR, these sights will physically slew to the location of the selected acquisition source. In the case of the HMD, the crewmember will receive cueing indications in their helmet symbology of where they should look to point their head toward the selected acquisition source (in lieu of a robotic arm physically grabbing their head and forcibly turning it in the correct direction).

As is the case with sight selections, choosing the best acquisition source in any given situation is key to reducing the time it takes to search, acquire, and engage enemy targets.

(See Acquisition Sources for more information.)

How do I enter a set of MGRS coordinates if a JTAC or other ground unit gives me MGRS in 4-, 6-, or 10-digit formats?

The AH-64D will only accept MGRS coordinates in an 8-digit format. If coordinates are entered using a 4-, 6-, or 10-digit MGRS format, the Keyboard Unit (KU) will not accept this entry and the KU display will simply flash to indicate an invalid data entry. If given a 4-digit or 6-digit MGRS location, simply append zeros to the easting and northing to achieve the number of required digits, such as 12001200 when given "1212" or 12301230 when given "123123". Conversely, when given a 10-digit MGRS coordinate, simply remove the fifth digit from both the easting and northing to achieve the required 8-digit format, such as 12341234 when given "12345123~~45~~".

(See Military Grid Reference System for more information.)

APPENDIX E – GLOSSARY OF TERMS

AA	Anti-Aircraft.
AAA	Anti-Aircraft Artillery.
A/C	Aircraft; MPD fixed action button or COLOR BAND option on the TSD>MAP page.
ACK	Acknowledge; regarding the automatic acknowledgement that is transmitted by the datalink modem to the originator of a datalink message after reception.
ACM	Automatic Control Mode; automatic gain control of the FLIR sensors.
ACQ	Acquisition source; method of cueing sensors or sights to locations on the battlefield.
ADF	Automatic Direction Finder; a receive-only radio antenna for determining relative bearing to radio transmissions.
ADU	Air Defense Unit.
AGL	Above Ground Level; altitude above the surface directly underneath the aircraft as indicated by the radar altimeter.
ALT	Alternate missile channel; the laser code to which the follow-on SAL missile is scanning when missile system is set to RIPL mode of operation.
APC	Armored Personnel Carrier.
APU	Auxiliary Power Unit; a small gas turbine engine that powers the accessory section of the main transmission (which provides generator power and hydraulic pressure) and provides pneumatic pressure to the air turbine starter of each main engine.
ARH	Active Radar-Homing missile.
ARS	Aerial Rocket Subsystem; the M261 rocket launchers and associated aircraft interface systems.
ASE	Aircraft Survivability Equipment; the suite of sensors and external components designed to enhance the survivability of the aircraft.
ASN	Assign; format of the BAM sub-page of the TSD in which a crewmember assigns other AH-64D Primary members to specific Priority Fire Zones (PFZ).
ATGM	Anti-Tank Guided Missile.
ATM	Air Targeting Mode; a mode of the APG-78 Fire Control Radar.
AWS	Area Weapon System; the M230 gun, its turret, the ammunition handling system, and associated aircraft interface systems.
AWT	Air Weapons Team; the smallest fighting echelon of AH-64's within a unit, comprising two AH-64 helicopters.
AZ	Azimuth; regarding angular direction along the horizontal plane, either in relative azimuth from the aircraft nose or relative azimuth from North.
BAM	Battle Area Management; sub-page of the TSD which provides a means of creating, editing, and deleting Priority Fire Zones (PFZ) and No Fire Zones (NFZ), or transmitting them to other flight members.
BDA	Battle Damage Assessment; a tactical report in which the SHOT files of the ownship are transmitted to other Primary members across the datalink network.

BIT	Built-In Test; self-diagnostic test that can provide indications to equipment or system malfunctions.
BL	Boundary Line; a linear maneuver control measure that delineates sectors of the battlefield to facilitate coordination and deconfliction between adjacent units, formations, or areas.
BP	Battle Position; a maneuver control measure within which units are positioned to fire into a designated Engagement Area (EA) or engage targets of opportunity.
BRU	Boresight Reticle Unit; scope-like device mounted on top of the glareshield in each crewstation that provides a reticle to align the HMD LOS crosshairs during an IHADSS boresight procedure.
B-SCOPE	A type of radar display that presents a rectangular, top-down view of the area being scanned by the radar, with radar contacts projected in relative azimuth and range.
C/S	Callsign; the 3- to 5-character alphanumeric designation of a datalink subscriber within a network.
CG	Center-of-Gravity; the average location of the weight of an aircraft, around which the force of gravity appears to act.
CHAN	Channel; one of four possible missile channels set on the WPN page for SAL missile guidance, of which at least one needs to be set as the PRI channel, and another may be set as ALT; corresponds to one of 16 laser code presets.
COM	Communications; MPD fixed action button.
COOP	Cooperative; a mode of rocket employment in which the CPG uses the TADS to provide a targeting solution for the PLT during a rocket engagement.
COORD	Coordinate; an MPD sub-page accessed via the WPN or TSD pages to view detailed information of any Point, Line, Area, Shot-At or FARM files stored within the database.
CPG	Copilot/Gunner; the crewmember occupying the front crewstation.
C-SCAN	Continuous Scan; a scan mode of the APG-78 Fire Control Radar.
C-SCOPE	A type of radar display that presents a forward-looking view of the area being scanned by the radar, with radar contacts projected in azimuth and elevation relative to a central line-of-sight.
CTR	Center; regarding the TSD option to center or de-center the TSD relative to the ownship position.
CTRLM	Control Measure; a Point type within the database used to control the positioning of the flight, aid in navigation, or provide situational awareness on the battlefield.
DE	Dual Engine power or Dual Engine operations.
DEL	Delete; an option to remove data corresponding with the page, format, or data field to which the option pertains.
DIR	Direct; LOAL trajectory option on WPN page in MSL format, or a method of navigation directly to a Point within the database independent of the currently selected route (accessed via the TSD>RTE page).
DL	Datalink; a modem-based communications network that relays digital data between aircraft using radio transceivers.
DTED	Digital Terrain Elevation Data; stored data within the aircraft memory of the surface elevation above sea level of any location or set of coordinates at ground level.

DTV	Day Television; a passive sensor within the TADS for electro-optical-based targeting at medium- to long-ranges.
DVO	Direct View Optics; a passive sensor within the TADS for optical-based targeting, but was removed from the AH-64D fleet and is not present in aircraft equipped with the M-TADS upgrade, despite the switch option being present on the LHG.
EA	Engagement Area; a maneuver control measure within which an enemy force is planned to be contained and destroyed using the massed effects of multiple weapon systems.
ECS	Environmental Control System; provides temperature management for the EFAB compartments, TADS and PNVS turrets, and crewstations.
EFAB	Extended Forward Avionics Bays; equipment bays that run alongside the fuselage from just aft of the TADS turret to underneath each stub wing and provide storage and mounting to much of the aircraft avionics.
EGI	Embedded GPS/INS; a navigational device that uses a combination of inertial measurement devices coupled with a Global Positioning System for enhanced accuracy and calibration correction.
EL	Elevation; regarding angular direction within the vertical plane, either in relative elevation from the aircraft nose or relative elevation above or below the horizon.
ELEV	Elevation; regarding the COLOR BAND option on the TSD>MAP page.
ENDR	Endurance; indication of the flight time remaining based on fuel quantity on board and current burn rate.
ENG	Engine; regarding Engine 1 or Engine 2 on the cockpit panels and displays.
ETA	Estimated Time of Arrival; the clock time (Local or Zulu) at which the aircraft will arrive at the designated reference point.
ETE	Estimated Time Enroute; the amount of time (duration) it will take the aircraft to travel to a reference point or a certain distance.
EUFD	Enhanced Up-Front Display; LED display under the glareshield of each crewstation that displays active Warnings, Cautions and Advisories; radio, transponder and modem configurations; total fuel quantity; system time; and a stopwatch function.
FARM	Fuel/Ammo/Rockets/Missiles; a tactical report in which the fuel and munitions onboard the ownship are transmitted to other Primary members across the datalink network.
FARP	Forward Arming and Refueling Point; a location relatively close to the combat area or objective that can provide rearming and/or refueling services.
FAT	Free Air Temperature; an indication of the ambient air temperature as directly read by probes outside the aircraft unaffected by nearby component heating.
FCR	Fire Control Radar; sight selection option, acquisition source option, MPD fixed action button, or the FCR component of the MMA.
FEBA	Forward Edge of the Battle Area; a linear maneuver control measure that marks the forward most point of the main battle area in which combat units are deployed, not including units that are performing screening or covering operations.
FLET	Forward Line of Enemy Troops; a linear maneuver control measure that marks the forward-most positions of enemy units, either based on intelligence estimates or direct observation.

FLIR	Forward-Looking Infrared; a passive sensor within the PNVS and TADS for navigating under darkness/low-visibility conditions, or thermal-based targeting at short- to long-ranges (TADS FLIR only).
FLOT	Forward Line of Own Troops; a linear maneuver control measure that marks the forward-most positions of friendly units, including units that are performing screening or covering operations, but excluding small, long-range reconnaissance units.
FMC	Flight Management Computer; provides enhanced aircrew control of the aircraft via the SCAS.
FOR	Field-Of-Regard; the large box within the High Action Display (HAD) that indicates the slew limits of the crewmember's selected sight or NVS sensor, as well as the relative direction of the crewmember's acquisition source.
FOV	Field-Of-View; the small box within the FOR that indicates the current azimuth and elevation of the crewmember's selected sight or NVS sensor.
FPV	Flight Path Vector; airplane-shaped symbology within the HMD flight symbology that indicates the three-dimensional flight direction of the aircraft when above 5 knots of 3D ground speed.
FSCL	Fire Support Coordination Line; a linear fire support coordination measure that marks the forward-most limit of a unit's own organic weapon systems, beyond which any air- or surface-based fires must be coordinated with other units that may be affected.
FTR	Force Trim Release; when pressed, the magnetic brake system on the Pilot's cyclic and pedals releases; suspends any active hold mode inputs to the flight control servos.
FXD	Fixed; acquisition source option, AWS mode of operation, or NVS mode of operation.
GRBX	Gearbox; regarding the Intermediate Gearbox (IGB) or the Tail Rotor Gearbox (TGB), both of which are mounted to the vertical stabilizer.
GEN	Generator; regarding Generator 1 or Generator 2 on the cockpit panels and displays.
GHS	Gunner Helmet Sight; acquisition source option.
GPS	Global Positioning System; constellation of United States Government-owned satellites that provide radio-based precise navigation and timing signals to receivers anywhere in the world.
G-S	Ground Stow; regarding the "RKT G-S" indication of the weapon pylons manually selected to GND STOW on the WPN>UTIL page when a crewmember actions rockets.
GTM	Ground Targeting Mode; a mode of the APG-78 Fire Control Radar.
GWT	Gross Weight; the current total weight of the aircraft to include fuel, munitions, expendables such as chaff and flares, and crew.
HAD	High Action Display; the bottom portion of each crewmember's HMD, TADS or FCR symbology that provide key information regarding sight and acquisition source selection, range data, sight and weapon data, and any messages that affect successful engagement using the currently actioned weapon.
HDD	Head Down Display; button on RHG that has no function on TEDAC-equipped aircraft.
HDU	Helmet Display Unit; the physical device that is clipped to the crewmember's IHU that projects symbology and video onto a combiner lens in front of the right eye.
HIT	Health Indicator Test; regarding a check of an engine's expected performance by comparing its current TGT at a set torque output to a baseline TGT for a given pressure altitude (PA) and free air temperature (FAT).

HMD	Helmet Mounted Display; sight selection option to utilize the IHADSS for sensor cueing or weapon aiming.
IAFS	Internal Auxiliary Fuel System (aka "Robbie tank"); an assembly manufactured by Robinson Fuel Systems that can be mounted in place of the standard ammunition magazine; can hold 100 gallons of fuel along with 242 rounds of 30x113mm ammunition.
IAS	Indicated Airspeed or Knots Indicated Airspeed (KIAS); airspeed measured directly within the pitot-static system.
IAT	Image Auto Track; an automatic tracking mode of the ASQ-170 TADS that uses image contrast to control turret slew.
ICS	Inter-Communication System; regarding the audio communication system between each crewstation.
ID	Identification; the 1- or 2-character alphanumeric address of a datalink subscriber within a network.
IDENT	Identification; regarding the button on the communications panel that highlights the aircraft position to air traffic controllers via an additional signal via the transponder Mode 3A.
IFF	Identification Friend or Foe; a series of coded replies sent via the transponder antennas to interrogating IFF transmitters to indicate that the aircraft is friendly.
IFV	Infantry Fighting Vehicle.
IGN ORIDE	Ignition Override; motors the T701C engines using the air turbine starters but inhibits the ignitors from firing to prevent combustion.
IHADSS	Integrated Helmet And Designation Sight System; the entire system that tracks the position of each crewmember's IHU, generates symbology for display on the HDU, and processes weapon solutions based on sighting through the HMD.
IHU	Integrated Helmet Unit; the crewmember's flight helmet with integrated helmet position tracking sensors.
IMC	Instrument Meteorological Conditions; weather conditions exist in which visual separation from terrain, obstacles and other aircraft cannot be achieved through visual means; requires navigational aids to fly safely.
IN	Inches; regarding the UNIT setting on the FLT page that displays the barometric pressure setting in inches of Mercury.
INU	Inertial Navigation Unit; a navigational device that uses inertial measurement devices to output attitude, velocity, and position information.
KM	Kilometer; regarding the UNIT setting on the FLT page that displays navigational distances, TSD range scale, and TSD grid-lines in kilometers.
KU	Keyboard Unit; device in each crewstation for inputting data into the avionics; includes calculator functions for basic arithmetic.
LAT	Latitude; regarding the North/South portion of a set of Lat/Long coordinates.
LB	Pound; regarding the unit of weight measurement in determining the aircraft gross weight and/or fuel quantity on board.
HMMS	Hellfire Modular Missile System; the M299 missile launchers and associated aircraft interface systems.
LD	Line of Departure; a linear maneuver control measure that marks the starting location of friendly units when performing an attack, used for coordination of maneuvering units.

LHG	Left Handgrip; the CPG left TEDAC handgrip.
LMC	Linear Motion Compensation; a toggleable slew logic within the ASQ-170 TADS that allows the CPG to adjust and maintain continuous turret slew rates instead of using raw MAN TRK controller inputs.
LN	Line; a method of drawing PF or NF zones on the BAM sub-page of the TSD.
LOAL	Lock-On After Launch; the AGM-114 Hellfire missile will lock on to a target designation or achieve a target track after the missile has been launched.
LOBL	Lock-On Before Launch; the AGM-114 Hellfire missile will lock on to a target designation or achieve a target track prior to the missile being launched.
LONG	Longitude; regarding the East/West portion of a set of Lat/Long coordinates.
LRFD	Laser Rangefinder/Designator; an active ranging sensor within the TADS; designates targets for weapons utilizing SAL guidance.
LST	Laser Spot Tracker; a passive sensor within the TADS for detecting laser designations from other platforms.
MAN	Manual; missile management mode of operation.
MANPADS	Man Portable Air Defense System.
MANRG	Manual Range; regarding the option to set a manual range value for ballistic solutions using the WPN page MANRG option.
MB	Millibars; regarding the UNIT setting on the FLT page that displays the barometric pressure setting in millibars.
MBR DIR	Member Directory; COM sub-page in which all pre-planned network subscribers are listed.
MBT	Main Battle Tank.
MGRS	Military Grid Reference System; a UTM-derived coordinate system that divides each UTM grid zone into a series of square identifiers that measure 100 kilometers wide, and is in widespread use by various military services in many nations.
MMA	Mast-Mounted Assembly; the entire assembly that includes the FCR, RFI and de-rotational mount on top of the main rotor mast.
MPD	Multi-Purpose Display; one of two primary displays in each crewstation.
M-PNVS	Modernized PNVS; an upgraded version of the AAQ-11 PNVS that includes a next-generation FLIR (part of the M-TADS upgrade).
MPS	Mission Planning System; a type of text message that has been pre-composed prior to a mission through the use of a mission planning computer.
MSG	Message; COM sub-pages in which messages or files may be sent or received across a datalink network.
MSL	Missile *or* Mean Sea Level; WAS option of the HMMS *or* altitude above Mean Sea Level as indicated by the barometric altimeter.
M-TADS	Modernized TADS; an upgraded version of the ASQ-170 TADS system that includes a next-generation FLIR along with enhanced tracking, processing and boresighting functions.
MTT	Multi-Target Tracker; regarding the ability to set automatic tracking onto multiple targets using the ASQ-170 IAT function.

NAK	No Acknowledgement; an advisory displayed on the EUFD that indicates the ownship's modem did not receive an acknowledgement of reception from the modems of all network subscribers to which a datalink message was addressed.
NDB	Non-Directional Beacon; an omni-directional radio navigational aid that can be tuned by the ADF receiver.
NET	Network; COM sub-page that permits crewmembers to add, edit, or delete individual subscribers from the selected datalink network.
NF	No Fire; format of the BAM sub-page of the TSD that allows a crewmember to create, delete, or activate individual No Fire Zones on the TSD.
NFZ	No Fire Zone; a geographical area set on the BAM sub-page of the TSD that precludes target prioritization by the APG-78 Fire Control Radar.
N_G	RPM speed of the gas generator stage (sometimes referred to as N1 stage or gas producer stage) as measured from the accessory gearbox of each T701C engine.
NGB	Nose Gearbox; regarding the gearbox mounted to the front of each engine that redirects shaft horsepower into the main transmission.
NM	Nautical Mile; regarding the UNIT setting on the FLT page that displays navigational distances, TSD range scale, and TSD grid-lines in nautical miles.
NOE	Nap-Of-the-Earth; a mode of terrain flight in which the aircraft flies as close to the ground as possible with varying airspeeds and altitudes.
NORM	Normal; missile management mode of operation, gun mode of operation, or NVS mode of operation.
N_P	RPM speed of the power turbine stage (sometimes referred to as N2 stage) as measured from the power turbine shaft of each T701C engine.
N_R	RPM speed of the AH-64D drive train system as measured from the main transmission.
NTS	Next-To-Shoot; the current target being engaged when using the APG-78 Fire Control Radar as the selected sight.
NVG	Night Vision Goggles; AN/AVS-6 aviator night vision goggles.
NVS	Night Vision System; the PNVS or TADS being utilized as an aided pilotage system to a crewmember.
OPER	Operate; sets the selected system or device to operational status.
ORIG DIR	Originator Directory; COM sub-page in which all pre-planned originator identification configurations are listed.
ORIG ID	Originator Identification; COM sub-page in which the digital identification settings may be configured to uniquely identify the ownship on a datalink network.
PA	Pressure Altitude; the altitude above the standard datum plane, which is the point where the atmospheric barometric pressure is 29.92 inches of mercury or 1013.2 millibars (not to be confused with true altitude as reported by the barometric altimeter when corrected for non-standard temperature/pressure via the Kollsman window).
PEN	Penetration; time delay setting on the WPN page for the M433 fuze when used in conjunction with the 6RC rocket type selection.
PERF	Performance page; provides key performance-related data of the helicopter given current or predicted pressure altitude (PA), free air temperature (FAT) and gross weight (GW).

PF	Priority Fire; format of the BAM sub-page of the TSD that allows crewmembers to create, delete, or activate PFZs on the TSD.
PFZ	Priority Fire Zone; a geographical area set on the BAM sub-page of the TSD that increases target prioritization by the APG-78 Fire Control Radar.
PHS	Pilot Helmet Sight; acquisition source option.
PL	Phase Line; a linear maneuver control measure that facilitates control and coordination of a military operation, typically coinciding with a visually identifiable terrain feature.
PLRT	Polarity; toggles FLIR sensor between White-Hot and Black-Hot brightness scales.
PLT	Pilot; the crewmember occupying the aft crewstation.
PNVS	Pilot Night Vision System; the top sensor turret on the nose consisting of a FLIR sensor.
PP	Present Position; the 3-dimensional position of the ownship or a tactical report in which the present position of the ownship is transmitted to other Primary members across the datalink network.
PPI	Plan Position Indicator; a type of radar display that presents a circular, top-down view of the area being scanned by the radar, with the position of the radar antenna in the center and radar contacts projected around the radar antenna in true azimuth and range. A "Sector PPI" display is limited to an area less than 360°.
PRI	Priority missile channel *or* Primary member; the laser code to which the next to fire SAL missile is scanning *or* a datalink network subscriber that is designated to receive Primary datalink messages.
PSI	Pounds per Square Inch; unit of measurement of pressure within the various oil and hydraulic systems of the AH-64D.
PTT	Push-To-Talk; initiates radio transmission when activated.
RAD ALT	Radar Altimeter; uses radar pulses transmitted by a ventral-mounted radio antenna below the aircraft to measure absolute altitude above ground level (AGL).
REC	Receive; option presented on the main TSD page to receive a report, a point, or a file residing in the datalink buffer.
RF	Radio Frequency missile; the AGM-114L air-to-surface missile that utilizes active radar guidance.
RFHO	RF Hand-Over; method of receiving a target location for an AGM-114L missile engagement via the datalink.
RFI	Radar Frequency Interferometer; acquisition source option or the RFI component of the MMA.
RHG	Right Handgrip; the CPG right TEDAC handgrip.
RIPL	Ripple; missile management mode of operation.
RJAM	Radar Jammer; regarding the ALQ-136 electronic countermeasure (ECM) device.
RKT	Rocket; WAS option of the ARS.
RMAP	Radar Mapping Mode; a mode of the APG-78 Fire Control Radar.
RLWR	Radar/Laser Warning Receiver; regarding the combined components and functions of the APR-39 Radar Signal Detecting Set and the AVR-2 Laser Detecting Set.

RPT	Report; sub-page of the TSD for sending or requesting reports to/from flight members via the datalink.
RQST	Request; a datalink message in which the ownship sends a query for a tactical report to be transmitted from Primary members across a datalink network.
RST	Reset; regarding the generator reset switches in the Pilot cockpit, which permits the Pilot to reset generator power when the MPDs are not operational due to lack of DC power.
RTE	Route; sub-page of the TSD within which the crew can edit routes or set direct routes to individual points.
RTM	Route Menu; sub-page of the TSD within which the crew can select or delete routes.
RTS	Radio Transmit Select; voice radio controls on the cyclic and EUFD.
RVW	Review; regarding the review of data, messages or points that reside within the aircraft memory.
SAL	Semi-Active Laser missile; the AGM-114 family of air-to-surface missiles (excluding the AGM-114L) that utilize semi-active laser guidance.
SAM	Surface-to-Air Missile; individual missile or SAM-equipped air defense emplacement/battery.
SCAS	Stability and Command Augmentation System; the system that enhances the stability of the aircraft for weapons delivery, increases the maneuverability of the aircraft at lower airspeeds, and provides hold mode functionality for decreased pilot workload.
SE	Single Engine power or Single Engine operations.
SFR	Specific Fuel Range; a calculation of speed across the surface divided by the fuel flow rate.
SHOT	Shot-At; a TSD sub-page that displays the locations of all AGM-114 missile engagements conducted by the ownship in addition to any SHOT files within BDA reports received from Primary members across a datalink network.
SINC	SINCGARS; Single Channel Ground and Airborne Radio System family of radios used by militaries of the United States and NATO members that permit secure voice and data radio transmissions between a wide number of military units.
SKR	Seeker; acquisition source option utilizing a SAL missile tracking a laser designation matching the PRI missile channel or an RF missile tracking a target in LOBL mode.
SMDL	Secure Modem Datalink; a modem-based datalink network which exchanges short bursts of data across voice radios onboard the aircraft.
SP	System Processor; commands all subsystem initiated tests, monitors system status and faults, and processes information for display.
SPAAA	Self-Propelled Anti-Aircraft Artillery.
SPQ	Super Quick; minimal time delay setting on the WPN page for the M433 fuze when used in conjunction with the 6RC rocket type selection.
SQL	Squelch; a function that suppresses the audio output of a radio system until a signal is received that exceeds the set squelch threshold.
S-SCAN	Single Scan; a scan mode of the APG-78 Fire Control Radar.
STAB	Stabilator; regarding the movable horizontal tail plane mounted to the end of the tailboom that provides additional attitude control in the pitch axis.
STBY	Standby; sets the selected system or device to standby status.

STO	Store; regarding the STO format of the TSD POINT sub-page to perform a position store of a location designated by the CPG HMD or TADS line-of-sight, or a fly-over store using the aircraft position.
SUB	Subscriber; a network member that has been designated to receive datalink messages from the ownship.
SYM	Symbology; regarding any characters, shapes or symbols that are displayed to the crew to represent quantifiable data, provide feedback regarding system status, or indicate current settings/selections/modes of operation.
TADS	Target Acquisition Designation Sight; sight selection option, acquisition source option, or the bottom sensor turret on the nose consisting of FLIR, DTV, LST, and LRFD.
TAS	True Airspeed or Knots True Airspeed (KTAS); the speed of the aircraft through an air mass, corrected for air density that affects the measurement of indicated airspeed.
TDU	TEDAC Display Unit; the video screen component of the TEDAC assembly.
TEDAC	TADS Electronic Display And Control; the assembly that includes both TEDAC grips (LHG and RHG) and the TDU.
TGT	Turbine Gas Temperature *or* Target; temperature of the hot expanding gases entering the power turbine stage of the T701C as measured between the 2nd stage of the gas generator section and the 1st stage nozzle of the power turbine section; *or* a tactical report in which FCR target data is transmitted to other Primary members across the datalink network.
TGT/THRT	Target/Threat; a Point type within the database used to designate targets for engagement, or locations of air defense threats.
TOF	Time Of Flight; the duration of time a munition is in the air toward its intended ballistic solution, target or impact point.
TPM	Terrain Profile Mode; a mode of the APG-78 Fire Control Radar.
TQ	Torque; the measurement of engine power applied to the transmission as measured from the power turbine shaft of each T701C engine.
TRAJ	Trajectory; regarding the selection of DIR (Direct), LO (Low), or HI (High) LOAL trajectory options on the WPN page in MSL format.
TRK	Track; regarding the Hellfire missile tracking in LOBL mode.
TRN	Terrain; acquisition source option via the TSD page.
TRP	Target Reference Point; a geographic location (that can typically be identified through visual or optical means) from which fires can be referenced and, if necessary, adjusted.
TSD	Tactical Situation Display, MPD fixed action button.
TSE	Target State Estimator; processing logic that provides lead angle ballistic compensation against moving ground targets when using TADS as the selected sight while employing a continuous laser designation.
UPDT	Update; regarding the STORE/UPDT button on the CPG left TEDAC grip pressed to perform a navigational position update.
UTM	Universal Transverse Mercator; a grid coordinate system from which the Military Grid Reference System (MGRS) is derived.
VID	Video; MPD fixed action button.

VMC	Visual Meteorological Conditions; weather conditions exist in which visual separation from terrain, obstacles and other aircraft can be achieved through visual means; does not require navigational aids.
VNE	Velocity Never Exceed; an airspeed that, if exceeded, may cause structural damage to the AH-64D.
VSDE	Velocity Safe Dual Engine; the minimum airspeed at which the aircraft can maintain level flight under dual-engine power.
VSSE	Velocity Safe Single Engine; the minimum airspeed at which the aircraft can maintain level flight under single-engine power.
VY	Velocity for max rate of climb; the airspeed at which the least amount of aerodynamic drag is acting upon the aircraft and the best vertical rate of climb can be achieved.
WAS	Weapon Action Switch; pronounced "Woz" or "Wahz", or used as a verb as "WASing", a crewmember selects or "actions" one of the three available weapon systems for engaging their intended target.
WCA	Warnings, Cautions, Advisories.
WPN	Weapon; MPD fixed action button.
WPTHZ	Waypoint/Hazard; a Point type within the database used for navigation, routing or to designate locations of hazards to flight such as towers and wires.
WSPS	Wire Strike Protection System; assortment of devices mounted to the external fuselage to guide wires around key portions of the airframe and into sharp blades to aid in severing the unseen wire obstacles that may be encountered during low-altitude flight.
XMIT	Transmit; regarding the FCR transmitting while performing scans of the surrounding battlespace or transmitting a datalink message.
XMSN	Transmission; regarding the main transmission.
XPNDR	Transponder; regarding the APX-118 transponder.
ZN	Zone; sets the number of PFZs to be drawn on the BAM sub-page of the TSD when in PF format.

APPENDIX F – FORMULAS

Use these calculation and conversion formulas for pre-mission planning or while in flight. Desired resultants are bolded.

Speed/Time/Distance Calculations

Ground Speed Required (knots) = (Distance ÷ Minutes) × 60

Time of Flight (mins) = (Distance ÷ Ground Speed) × 60

Fuel/Endurance Calculations

Bingo Fuel (lbs) = (Time of Flight ÷ 60) × Fuel LB/HR

Objective Time (mins) = ([Total Fuel – Bingo Fuel] ÷ Fuel LB/HR) × 60

Fuel/Range Calculations

Specific Fuel Range (SFR) Factor = Ground Speed ÷ Fuel LB/HR

Flight Range (NM) = SFR × Total Fuel

Fuel Required (lbs) = Distance ÷ SFR

Distance Conversions

Kilometers (km) to **Nautical Miles (NM)** = [km] ÷ 1.85

Nautical Miles (NM) to **Kilometers (km)** = [NM] × 1.85

Altitude/Elevation Conversions

Feet (ft) to **Meters (m)** = [ft] ÷ 3.281

Meters (m) to **Feet (ft)** = [m] × 3.281

Latitude/Longitude Conversions

DDD-MM-SS.SS to **DDD-MM.MMM**

SS.SS ÷ 60 = .MMM

DDD-MM.MMM to **DDD-MM-SS.SS**

.MMM × 60 = SS.SS

Good hunting!

The Eagle Dynamics SA team

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US Army photo
by SGT Richard Wrigley