Future-Proofing Aerospace

Rochester Electronics' Role in Preserving Legacy Systems

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Forward

The aerospace industry is in a continuous state of evolution, driven by the need to modernize, improve efficiency, and drive down costs. Yet, as the underlying avionics – or electronic systems that power the aircraft – continue to advance, the preservation of legacy systems has become more vital than ever.

Preserving legacy systems in avionics is crucial for several reasons. These systems have a proven track record of reliability and performance, having undergone extensive testing and validation over the years. Replacing them with new, untested systems can introduce unforeseen risks, non-compliance with regulatory standards, and potential failures. Furthermore, the cost of replacing legacy systems can be prohibitively expensive, encompassing the new equipment as well as the integration, testing, and training required for seamless operation.

In this context, component obsolescence is a major challenge for designers of avionics systems[1]. As technology evolves, many integral components used in avionics systems become outdated or are discontinued by their manufacturers. This threatens the continuity of legacy systems and creates significant hurdles for aerospace designers, who must navigate the complex task of maintaining systems that are functional, affordable, and compliant with regulatory standards. Unfortunately, managing obsolescence is complex, involving the actual sourcing of obsolete components and addressing the technical and economic impacts of integrating modern technologies with legacy systems.

As a leading semiconductor lifecycle solutions provider, Rochester Electronics is at the forefront of solving these challenges. We specialize in preserving and replicating obsolete components such that legacy avionics systems continue to operate using the same boards, systems, and software that have proven reliability. By leveraging our extensive inventory and manufacturing capabilities, we help aerospace companies maintain the operational integrity of their systems, avoid costly redesigns, and ensure continued compliance with aviation standards.

This whitepaper aims to highlight Rochester Electronics' role in the aerospace industry. We will explore the importance of preserving legacy systems, dissect the causes of component obsolescence, and examine the challenges faced by aerospace designers in the face of such obsolescence. Additionally, we will display the myriad of ways that Rochester Electronics addresses these challenges.

The Importance of Preserving Legacy Systems in Avionics

Preserving legacy avionics systems is essential for several key reasons. These systems, which have been the foundation of aerospace operations for decades, offer unique advantages that modern technologies cannot easily replicate.

Regulatory Compliance

The certification process for avionics systems is notoriously rigorous[2]. It involves extensive testing, validation, and documentation to ensure that each component and system meets the necessary safety and performance criteria. This process typically encompasses multiple phases, including design approval, production oversight, and continuous operational assessment.

During design approval, every aspect of the system undergoes detailed scrutiny to verify its adherence to established safety standards. Production oversight requires meticulous record-keeping and regular audits to guarantee that manufacturing processes consistently produce components that meet these exacting standards. Continuous operational assessment mandates ongoing testing and maintenance to confirm that the systems perform reliably under real-world conditions. These exhaustive processes aim to mitigate any risk of failure, guaranteeing that the avionics systems will perform safely and effectively throughout their operational life.

Unfortunately for designers, most changes to avionics systems necessitate re-certification to comply with these standards[3]. When component obsolescence necessitates system redesigns, designers are forced to start from scratch. This is a major reason why preserving legacy systems is so important. Whereas the time, engineering, and cost investments necessary to bring new systems through compliance are extremely high, legacy systems used in production have already undergone certification processes.

Proven Reliability

Before an avionic system can be used in production and commercial settings, it must undergo extensive and thorough testing. This process includes rigorous validation and verification to ensure that each component meets safety and performance standards. After these initial phases are passed, the systems are implemented in actual flight operations, accumulating thousands of flight hours. These operational hours serve as a real-

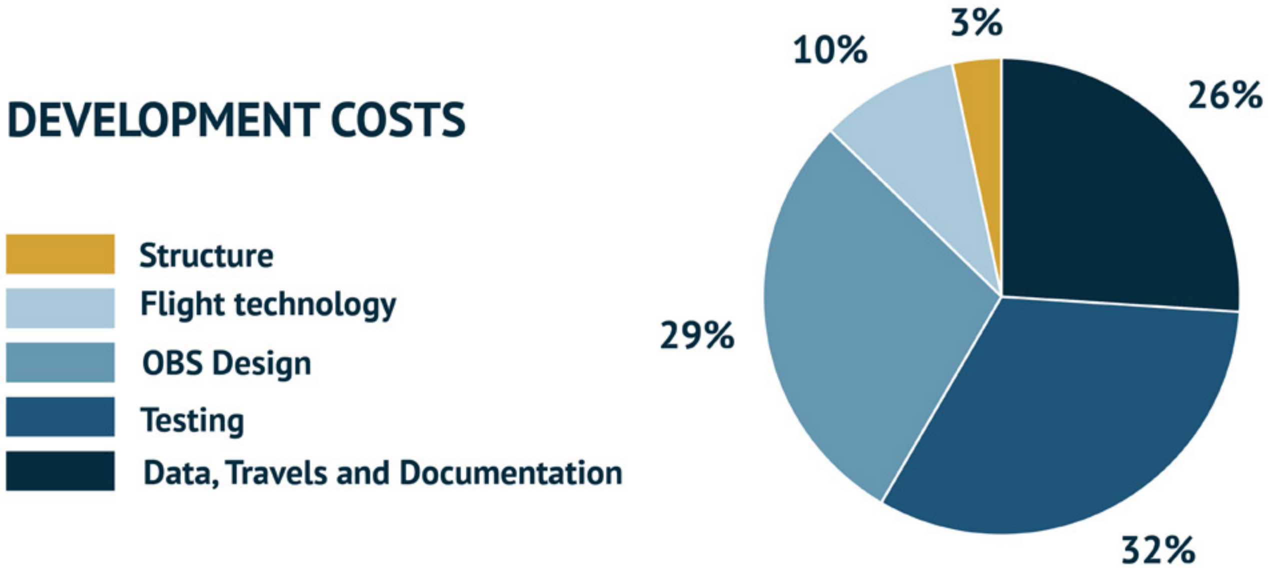


Image credit: Vecchia

world test bed, providing invaluable data on the system's long-term reliability and efficacy.

Legacy systems' extensive track record of proven performance is indispensable in mission-critical applications like avionics. The thousands of flight hours translate directly into a comprehensive understanding of their behavior under diverse conditions. Further, the established reliability of these systems guarantees higher safety margins and operational stability, which are necessary in an industry where the consequences of failure are severe.

When components in these systems become obsolete, the challenge arises of replacing them without compromising the system's already proven reliability[4]. Introducing new, untested technology can pose significant risks, as these components have not undergone the same extensive field validation as the legacy systems. Replacing obsolete components with new ones disrupts this continuity and undermines confidence in the system.

Cost Efficiency

Replacing legacy avionics systems can be prohibitively expensive, as the costs associated with new equipment, integration, and certification are substantial[5].

For example, developing and implementing new avionics systems involve significant financial investments for phases like research and development, manufacturing, and testing. Additionally, new systems often require extensive retraining for maintenance personnel and pilots, adding to the overall expense. To further confound things, integrating new systems into existing aircraft infrastructure often necessitates modifications to other related systems, incurring additional costs.

By maintaining legacy systems, aerospace companies can avoid these hidden costs and attain a more predictable financial landscape. With well-documented performance and maintenance histories, companies can accurately forecast maintenance costs and plan for parts replacement or system upgrades. In an industry where margins are often thin and competition is fierce, the ability to efficiently manage resources and maintain proven, reliable systems is a significant advantage.

Interoperability

Legacy systems are often deeply integrated with other aircraft systems and ground infrastructure. The complex interplay between avionics and other systems, such as navigation, communication, engine control, and even passenger entertainment, is the result of years of fine-tuning and optimization. This established compatibility ensures that all systems work together seamlessly to provide reliable performance across a wide range of operational scenarios.

When components within these legacy systems become obsolete, replacing them with modern technology can introduce unforeseen compatibility issues[6]. Modern avionics systems might not interact as smoothly with existing infrastructure, leading to potential disruptions in the aircraft's operations. For instance, a new communication system might not integrate well with the existing navigation system, causing data transmission delays or errors that could impact flight safety. Similarly, new engine control systems might not be fully compatible with legacy diagnostic tools, complicating maintenance procedures and potentially leading to undiagnosed issues.

Maintaining legacy avionics systems helps to avoid these compatibility issues and the associated costs and risks. By preserving the established integration between avionics and other aircraft systems, operators can guarantee that all components continue to function as intended, maintaining their operations' safety, reliability, and efficiency.

Technical Expertise

The extensive training and experience of maintenance personnel and pilots with legacy avionics systems represent a significant asset for aerospace companies. These individuals have accumulated deep technical knowledge and familiarity with these systems through years of hands-on experience and formal training. This expertise enables them to perform quick and effective troubleshooting and repairs to facilitate the smooth operation and safety of the aircraft.

The transition is not always straightforward when components become obsolete and new systems are introduced[7]. Introducing new avionics systems necessitates extensive retraining for maintenance personnel and pilots. This retraining process is both time-consuming and costly. Maintenance crews must learn the intricacies of the new systems, including diagnostics, repair procedures, and potential integration issues with existing aircraft infrastructure. Pilots need to become familiar with new interfaces, operational procedures, and any changes in system behavior. The retraining period can also temporarily reduce operational efficiency as personnel adjust to the new systems.

Preserving legacy systems helps preserve the existing expertise of maintenance crews and pilots. Maintenance personnel already well-versed in the legacy systems can quickly identify and address issues, minimizing downtime and keeping that aircraft operational and safe. Pilots familiar with the behavior and operation of legacy systems can maintain a high level of proficiency and ensure effective responses to any in-flight issues.

The Causes of Component Obsolescence

One of the biggest threats to the continuity of legacy systems is component obsolescence. Obsolescence occurs when a component is no longer produced, supported, or available from the original manufacturer, rendering it difficult or impossible to procure. This situation poses a considerable risk to the ongoing operation and maintenance of aerospace systems, as finding suitable replacements can be challenging and costly.

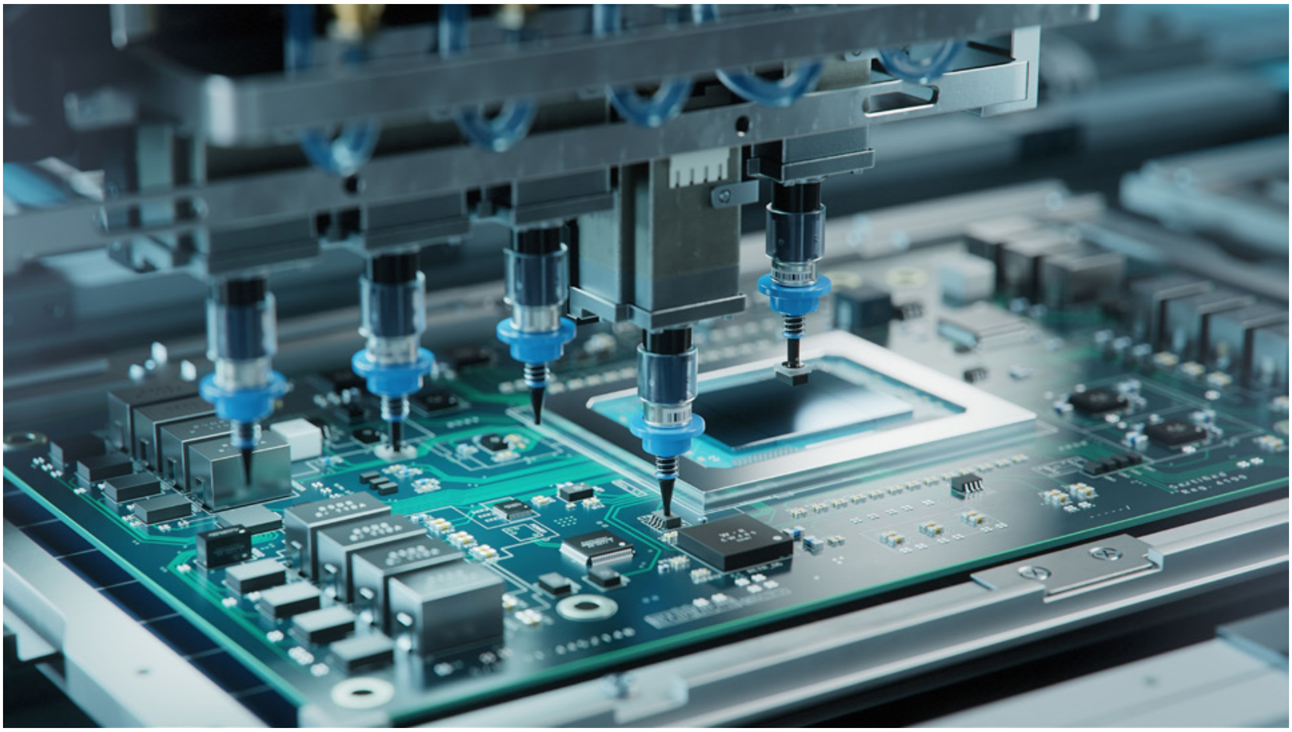
Understanding the causes of component obsolescence is necessary for developing effective strategies to mitigate its impact.

Tester Platform Evolution

The equipment and platforms used to test electronic components are continuously advancing, driven by the need to accommodate newer, more complex technologies. These modern tester platforms are designed to handle the sophisticated requirements of contemporary semiconductor devices, which often involve higher speeds, greater integration, and advanced functionalities. As a result, the older tester platforms, which were once state-of-the-art, become obsolete as they can no longer support the testing demands of current technology.

When older tester platforms become obsolete or unsupported, manufacturers face significant challenges in maintaining their ability to test legacy components. New tester platforms are often incompatible with legacy components, as modern testing equipment is built to accommodate the advanced features of the latest semiconductor devices, such as higher clock speeds, smaller geometries, and more complex packaging[8]. For instance, older components may require specific testing protocols, signal interfaces, and environmental conditions that are no longer supported by the new platforms. This incompatibility creates a significant hurdle for maintaining legacy systems since the inability to test these components effectively can lead to increased risks of failures and reduced reliability[9].

This technological gap exacerbates the challenge of keeping legacy systems operational. As the ability to test legacy components diminishes, the risk of undetected failures increases. Without proper testing, components that have aged or been subjected to various operational stresses over time might fail to meet the required performance standards, leading to potential system failures.



Advances in Silicon Fabrication Processes

As silicon fabrication technology progresses, older processes are often phased out in favor of newer, more advanced techniques that offer improved performance, efficiency, and miniaturization[10]. This technological progression can make it increasingly difficult, if not impossible, to produce legacy components. The specialized equipment and expertise needed to manufacture these older components become scarce or entirely unavailable, and components designed using older nodes may no longer be manufacturable without significant retooling.

The shift to more advanced silicon fabrication processes also impacts the availability of raw materials and manufacturing equipment. Suppliers may discontinue the production of materials used in older processes, and the specialized machinery required for these techniques may no longer be supported or available. Consequently, aerospace companies face challenges in sourcing components that meet the specific requirements of legacy systems, leading to increased obsolescence risks.

Package Obsolesensce

Changes in assembly techniques and materials significantly drive component obsolescence in the aerospace industry[11]. As manufacturers seek to improve efficiency, reliability, and performance, they often adopt new assembly processes that are incompatible with older components. While beneficial in many respects, these innovations can inadvertently render legacy components obsolete.

The materials used in the assembly of electronic components also evolve over time. New materials may offer superior performance characteristics, such as higher thermal stability, better conductivity, or reduced environmental impact. However, the transition to these new materials can result in the discontinuation of older materials, making it challenging to produce and support legacy components. This shift in assembly techniques and materials necessitates the development of new manufacturing processes, further complicating the maintenance of legacy systems.

Moreover, as manufacturers adopt new assembly processes, they may also standardize on new component packages, footprints, and form factors that differ from those used in legacy systems. This shift can lead to the obsolescence of components with older form factors, which may no longer be supported by current manufacturing lines. For example, transitioning from larger, bulkier components to more compact, surface-mounted packages can leave legacy systems without compatible replacement parts.

Economic Factors

Manufacturers may discontinue the production of no longer profitable components, particularly if demand has shifted to newer technologies[12]. Like many others, the aerospace industry is subject to market dynamics that influence the availability of components. As newer, more advanced technologies become prevalent, the demand for older components declines, leading to their obsolescence.

A notable variable in this equation is the cost inefficiencies associated with producing small quantities of obsolete components can be prohibitive for manufacturers. For instance, maintaining production lines for older components requires significant machinery, tooling, and skilled labor investments. These production lines often need specialized equipment and processes tailored to the specific requirements of the legacy components. As these components age, the machinery and tooling needed to produce them may also become obsolete, requiring costly upgrades or replacements.

Additionally, sourcing raw materials for obsolete components can present significant challenges. Materials used in older manufacturing processes may no longer be readily available, or their supply may have dwindled, driving up costs. Manufacturers must navigate these supply chain complexities, often dealing with higher prices for limited quantities of materials. This situation can further erode the profitability of producing obsolete components.

Given these economic realities, manufacturers often prioritize the production of components with higher demand and better profit margins. Newer technologies attract larger markets due to their improved performance, enhanced capabilities, and greater efficiency. As a result, manufacturers allocate their resources to developing and producing these advanced components, leaving older technologies behind. This shift in focus accelerates the obsolescence of legacy components as manufacturers gradually phase out their production to concentrate on more lucrative opportunities.

Customer Challenges with Obsolete Components

Should components become obsolete, avionic system designers will encounter many challenges that can significantly impact the operational efficiency, safety, and financial stability of aerospace operations.

Redesign Complexity

When a component becomes obsolete, avionics designers must often redesign affected systems to accommodate new, compatible components. This can be complex and time-consuming[13].

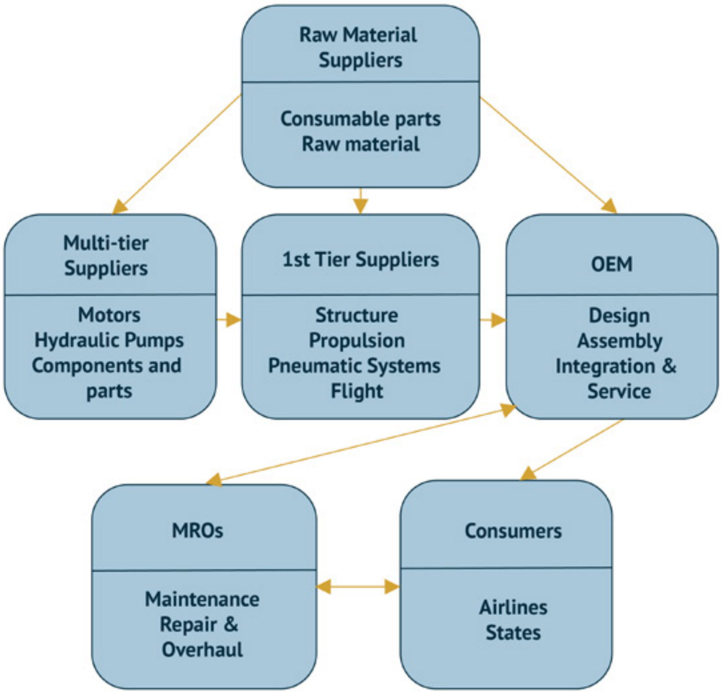
Redesigning avionics systems is not straightforward; it requires a detailed analysis of the existing system architecture, identification of compatible replacement components, and extensive testing to guarantee seamless integration. Evaluating potential replacements involves a thorough examination of electrical, mechanical, and software interfaces to ensure physical fit, electrical compatibility, and proper communication with other components. This effort often reveals subtle differences that must be addressed to avoid integration issues.

The complexity of redesign is further exacerbated by the need to maintain the system's original functionality and performance characteristics. Designers must confirm that the new components do not introduce unforeseen issues or incompatibilities that could compromise the system's reliability. To this end, an extensive validation and testing phase is needed. This process is notoriously resource-intensive, involving laboratory and real-world simulations to assess the new design's performance under various conditions. Engineers use advanced diagnostic tools to monitor performance and identify anomalies, requiring iterative testing and refinement to resolve issues. All things considered, the testing and validation process can take weeks or months, depending on system complexity.

Certification and Compliance

Any changes to avionics systems necessitate re-certification to comply with aviation regulatory standards, which is a rigorous and costly process[14].

The certification process ensures that modified systems maintain airworthiness by meeting safety and performance requirements set by regulatory bodies such as the Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA). This involves extensive documentation, testing, and validation, which can significantly extend the timeline for implementing new components.



The avionic component supply chain is vast and complex, consisting of dozens of stakeholders across the globe: Image credit: Ghadge

The certification process itself is inherently expensive. The fees for testing, documentation, and regulatory approvals add up quickly. Testing involves extensive use of specialized equipment and facilities and often requires multiple iterations to meet all safety and performance criteria. Documentation must be thorough and precise, requiring skilled personnel to prepare and review the materials. Regulatory approvals can also be a lengthy and costly process involving interactions with multiple agencies.

Supply Chain Disruptions

Obsolete components can cause significant disruptions in the supply chain, creating a cascade of challenges that impact avionics systems' production and maintenance schedules[15].

When a component becomes obsolete, avionics designers must identify and source suitable replacement components: a process fraught with difficulties, including varying lead times, availability issues, and the need to establish new supplier relationships. Each of these factors can introduce delays and uncertainties into the supply chain, ultimately affecting the timely delivery and operation of aircraft.

Once potential replacements are identified, avionics designers face the challenge of sourcing these components. The lead times for obtaining replacement parts vary significantly based on availability and demand. Components still in production but not widely used may have longer lead times as manufacturers produce them in smaller batches. In contrast, discontinued components no longer produced may require sourcing from specialized distributors or suppliers who deal in surplus or end-of-life inventory. Establishing relationships with these suppliers is critical but can be challenging due to the niche nature of the market and the variability in stock levels.

Another significant challenge in sourcing replacement components is ensuring their authenticity and quality. The aerospace industry has zero tolerance for counterfeit or substandard components, as they pose serious risks to the safety and reliability of avionics systems. To mitigate these risks, avionics designers and procurement teams must implement robust quality control measures. This includes thorough vetting of suppliers, rigorous inspection of incoming components, and adherence to industry standards such as AS5553, which provides guidelines for detecting and avoiding counterfeit parts.

Compatibility Issues

New components may not be directly compatible with existing systems, leading to integration challenges. Avionics designers must address potential electrical, mechanical, and software compatibility issues to guarantee seamless operation within the aircraft's existing architecture[16].

New components might operate at different voltages or have different power requirements compared to the legacy parts they replace. This discrepancy can lead to compatibility issues necessitating redesigning power supply circuits to provide the appropriate voltages and currents. Additionally, changes in electrical characteristics can affect signal integrity and EMI, requiring adjustments to signal conditioning circuits to ensure proper functioning.

Communication protocols present yet another layer of complexity. Legacy systems often use older communication standards that may not be directly compatible with modern protocols. Integrating new components might require updating or completely reconfiguring communication interfaces to facilitate seamless data exchange between components. For instance, if a legacy system uses a parallel communication interface and the new component supports only a serial interface, designers must develop bridging solutions such as protocol converters or implement software-based solutions to translate between the two communication standards.

Finally, software compatibility is a factor in the integration process. New components often come with different firmware or drivers that might not be compatible with the existing system's software. Updating the system's software to support new components can be a complex and time-consuming task. Engineers need to rewrite or modify existing code to confirm the system can control and monitor the new components correctly. This process involves thorough testing and validation so that the updated software does not introduce bugs or vulnerabilities that could compromise the system's safety and reliability.

Increased Costs

Addressing component obsolescence often incurs additional costs, including redesign, re-certification, sourcing of new components, and potential retraining of maintenance personnel. These expenses can strain budgets and impact overall project timelines and financial planning. The cumulative cost of managing obsolescence can be substantial, encompassing both direct and indirect expenses associated with maintaining and updating avionics systems[17].

For instance, the redesign process is highly intricate and involves substantial engineering efforts. Each affected system must be re-evaluated to ensure new components integrate seamlessly with existing avionics. This often requires comprehensive system analysis, simulation, and prototyping to validate that the new components meet aviation applications' performance and safety standards. Engineering hours must be spent documenting every modification to maintain a detailed record that supports the recertification process.

The financial burden of obsolescence management extends beyond the immediate costs of replacement components and redesign efforts. Companies must also consider the long-term costs of training personnel to handle new components, maintaining updated documentation and technical manuals, and ensuring continuous compliance with evolving regulatory standards. These ongoing expenses can significantly impact the financial sustainability of aerospace operations, necessitating careful planning and resource allocation to mitigate the impact of component obsolescence.

Solving Obsolescence with Rochester Electronics

Addressing the multifaceted challenges of component obsolescence in the aerospace industry requires a comprehensive approach that combines expertise, innovation, and strategic partnerships. At Rochester Electronics, we're heavily involved in solving these challenges so that our customers can maintain the continuity and reliability of their legacy avionics systems. Our extensive range of services and capabilities offer a robust framework for mitigating the impacts of component obsolescence.

Authorized Distribution and Licensed Manufacturing

At Rochester Electronics, we excel in providing a continuous supply of both active and end-of-life (EOL) semiconductors through our authorized distribution and licensed manufacturing services[18]. With an inventory of over 15 billion devices and the capability to manufacture more than 70,000 different device types, we ensure that aerospace companies can access the components they need without the risk of counterfeit parts.

Our authorized distribution guarantees that all components we supply are genuine and meet the original manufacturer's specifications. By partnering with Rochester Electronics, aerospace companies can confidently source the components they need to maintain and repair their legacy systems, knowing these parts are authentic and reliable. Our commitment to quality and authenticity safeguards against the risks associated with counterfeit components.

Wafer Storage and Processing

At Rochester Electronics, we provide comprehensive and reliable wafer storage and processing solutions essential for maintaining the integrity of semiconductor components over extended periods[19]. Our state-of-the-art Newburyport, MA facilities feature ISO-8 and ISO-7/10 K-certified nitrogen-controlled environments with relative humidity control and real-time temperature and humidity monitoring. These controlled conditions are crucial for preventing contamination and degradation of wafers, allowing us to maintain a stockpile of components without long-term storage risks.

Our services extend to back-side grinding, dicing with dual spindle saws, and dice inspection using Automated Optical Inspection (AOI) systems. With these systems, we offer precise defect detection and measurement to ensure adherence to the highest quality standards. We also provide manual or automated pick-and-place services under ISO-5 hoods, delivering individual dies in various packaging options such as waffle packs, film frames, gel packs, or tape and reel.

With over 35 years of experience, our capabilities ensure that aerospace companies can rely on a consistent supply of high-quality wafers to manufacture obsolete components even as assembly and test platforms evolve.

Replication Services

One of our most unique tools for fighting component obsolescence is [our replication services](), which allow us to replicate obsolete devices with authorization from original manufacturers[20].

For instance, our Design team, with over 400 years of combined experience, specializes in authorized porting of products from original fab processes, including DO-254 minor change classification – which avoids the need for system recertification – and DO-178 compliance. To this end, we employ unique proof-of-duplication methodologies and advanced electrical performance replication techniques, such as output edge-rate matching and detailed signal integrity analysis. Our labs perform electrical device characterization of original and replacement devices across temperature and voltage limits. This rigorous process ensures that our ported products match the I/O performance of the original components, maintaining system stability and preventing the introduction of new signal integrity concerns. Our comprehensive approach includes legacy voltage ASIC designs for FPGA replacements and creative board-level solutions to support long-life systems.

By replicating obsolete components, we help aerospace companies avoid the substantial costs and risks of redesigning systems to accommodate new parts. Our ability to provide exact matches to original components guarantees the continued reliability and performance of aerospace systems, mitigating the impact of component obsolescence and supporting the long-term viability of your legacy designs.

Comprehensive Testing and Assembly Services

We invest in advanced testing and modern assembly technologies to meet aerospace companies' rigorous demands. We employ a thorough approach that fully validates that components meet performance standards before deployment.

For testing, our 30,000-square-foot test facilities feature a variety of automated test equipment and full computer-aided design capabilities[21]. We provide testing for digital, analog, RF, memory, ECL, mixed-signal, ASICs, PLDs, and FPGAs, including military, special screening, up-screening, selected item drawing, source control documents, and tier-2 automotive testing. Additionally, our capabilities extend to custom high-quality test solutions, temperature profiling, ATE platform conversion, component programming, and electrical and mechanical interface design.

For assembly, we invest in both classic and modern technologies, including lead frame, QFN, and BGA assemblies[22]. Our assembly capabilities encompass both hermetic and plastic assembly technologies. For hermetic assembly, we use automated and semi-automated equipment for eutectic, silver glass, and epoxy die attach, and we offer package replications including, leadframes. Our plastic assembly includes automated saw, die attach, wire bond, and full automold equipment. Our component lead finishing services include SnPb and 100% tin plating, with flexible rack plating systems and solder dip options. These efforts are validated by DLA-certified processes and in-house reliability testing.

Combining these capabilities allows us to create tailored solutions that meet the specific requirements of aerospace companies, whether it involves testing legacy components or assembling new ones to precise specifications. Ultimately, we minimize the risks associated with component obsolescence and guarantee all components are fully validated before integration into critical systems.

Conclusion

The challenges of component obsolescence in the aerospace industry are significant, but designers can effectively manage them with the right strategies and partnerships. Rochester Electronics offers a robust suite of solutions to address these challenges head-on. We provide the tools and expertise to maintain and support legacy avionics systems through our authorized distribution and licensed manufacturing, advanced wafer storage and processing, replication services, and comprehensive testing and assembly capabilities.

By partnering with Rochester Electronics, aerospace companies can ensure the continuity, reliability, and safety of their operations, even as they navigate the complexities of component obsolescence. Together, we can help the industry continue to thrive and balance the desire for modernization with the need to preserve proven, reliable systems.

About the sponsor

As an original manufacturer stocking distributor, Rochester has over 15 billion devices in stock encompassing more than 200,000-part numbers, providing the world's most extensive range of end-of-life (EOL) semiconductors and broadest range of active semiconductors. As a licensed semiconductor manufacturer, Rochester has manufactured over 20,000 device types. With over 12 billion die in stock, Rochester has the capability to manufacture over 70,000 device types. Rochester offers a full range of manufacturing services, including Design, Wafer Processing, Assembly, Test, Reliability, and IP Archiving, providing single solutions through to full turnkey manufacturing, enabling faster time-to-market.

By partnering with Rochester Electronics, aerospace companies can ensure the continuity, reliability, and safety of their operations, even as they navigate the complexities of component obsolescence. Together, we can help the industry continue to thrive and balance the desire for modernization with the need to preserve proven, reliable systems.

About the author

Jake Hertz is an Electrical Engineer and Technical Writer. After he received his M.S. and B.S. in Electrical and Computer Engineering from the University of Rochester, he spent three years working as an Electrical Engineer at MakerBot Industries. There, he helped develop the next generation of consumer 3D printers. Now, he works with numerous startups to help engineer their hardware products. He is also a Co-Founder of Origin Labs, a NYC-based design firm for tech startups in the hardware space.

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Wevolver is a global platform and community that provides engineers with the knowledge and connections to develop better technology.

We bring a professional audience of engineers informative and inspiring content, such as articles, videos, podcasts, and reports, about state-of-the-art technologies.

The knowledge on Wevolver is published by various sources: universities, tech companies, and individual community members. Next to that, we manage a network of over 50 technical writers who create content for our customers and publish that on Wevolver.com

Millions of engineers leverage Wevolver to stay up to date, find knowledge when they are developing products, and leverage the platform to make meaningful connections.

Wevolver has won the SXSW Innovation Award, the Accenture Innovation Award, and the Top Most Innovative Web Platforms by Fast Company. Wevolver is how today's engineers stay cutting edge.

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