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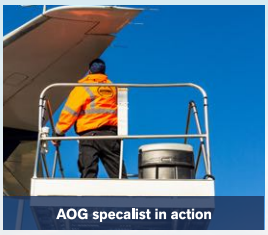

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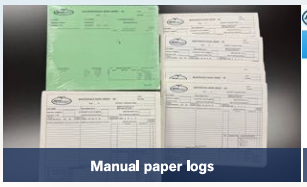

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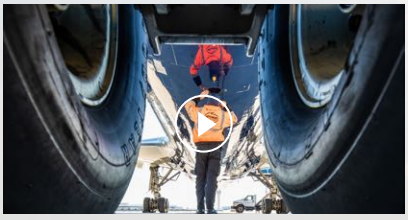

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CONTENTS

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Inflection Point

BY JOY FINNEGAN
EDITOR-IN-CHIEF

MRO is in a very active, somewhat strained growth phase, driven by post-pandemic demand, supply chain issues, workforce challenges and new technology. As all the forecasts predict, MRO demand is growing steadily at between 3% and 7% annually.

With aircraft production levels lagging, by some estimates 24% below 2019 levels, older aircraft are flying longer. Some estimates say they are operating for two years longer than the long-term average. The airlines have done a remarkable job getting utilization rates high and having planes flying more hours. All of that means more heavy checks, component replacements and life extensions. Simply put, older fleets means more maintenance.

The engine MRO segment is growing the fastest. Engines like LEAP and GTF are more efficient, but require more frequent and complex maintenance, creating backlog and cost pressure.

One airline is taking proactive steps to take control of its engine maintenance. Ryanair signed a multi-billion-dollar service agreement with engine maker CFM and will be bringing its engine maintenance in-house. The agreement included a multi-billion-dollar engine material services agreement under which CFM will support Ryanair's engine maintenance program which is expected to include the opening of two engine MRO shops, which Ryanair plan to open in 2029 to support its fleet of almost 2,000 B737 engines.

"From 2029 onwards, Ryanair expects to bring the maintenance of its engines 'in-house,' and we are pleased to do so with the help and support of our partners CFM," said Ryanair's Group CEO, Michael O'Leary. "Ryanair will place substantial orders for initial spare parts provisioning with CFM to support the opening of each of these two Ryanair engine maintenance facilities."

For more expert insight on the engine capacity crunch, check out our story beginning on page 30.

Supply chain problems are nothing new. Some are calling supply chain challenges the new normal. Persistent shortages of parts, labor and materials such as titanium impact manufacturing more than MRO. Engine makers and other suppliers are fighting competing demands from new plane assembly and maintenance for existing fleets. Some manufacturers and MRO have tried stockpiling engines and parts to alleviate the situation, but this creates production costs that add up down the line.

Digital and AI maintenance and training are speeding up. These formerly futuristic ideas are finally becoming if not mainstream, then at least they are gaining traction. We have two stories in this issue that take a look at these incredible technological systems. The first is our cover story about extended reality's (ER) use in training. Extended reality is the combination of virtual reality (VR), augmented reality (AR), and mixed reality (MR). With the continuing shortage of maintenance professionals, being able to train quickly without risk to actual aircraft is crucial. Utilizing extended reality bridges the gap between the classroom and the hangar. It can be used for critical situations that can't be taught in real life. And the potential is limitless. Expect to see ER becoming rapidly more prevalent. Read more about ER used in maintenance training starting on page 42.

The second is a story on digital twins and threads. These virtual replicas of physical assets like aircraft and engines are coming into maturity but they are not without their challenges. Going from reactive maintenance to a more predictive, evidence-based format is key and every avoided disruption reinforces the business case. Data standardization and integration complexity are major hurdles to further implementation, as are silos and inconsistent data formats. These create a significant data engineering effort. And there is also the hefty price tag. Our story on digital twins begins on page 22.

Workforce shortages continue to dog the industry. More concerted efforts to entice workers into the industry are still needed. Successful MRO recruitment in 2026 and beyond will require a multi-faceted approach that combines competitive compensation, robust training programs, technological integration and strategic partnerships with educational institutions. Many companies are already doing some or all of these things, but the shortage persists. Our frequent contributor, Marijan Jozic, has some thoughts about knowledge management. After Covid packages encouraging retirements, a new generation of engineers is coming into the hangar. Jozic says reports abound that this new cohort was not operating efficiently. See what he says is a major player in this situation and how he suggests improving it. His column starts on page 66.

In another story, we take a look at smart tools that can help cut inspection downtime. Smart tools can help open up new opportunities for data-driven decision-making and optimization in aircraft maintenance, enhancing efficiency, productivity and overall performance. They can also prevent mistakes by warning users when they are not being used correctly. All of those things are not just helpful but necessary when workforce shortages exist or the hangar is full of FNGs. Check out the story on smart tools starting on page 50.

Since this issue will be with us at MRO Americas, let me also direct you to our map of the event showing each of our advertisers' booth locations, as well as a listing of our advertisers, without whom we would not be here. We are grateful to each and every advertiser and we thank you for your support. Map and listing can be found starting on page 38.

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ADAPTIVENESS®

AAR Completes Airframe MRO Expansion in Oklahoma City, Prepares to Induct Additional Alaska Airlines Aircraft

AAR CORP. has substantially completed the expansion of its Airframe MRO facility in Oklahoma City.

The company says the expansion was driven by an increased demand for AAR's MRO services, the 80,000+-square-foot facility expansion includes three maintenance bays capable of accommodating all 737 variants. The company will soon induct additional Alaska Airlines aircraft for service as part of a long-term customer commitment.

AAR hosted a ribbon-cutting ceremony celebrating the project's near completion, the creation of 200 additional full-time careers with AAR, and the upcoming digitization of the company's maintenance processes in Oklahoma City in collaboration with Alaska Airlines.

"We celebrate AAR's growth and our long-standing relationship with Alaska Airlines. We are very grateful for Alaska's trust and for the outstanding support we have received in Oklahoma City. We are excited for this new chapter and our decades-long relationship," said John M. Holmes, AAR's chairman, president and CEO.

The company's maintenance operations in Oklahoma City date back more than 50 years, with AAR's facility located on the site of Will Rogers International Airport's original Hangar 2.

StandardAero Signs General Terms Agreement with AviLease for LEAP and CFM56-7B MRO Services

StandardAero, an independent provider of aerospace engine aftermarket services including engine maintenance, repair and overhaul (MRO) and engine component repair, has signed a General Terms Agreement (GTA) with global aircraft lessor AviLease. This GTA paves the way for StandardAero to provide AviLease with MRO services for the CFM International LEAP-1A/LEAP-1B and CFM International CFM56-7B in support of its global leasing activities.

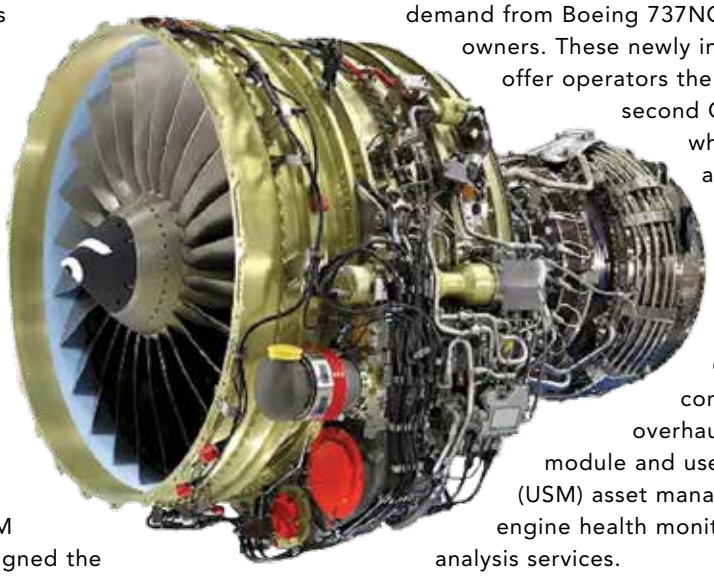
Headquartered in Saudi Arabia and backed by the long-term capital of its visionary shareholder PIF, AviLease aims to become a top 10 global player in aircraft leasing. As dynamic capital allocators, AviLease owns and manages a portfolio of 200 predominantly new-technology, fuel-efficient aircraft on long-term lease to 53 airline customers. With a seasoned global team of 95 professionals across five offices, AviLease serves as a national champion in aircraft leasing and plays a pivotal role in Saudi Arabia's Vision 2030 and National Aviation Strategy.

"StandardAero is delighted to establish a relationship with AviLease through this new agreement, which will enable our teams of LEAP and CFM56 engine MRO experts to provide responsive support to AviLease and its airline customers," said Olivier Ruffet, vice president sales — EMEA, StandardAero. "We look forward to supporting AviLease with high quality engine services as it continues its dynamic growth journey over the coming years."

StandardAero provides support for the next-generation CFM International LEAP-1A and LEAP-1B engine family from its 810,000 sq. ft. facility in San Antonio, Texas, as a CFM LEAP Premier MRO provider, having signed the first non-airline CFM Branded Service Agreement (CBSA) in the Americas for the LEAP-1A and LEAP-1B in March 2023.

In addition to establishing MRO capability for the LEAP-1A and LEAP-1B at its San Antonio facility, StandardAero is also industrializing new engine component repairs for the LEAP family through its Component Repair Services (CRS) team's network of locations, and its Repair Development Center of Excellence. To date, StandardAero's CRS team has industrialized more than 475 component repairs for the LEAP-1A and LEAP-1B. StandardAero also continues to grow its team of LEAP technicians through its in-house Aviation Mechanic Training Program, located at its San Antonio site's Training Academy.

StandardAero is also a CFM International authorized CFM56-7B MRO provider, having supported the global CFM56-7B operator community with a range of MRO services from its Winnipeg location since 2010. StandardAero now also provides CFM56-7B MRO support from its DFW International Airport, Texas location, which is seeing strong demand from Boeing 737NG operators and asset owners. These newly introduced capabilities offer operators the convenience of a second CFM56-7B engine line while also providing the assurance of test cell capability redundancy.



The company provides an extensive range of additional services for the CFM56 family, including component repair and overhaul capabilities; engine, module and used serviceable material (USM) asset management support; and engine health monitoring (EHM) data analysis services.

HAECO Extends Line Maintenance Partnership with ANA in Hong Kong

HAECO announced the extension of its line maintenance partnership, covering both technical and non-technical support services, with All Nippon Airways (ANA) through 2030 in Hong Kong.

Under the extended partnership, HAECO will continue to provide comprehensive line maintenance support for ANA's fleet of Boeing 787 Dreamliners, along with its Boeing 767 and 777 freighters. The extension of non-technical services underscores HAECO's commitment to supporting ANA's passenger operations by providing dedicated cabin and other support services that uphold the airline's renowned standards of comfort, safety and reliability.

"We are proud to extend our long-standing partnership with ANA, which now spans over two decades," said Gerald Steinhoff, chief commercial officer of HAECO. "This extension reflects the mutual trust and shared commitment to excellence that define our collaboration. HAECO remains dedicated to supporting ANA's operational success with reliable, innovative, and high-quality maintenance solutions."

Tatsuhiro Shioda, vice president of aircraft operations, ANA Engineering & Maintenance Center, added, "HAECO's line maintenance services in Hong Kong have significantly contributed to ANA earning SKYTRAX's 5-Star rating every year since 2013. Our long-term partnership with a trusted partner like HAECO enables ANA to be highly regarded in Hong Kong and globally."

GE Aerospace to Invest €110M+ in European Manufacturing, Boost Workforce Development

GE Aerospace has announced plans to invest more than €110 million across its European manufacturing sites this year as the company seeks to expand production capacity and accelerate advanced manufacturing and to strengthen delivery for its customers. Today's announcement includes plans to hire more than 1,000 new workers across Europe this year.

"This significant investment reflects our long-term commitment to the European aerospace industry, a crucial market for many of our key customers," said Riccardo Procacci, president and CEO, Propulsion & Additive Technologies at GE Aerospace. "By expanding advanced manufacturing and testing capabilities across Europe, we are better positioned to meet growing customer demand while supporting the communities and economies where we operate."

A substantial portion of the investment will be directed toward state-of-the-art engine test cells, advanced machining equipment, additive manufacturing expansion, and upgrades to buildings and infrastructure. These enhancements will support multiple commercial narrow- and wide-body engine programs, as well as military fighter jet and helicopter engines.

Investments will be made across five European countries:

- Italy – €77 million: advanced manufacturing and testing capabilities for multiple commercial and defense engine programs. This includes new and upgraded test cells, advanced machining equipment, additive manufacturing expansion, and building improvements across multiple sites.
- Poland – €15 million: advanced grinding and machining equipment, extensive welding and inspection tooling, and building improvements across multiple sites.
- Czech Republic – €8 million: precision machining and grinding systems, quality inspection technology, assembly tooling, and building improvements.
- United Kingdom – €10 million: upgrades to test and manufacturing equipment, expand electronics and component manufacturing capabilities, and modernize building and infrastructure across multiple sites.
- Romania – €3 million: multiple metal-cutting machines, tooling and fixtures, as well as building upgrades.

GE Aerospace also plans to invest approximately €40 million across its MRO and component repair facilities in Europe this year. This is part of a global $1 billion investment for MRO facilities first announced in 2024.

Parallel to its manufacturing investments, GE Aerospace is addressing the critical skills shortage in high-tech industries by investing to build a larger skilled workforce across Europe. These efforts focus on recruiting top talent and equipping today's manufacturing workforce and future engineers through workforce training grants to vocational schools in the UK and Italy, reaching more than 800 students this year. GE Aerospace is also expanding its Next Engineers program in Warsaw, Poland, which will ultimately reach more than 4,000 students.

"Our commitment extends beyond facilities and equipment; it is equally focused on our people. In an evolving industry, investing in skills, training, and talent pipelines across Europe is not just a tactical necessity but a strategic imperative," said Christian Meisner, chief human resources officer (CHRO) at GE Aerospace. "We are dedicated to ensuring that the European aerospace sector has the skilled workforce required to innovate, grow, and deliver exceptional value to our customers for decades to come."

Pilatus Officially Opens Pilatus Aircraft Ibérica

Pilatus has officially opened its subsidiary, Pilatus Aircraft Ibérica SA, near Seville, Spain. Pilatus says the new production facility will expand capacity to meet the sustained demand for its PC-12 and PC-24 aircraft.

Production ramp-up at Pilatus' Seville facility has been underway since early 2025. Structural assemblies for the PC-24 and wiring harnesses for the PC-12 are already produced in Seville. Structural manufacturing for the PC-12 began early this year. Currently, approximately 75 employees work at Pilatus, with further staff expansion planned, going forward.

The opening ceremony was accompanied by alphorns and guitars, providing a symbolic musical link between Switzerland and Spain. The welcome address by Victoria Vallecillos Gómez, managing director, was followed by speeches from CEO Markus Bucher, Juan Manuel Moreno, president of the Regional Government of Andalusia, and the Secretary of State for Defense, María Amparo Valcarce García. As the grand finale, the Spanish Air Force's Formación Mirlo flew over the site and demonstrated the PC-21's exceptional performance – a moment which was enjoyed with great enthusiasm.

"To meet the growing demand for our aircraft, we decided to open a facility in Seville," said Markus Bucher, CEO of Pilatus. "Spain has a long aviation tradition, an excellent network of subcontractors and suppliers, outstanding educational institutions, highly qualified professionals, and an attractive investment environment. In this context, Pilatus thanks the Spanish government, local authorities in Andalusia, and the economic development agency TRADE for their outstanding support of our project."

Pilatus said it no longer has sufficient production space at its headquarters in Stans, Switzerland. With the Seville facility, Pilatus aims to strengthen its international capabilities while focusing growth, innovative strength and commitment to long-term partnerships, the company said.

HEICO Completes EthosEnergy Accessories and Components Acquisition

HEICO announced that its flight support group subsidiary, Wencor Group, completed its previously announced acquisition of EthosEnergy Accessories and Components and EthosEnergy Accessories and Components.

Ethos A&C is expected to be accretive to HEICO's earnings within the year following closing. Other transaction terms and financial details were not disclosed.

Ethos A&C repairs a large portfolio of engine accessories including fuel nozzles, wire harnesses, starters, valves, plenum assemblies, air diffusers and engine components including blades, vanes, seals and other related components.

Ethos A&C has grown from its inception in 1979 into a leading provider of engine component and accessory repair solutions for the aeroderivative gas turbine, aerospace, and defense markets. Ethos A&C has 175 employees at three leased locations in Connecticut, South Carolina and Scotland, spanning over 175,000 square feet.

Eric A. Mendelson and Victor H. Mendelson, HEICO's co-chairmen and co-chief executive officers, together with Shawn Trogdon, Wencor's chief executive officer, commented: "We are excited to welcome Ethos A&C to the Wencor and HEICO families. Bringing our teams together strengthens our capabilities in the aeroderivative industrial gas turbine market and expands our ability to serve customers worldwide as energy demand continues to grow."

CFM and ST Engineering Sign Service Agreement to Expand LEAP Open MRO Network

CFM International and ST Engineering's Commercial Aerospace business have signed a CFM Branded Service Agreement (CBSA) for LEAP-1A and LEAP-1B engines. Under the terms of the CBSA, ST Engineering will provide the full scope of LEAP maintenance, repair & overhaul (MRO) services for operators worldwide.

ST Engineering is the first provider in Asia to join the LEAP MRO network under a CBSA agreement. Comprehensive MRO services will be provided at their facility in Singapore.

ST Engineering has been a LEAP MRO network provider since 2020, providing quick turns for the LEAP-1A and LEAP-1B engines. The company also plans to add test cell capabilities for LEAP-1B engines this year. This CBSA agreement further expands their scope to provide a full range of maintenance solutions for LEAP engines. CBSA license holders are provided the highest level of CFM support and training, as well as expanded access to proprietary overhaul and repair technology as they work with CFM customers globally to provide comprehensive maintenance solutions.

"CFM is excited that ST Engineering is expanding its role within the LEAP MRO network as a CBSA provider," said Tom Levin, VP of CFM commercial programs for CFM parent company GE Aerospace. "They have significant experience in the CFM56 network and have already developed experience providing services for LEAP engines. This addition to the LEAP MRO network will further strengthen the support of our CFM customers."

"We are pleased to further strengthen the long-standing relationship that we have with CFM International through this new license agreement," said Jeffrey Lam, commercial aerospace president at ST Engineering. "With the new LEAP partnership, ST Engineering will now have an enhanced portfolio of engine MRO solutions that allows us to serve customers who transition into new-generation aircraft, as we continue in our comprehensive and dedicated support for their CFM56 engine needs. As one of a small number of CBSA providers, ST Engineering will be able to offer deep and broad LEAP OEM service solutions to drive down maintenance lifecycle costs, and provide fully-integrated overhaul and parts repair services for LEAP engines to our customers."

"This CBSA agreement will enable ST Engineering to expand its LEAP capabilities within the CFM MRO global network," said Nicolas Potier, VP support and services for CFM parent company Safran Aircraft Engines. "Their long-standing experience with CFM engines is a real asset for our airline customers as the LEAP fleet is growing fast. ST engineering will be a key player in our ambition to continue offering world-class support to our customers."

More than 5,000 LEAP engines have been delivered to customers worldwide, with more than 10,000 engines still in the backlog.

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Lufthansa Technik Lays the Foundation for Future Investments Worth Billions

Lufthansa Technik reports that once again it generated earnings of more than 600 million euros in the 2025 financial year, laying the foundation for further extensive investments in the future. The company's revenue exceeded eight billion euros for the first time, reaching 8.049 billion euros at the end of the year (up 12% year-on-year). Three-quarters of revenue now comes from business with customers outside the Lufthansa Group. Adjusted EBIT amounted to 603 million euros (down 1%), roughly on par with the previous year. In addition to U.S. tariffs, ongoing cost increases for materials and a dollar devaluation that was unfavorable for Lufthansa Technik weighed on earnings. The adjusted EBIT margin therefore declined to 7.5% (previous year: 8.5%).

"The past year presented us with very special challenges," said Soeren Stark, CEO of the global market leader in aircraft technical services. "The geopolitical changes, which were particularly marked by U.S. tariff policy, also affected the aviation industry with its global supply chains and close international networks. However, despite all the challenges, we are confident that we will continue to grow significantly this year." Based on this revenue growth, Lufthansa Technik plans to increase its earnings by more than ten percent annually until the beginning of the new decade as part of its Ambition 2030 program.

"Even with earnings at the previous year's level, 2025 was a further step on our multi-year growth path," said Soeren Stark. "Despite the increasingly challenging environment, we are sticking to our earnings targets set out in Ambition 2030." After investments in the triple-digit million euro range last year, Lufthansa Technik plans to invest more than two billion euros over the next five years in the development and expansion of new and existing facilities as well as in the company's component pool. The investments will be made in all three regions of the world – Americas, APAC (Asia/Pacific) and EMEA (Europe, Middle East and Africa).

Three new construction projects are underway at Lufthansa Technik's headquarters in Hamburg. They include additional workshop buildings for special aircraft services and aircraft component services. A new hydraulics workshop has already started trial operations back in November. A new warehouse and logistics center for aircraft engines and their spare parts has been put into operation at Lufthansa Technik AERO Alzey. Moreover, construction of a new production facility for the maintenance and repair of engine parts and aircraft components at the future location of Lufthansa Technik Portugal in Santa Maria da Feira, south of Porto, is progressing according to plan. The facility, which will eventually employ up to 700 people, is scheduled for completion at the end of 2027 and will expand Lufthansa Technik's repair capacities in Europe. A training center was opened in June 2025 and the qualification of the first employees has already begun.

Options for strengthening existing aircraft overhaul capacities are being examined in the APAC region. In the Americas region, the ground-breaking ceremony for a new engine facility for Lufthansa Technik Canada took place at Calgary Airport a few months ago. The planned repair workshop and integrated test stand are intended to create additional capacities in the North American market, especially for new-generation engine types. Additional capacities in the components sector are being created at Lufthansa Technik Component Services in Tulsa, USA. The facility is being expanded to enable further growth, and the service portfolio is being supplemented with additional repair services.

The company has also made progress outside its core business. With the start of the system integration phase for the German PEGASUS signal intelligence aircraft and the beginning support for the German Navy's P-8A Poseidon maritime patrol aircraft, the Lufthansa Technik Defense brand has achieved significant success in establishing Lufthansa Technik as a partner to the armed forces, particularly the German Bundeswehr. Other new business areas, technologies, and digital solutions were also developed and expanded: The Digital Tech Ops Ecosystem, consisting of AVIATAR, flydocs, and AMOS, enables Lufthansa Technik to offer smart solutions for all aspects of technical fleet management and support. Customers with 11,000 aircraft (representing one in three aircraft worldwide) are already using services from the ecosystem.

"We are delighted that our strategy is meeting the needs of our customers," said Soeren Stark. "Last year, we concluded new contracts with a volume of 8.8 billion euros, which for the first time were evenly distributed across all three regions of the world." A new sales record was achieved in the APAC region. Lufthansa Technik was also in high demand among customers in the Middle East, and it was able to expand its position in the engine business on the North American market. "We would like to thank our customers for their trust and close cooperation," said Soeren Stark. "Special thanks also go to our employees, of course. Their commitment is what makes Lufthansa Technik's success possible."

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Gulfstream President Mark Burns Inducted into Living Legends of Aviation

Mark Burns, president of Gulfstream Aerospace Corp., was inducted into the Living Legends of Aviation during the 23rd Annual Living Legends of Aviation Awards ceremony held Friday, January 23, 2026, in Beverly Hills, California. This distinguished honor follows his previous recognition in January 2024, when he received the Lifetime Aviation Industry Leader Award.

The Living Legends of Aviation Awards, produced by Kiddie Hawk Air Academy, was established in 2003 to celebrate people who have made significant contributions to aviation, including entrepreneurs, innovators, industry leaders, astronauts, record breakers, pilots who have become celebrities and celebrities who have become pilots. Each year, inductees and honorees are selected by Living Legends of Aviation committees, including past honorees of the different categories.

"Mark is a superb leader who embodies aviation," said Phebe N. Novakovic, chairman and chief executive officer of General Dynamics. "His comprehensive knowledge, leadership, courage and compassion exemplify a living legend of aviation."

Burns joined Gulfstream in 1983 as a computer-aided design operator and worked in numerous areas across the company, including Engineering and Customer Support, before being named president in July 2015. In this role, Burns has led Gulfstream through a period of significant investment in innovation and growth and has been instrumental in the expansion of Gulfstream Customer Support, as well as the development and certification of Gulfstream's next-generation family of aircraft. Burns also serves as an executive vice president of General Dynamics, Gulfstream's parent company.

A Savannah native, Burns earned his bachelor's degree in mechanical engineering from Georgia Southern University. He serves on the board of directors for the General Aviation Manufacturers Association (GAMA) and Georgia Power. He is a part of the associate member advisory council of the National Business Aviation Association (NBAA), a member of the National Committee for the Performing Arts and serves on the board of curators for the Georgia Historical Society.

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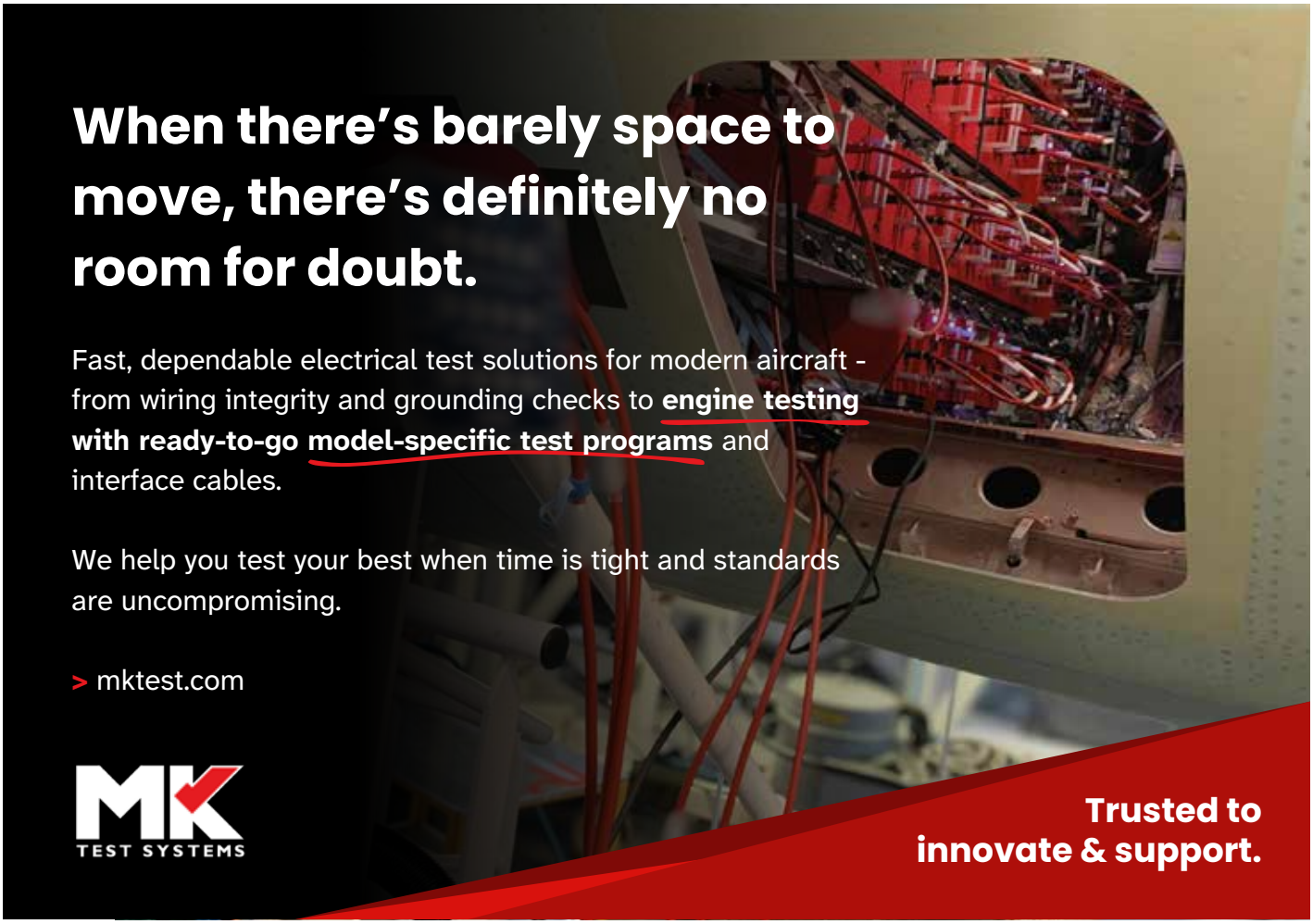

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ATEQ Aviation Bolsters Global Testing Portfolio with Acquisition of T-RX Avionics Solution

ATEQ Aviation announced the strategic acquisition of the T-RX avionics testing solution (formerly owned by CCX Technologies). This move significantly expands ATEQ's offering to the sector, merging world-class air data testing with advanced avionics diagnostics to better serve the aircraft maintenance industry.

The T-RX is a compact, highly reliable tester widely recognized for its performance in radio, pulsatory, and GPS testing. By integrating this technology, ATEQ Aviation now offers a unified testing environment that pairs its renowned ADSE series Air Data Test Sets with a versatile avionics testing platform.

This integration allows MRO organizations to perform comprehensive 14 CFR 91.411 and 91.413 compliance testing within a single, streamlined workflow. These critical inspections are essential for aircraft certification and ensuring continued airworthiness.

The combination of ATEQ's ADSE series and the T-RX tester delivers several key advantages:

- Comprehensive Testing: Simultaneous pitot-static and avionics verification.
- Operational Efficiency: Accelerated timelines for scheduled inspections and certifications.
- Reduced Footprint: Fewer individual tools required on the hangar floor, simplifying logistics.
- Proven Accuracy: Reliable data from a globally trusted manufacturer with a deep pedigree in aviation safety.

"Integrating the T-RX solution into our range of products represents a natural evolution of ATEQ Aviation's strategy," said Gabriel Nativel, ATEQ aviation global director. "By combining our industry-leading Air Data Test Sets with a high-performance avionics tester, we provide maintenance professionals with a more complete, efficient, and confident solution for their daily operations."

ATEQ says the acquisition will reinforce its mission to deliver innovative, reliable testing solutions that help operators maintain the highest safety standards while optimizing operational costs.


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Depot Innovation Drives Readiness, Saves Air Force Millions at Oklahoma City Air Logistics Complex

Airmen and civilian engineers across the Oklahoma City Air Logistics Complex are turning innovation into readiness, delivering faster repairs, improved inspections and millions of dollars in cost avoidance for the U.S. Air Force.

Several OC-ALC teams were recognized in January for cost-effective readiness initiatives that strengthen aircraft sustainment while reducing repair timelines and expenses.

A team from the 550th Commodities Maintenance Squadron and 76th Commodities Maintenance Group Engineering Directorate (76 CMXG/MXDEA) developed a rapid repair solution for F-16 cooling turbine housing assemblies.

Timothy Schantz, machinist; Adam Dorety, mechanical engineer; James Reid, machinist supervisor; and Faith David, aerospace engineer, created a method to repair or replace damaged housings in as little as 30 minutes. Previously, these assemblies often required more time-intensive processes or full replacement.

Their innovation has already saved the Air Force $225,122, while returning critical components to service faster and improving aircraft availability.

At the 76th Propulsion Maintenance Group's 548th Propulsion Maintenance Squadron, engineers and artisans implemented a cost-effective fix for F108 bearing assemblies during shaft strip operations.

The team — Forrest Raines and Tanner Grimes, process engineers; and Tony Cox, Todd Meeks, William Stambaugh, John Mounce and Tom Laird — refined procedures to preserve serviceable components and reduce unnecessary part replacement.

Their process improvements are projected to save the Air Force more than $2.5 million, directly supporting sustainment of engines that power the KC-135 Stratotanker fleet.

Engineers from the 76th Maintenance Support Group leveraged the Metallurgical Analysis Lab to expand the use of First Article Testing, preventing the purchase of unusable aircraft parts before they enter the supply system.

Matt Read and Jacquelyn Searcy, first article lead engineers; Isaac Pulscher, lead engineer; Peter Vik, Henri Blancett and Thomas Krauter from the engineering team; and Kathryn Lara, photographer, collaborated to analyze and validate components prior to acceptance.

Their efforts stopped procurement of a faulty F100 oil nozzle and a TF33 turbine stator lock, resulting in a cost avoidance of $99,483 while protecting aircraft safety and reliability.

Within the 76th Aircraft Maintenance Group, 76th AMXG/MXDEN, Chris Montgomery, an NDI process engineer, identified a solution to replace obsolete magneto-optic imaging equipment used in inspections.

By repurposing an imaging system already available in-house, Montgomery reduced set-up and inspection time by 50% and improved the probability of detecting microscopic cracks and faults by 25% on aging aircraft components.

The upgraded inspection capability enhances detection of surface cracking on KC-135 and B-52 airframes and has generated $174,860 in cost avoidance to date.

Together, these initiatives demonstrate how OC-ALC Airmen and civilians are increasing readiness, extending the life of critical aircraft systems and ensuring taxpayer dollars are used efficiently — all while keeping combat airpower ready for the fight.

U.S. Air Force Col. Grinston presents a certificate of recognition to a member of the 76th Aircraft Maintenance Group, 76th AMXG/MXDEN, during a January Cost-Effective Readiness recognition event Jan. 21 at Tinker Air Force Base, Oklahoma. The team was recognized for improving nondestructive inspection capabilities by repurposing in-house imaging equipment, reducing inspection time and increasing detection of surface cracks on KC-135 and B-52 aircraft components while saving the Air Force thousands of dollars. (U.S. Air Force photo by Ashley Roberts)

U.S. Air Force Col. Grinston presents a certificate of recognition to members of the 76th Propulsion Maintenance Group's 548th Propulsion Maintenance Squadron during a January Cost-Effective Readiness recognition event Jan. 21 at Tinker Air Force Base, Oklahoma. The team was recognized for implementing a cost-effective process improvement for F108 engine bearing assemblies that is projected to save the Air Force millions of dollars while supporting KC-135 engine sustainment. (U.S. Air Force photo by Ashley Roberts)

U.S. Air Force Col. Grinston presents a certificate of recognition to members of the 76th Maintenance Support Group during a January Cost-Effective Readiness recognition event Jan. 21 at Tinker Air Force Base, Oklahoma. The team was recognized for leveraging First Article Testing through the Metallurgical Analysis Lab to identify faulty aircraft components before purchase, preventing unusable parts from entering the supply system and saving the Air Force thousands of dollars. (U.S. Air Force photo by Ashley Roberts)

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GE Aerospace to Invest Another $1B in U.S. Manufacturing

GE Aerospace plans to invest another $1 billion in its U.S. manufacturing sites and supplier base during 2026 to help accelerate engine deliveries, ramp production of parts that safely extend time between maintenance shop visits and strengthen defense production to keep pace with military demand.

The 2026 investment — the company's second consecutive $1 billion U.S. investment — will benefit sites across more than 30 communities in 17 states. GE Aerospace also plans to hire 5,000 U.S. workers, including both manufacturing and engineering roles, in addition to the 5,000 people it hired last year.

"Maintaining U.S. aerospace leadership requires sustained investment in our people, our facilities, and the technologies that will define the future of flight," said H. Lawrence Culp, Jr., chairman and CEO of GE Aerospace. "This investment is for our customers, our communities, and our country."

Since 2024, GE Aerospace has announced plans to invest more than $2.5 billion across its U.S. manufacturing sites and supplier base, including approximately $600 million in sites producing defense engines during the last three years. This manufacturing investment is in addition to the nearly $3 billion GE Aerospace invests annually in research and development.

Accelerating Deliveries

The investment expands capacity at sites producing and assembling commercial and defense engines. This includes $115M in Cincinnati, Ohio — home to GE Aerospace's headquarters — to modernize infrastructure, increase test cell capacity, and expand advanced 3D metal printing capabilities.

Defense

More than $275 million of the $1 billion is planned to upgrade sites producing defense engines and components, helping to strengthen the U.S. defense industrial base to deliver at pace for the warfighter's evolving needs. Highlights include:

- $40+ million for Lynn, Mass., to refresh machinery, expand test cell capacity and flexibility to meet delivery pace, and make building upgrades.
- $10 million for Madisonville, Ky., to invest in new machines increasing part production, inspection equipment, tooling, and facility upgrades.

Commercial

The company is expanding commercial engine production capacity, particularly the CFM LEAP engine that powers the Boeing 737MAX and Airbus A320 aircraft families. These investments will increase part production for maintenance sites, helping reduce turnaround times. Highlights include:

- $200 million to expand manufacturing capacity for LEAP high-pressure turbine durability kits that will improve time-on-wing for customers by more than two times in hot and harsh conditions. The investment also supports production of the reverse bleed system, which reduces the need for on-wing maintenance.
- $20 million for Durham, N.C., for specialized tooling, engine line assembly systems, and building upgrades to support the increased assembly of narrowbody and widebody engines.

- $7 million for Lafayette, Ind., in new tools, equipment, and facility upgrades that support engine assembly and increase capacity to meet 2026 narrowbody engine deliveries.

Investing in Supply Chain

GE Aerospace is investing more than $100 million, as part of the $1 billion, in its external supplier base. These funds will provide tooling and equipment to help stabilize production schedules—critical to meeting delivery commitments. Deploying these investments alongside FLIGHT DECK, the company's proprietary lean operating model, already have helped improve material input last year by more than 40 percent from priority suppliers compared to the previous year. This, in turn, drove commercial engine deliveries up 25 percent and defense engine deliveries up 30 percent in 2025 compared to the previous year.

The company announced last fall a new, $30-million GE Aerospace Foundation program to train 10,000 workers by 2030 with the manufacturing skills to support the entire industry.

Business Aviation Icon Russ Meyer Dies at 93

Russell W. "Russ" Meyer Jr., the longtime chairman and CEO, and chairman emeritus, of Cessna Aircraft Company, has died at 93. Meyer, an aviation legend, led Cessna for 30 years, overseeing the development and launch of Citation business jets. He played a key role in stabilizing the industry through the General Aviation Revitalization Act of 1994, and earned top aviation awards including two Collier Trophies, the Wright Brothers Memorial Trophy and induction into the National Aviation Hall of Fame.

He believed in using aviation to help others, founding the Special Olympics Airlift — which has transported athletes to the games for forty years — and supporting workforce development by starting Wichita's 21st Street Training Program to create career opportunities for under-served residents. His passion for youth development extended to many important charitable organizations and causes.

"Russ was a remarkable human being and one of the most respected leaders I have ever known. I held Russ in the highest regard, not only for his extraordinary business acumen, but for the integrity, humility and genuine care he showed for people at every stage of his life. He led with conviction, compassion and an unwavering belief that leadership carries a responsibility to serve something greater than oneself," said Ron Draper, president and CEO, Textron Aviation. "On behalf of the entire Textron Aviation team, I extend my deepest condolences to Russ's family, friends and all who had the privilege of knowing and working with him. I was truly privileged to know Russ as a colleague, a mentor and a friend."

Meyer attended Yale University for undergrad and Harvard Law earning a doctor of law degree in 1961. He was known for his deep relationship building, including a lifelong friendship with golfer Arnold Palmer who would frequently fly into Wichita to have lunch with Meyer in the Cessna cafeteria.

Digital Twins and Threads in Action

This digital approach to preventive maintenance is transforming aviation — but how does it work?

By James Careless

"Digital twins" and "digital threads" are transforming aviation maintenance from a reactive stance to a preventive approach. But how are they making this change, and what substance is behind the buzzwords?

Making Sense of the Terms

First things first: What exactly are digital twins and digital threads, and how do they apply to aviation maintenance?

"A digital twin is a living, virtual replica of a physical asset, like an aircraft engine, mirroring its real-time behavior and history through connections to sensor data. It allows for simulation and prediction," said Paolo Colombo. He is the global industry development lead, aerospace and defense at Siemens Digital Industries Software. "A digital thread is the continuous, connected flow of data that links all information across an asset's lifecycle, from design to maintenance."

Siemens Digital Industries Software

In aviation maintenance, a digital twin provides the comprehensive view of an asset's health, while a digital thread is the essential conduit that feeds data into the

twin and disseminates its insights, ensuring seamless information exchange for proactive and efficient upkeep. "They are intrinsically linked, with the digital thread empowering the digital twin," Colombo said.

Digital Twinning in Action

Now that we have defined digital twins and digital threads, it is time to see how they are being applied in aviation maintenance.

Lufthansa Technik

Let's start with Lufthansa Technik, which uses AVIATAR's software products to help manage its aircraft maintenance program. "Digital twinning in Lufthansa

Paolo Colombo, Siemens Digital Industries Software

"Lufthansa Technik's Digital Tech Ops Ecosystem is used to know everything about the real-time condition of every aircraft and its components in the air and on ground, at any time and from anywhere, with managed data streams and centrally accessible up-to-date maintenance records," according to Lufthansa Technik's Frank Martens.

Frank Martens, Lufthansa Technik

Technik's Digital Tech Ops Ecosystem is used to know everything about the real-time condition of every aircraft and its components in the air and on ground, at any time and from anywhere, with managed data streams and centrally accessible up-to-date maintenance records," said Frank Martens, AVIATAR's senior director global sales and key account management. "The digital twin in this case is the aircraft as the physical counterpart, whereas digital threading means connecting these digital data with the broader IT landscape of an airline. We can use the data of the digital twin aircraft and combine it with other digital twins (e.g., MRO facilities, flight ops information and other aircraft) in order to create automated planning algorithms like AVIATAR's Line Maintenance Planning solution."

Dassault Systèmes

James Kornberg is the business consultant, aerospace and defense industry, at Dassault Systèmes. "The 'digital thread' is the digital continuity we are able to provide from design engineering to manufacturing, service engineering and maintenance activities," he told Aviation Maintenance. "It is now possible, with our solutions, to create maintenance instructions and spare parts catalogs that maintain a digital continuity from engineering data with the correct configuration of the aircraft in service."

According to Kornberg, Dassault Systèmes has advanced the digital twin model to create the "virtual twin" concept. "A virtual twin goes beyond a digital twin by not only mirroring physical objects but also simulating their behavior and evolution in real time," he explained. "This is a smart and dynamic replica of a product, a process, or a physical system in a virtual environment. The virtual twin is based on a holistic approach, meaning that it encompasses all the lifecycle phases from conception to disposal, on a unified platform, with digital continuity."

The Importance of Good Input

There is an old adage in the IT world: "Garbage in, garbage out." In plain language, the quality of any digital system's output can only be as good as the quality of the data used to create that output.

In the world of digital twins and threads, access to quality sensor and other input data is absolutely vital. Unfortunately, there's a wide range of aircraft in service today, many built decades ago when this kind of maintenance analysis was unheard of. For companies such as Siemens Digital Industries Software, this presents a problem.

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"We tackle this by designing solutions with open architectures and APIs to connect diverse systems," said Colombo. "We employ robust data harmonization tools from the Siemens Xcelerator portfolio to standardize information from various formats and units. For older aircraft, edge computing and data gateways collect and pre-process data locally before secure transmission. Semantic data models help interpret legacy data, and we often partner with experts for tailored integration strategies."

AVIATAR's ability to interconnect with maintenance and engineering systems, records management solutions and ERP systems, "allows our customers to create a single source of digital truth network-of-systems in an airlines operation, which are key to the digital transformation of the aviation industry," Martens said. "For example, Lufthansa Digital Tech Ops Ecosystem connects the AMOS maintenance system with AVIATAR's data analytics and flydocs' digital records and asset management solutions. Through seamless interfaces and secure data exchange, customers can integrate the Digital Tech Ops Ecosystem into their existing environment and extend its capabilities across the organization."

Of course, if the data from legacy aircraft is not available or not accessible, it is not possible to connect it to AVIATAR, the Ecosystem or any other digital tool. In these circumstances, "it is up to the operator to decide how to proceed, but we have always found solutions for customer challenges," said Martens. "Some AVIATAR solutions like the digital Technical Logbook do not need data from the aircraft. Instead, they use data coming from pilots, flight ops systems, or the tech ops team of an airline ideally via AMOS — while the 'paperwork' is stored digitally in flydocs' Digital Records Management."

James Kornberg, Dassault Systemes

As for Dassault Systèmes? "Depending on the IT system, some migrations are possible," said Kornberg. "We are leveraging AI to convert data from legacy aircraft to feed the virtual twin, to enhance the operation of legacy aircraft."

The Impact on Daily Workflows

So far, we have delved into the big picture view of digital twins and threads. So how does this theory play out on the MRO shop floor?

"Consider aircraft landing gear," replied Colombo. "For a maintenance technician, the digital twin transforms their work from reactive to proactive. Instead of relying solely on manuals, they receive real-time alerts from the digital twin about potential issues, like an unusual hydraulic pressure.

Some AVIATAR solutions like the digital Technical Logbook do not need data from the aircraft. Instead, they use data coming from pilots, flight ops systems, or the tech ops team of an airline ideally via AMOS.

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Using augmented reality on a tablet, they can overlay the twin's data onto the physical component, instantly accessing full historical data, repair instructions, and even precise tool requirements. This drastically reduces troubleshooting time and No Fault Found removals."

For a fleet engineer in their office, a digital twin can provide a real-time, holistic view of every landing gear across the entire fleet. They can use this overview to predict precisely component lifespans based on actual operational data, enabling highly optimized, condition-based maintenance planning. "This capability also allows for deep root cause analysis across the fleet and provides invaluable feedback for design improvements, moving beyond aggregated reports to granular, predictive insights. Through the full digital backbone Siemens provides, AI can tell operators if spare parts are available or order them, identify who is certified for this repair and much more, all to minimize the downtime of the aircraft," said Colombo.

On a more general scale, "The daily workflow of a maintenance technician on the ground is changing dramatically in a fully digitalized airline," Martens said. "While technicians used paper-based systems in the past, they are now using tablets or smartphones to get and sign off on work orders."

In Dassault Systèmes' case, their virtual twin console helps fleet engineers to update maintenance assets and technical documentation painlessly. "When a design change or a service bulletin has to be implemented, the fleet engineer has to analyze all the possible in-service configurations to implement a change," explained Kornberg. "This is a cumbersome task that consumes a lot of time. The virtual twin solves this problem by displaying all the possible configurations. The fleet engineer can then make their choice and implement the change only once."

Digital twins can provide a real-time, holistic view of components across a fleet. This overview can be used to precisely predict component lifespans based on actual operational data, enabling optimized, condition-based maintenance planning says Siemens' Paolo Colombo.

ROI: Are Digital Twins and Threads Worth the Cost?

It takes a lot of time and money to implement a digital twin system, and ROI (return on Investment) is a big priority for the aviation industry. So, is this technology worth the expense?

According to Paolo Colombo, the answer is yes. "The ROI is very concrete and measurable," he told Aviation Maintenance. "Industry studies and airline programs report double-digit reductions in AOG (Aircraft on Ground) time, often 15 to 30 percent; improvements of 10 to 20 percent in spare-parts inventory efficiency; and material reductions in No Fault Found removals, depending on fleet maturity, data quality, and operational scope."

What makes this ROI tangible is where the value shows up operationally. "AOG improvements are driven by earlier fault isolation and better decision-making before an aircraft ever reaches the gate, which shortens troubleshooting cycles and avoids cascading delays," said Colombo. "Inventory gains come from higher confidence in parts conditions and demand signals, allowing operators to position the right parts at the right stations instead of buffering uncertainty with excess stock. Reductions in No Fault Found removals stem from improved diagnostic precision — maintenance actions are more targeted, so components are removed because they are likely to be faulty, not simply because there is a suspected issue."

Most importantly, these benefits are spread across the entire maintenance ecosystem. Fewer AOG events reduce downstream disruptions to crew, schedules, and customer recovery costs. More accurate parts usage improves relationships with MROs and suppliers by stabilizing repair flows.

"Over time, the organization shifts from reactive maintenance to a more predictive, evidence-based model, where each avoided disruption reinforces the business case," Cervellera said. "The result is not a theoretical ROI, but one that is visible in daily operations, maintenance planning meetings, and network performance outcomes."

Frank Martens has a different take on this question. From his perspective, the ROI from digital twins can only be calculated by each airline and depends on the processes implemented to react to digital information and how this information is used. "It also depends on aircraft and engine types and other data connected," he said. "And it is also up to the airline to select the digital solutions they want to use."

Barriers to Widespread Adoption

Clearly, digital twins and digital threads offer real value to MROs and their customers. However, widespread adoption

of this technology has yet to take place. But why?

"Widespread adoption faces a combination of factors," said Colombo. "Data standardization and integration complexity are major hurdles, as organizations grapple with silos and inconsistent data formats, demanding significant data engineering effort. The initial investment cost for software, sensors, and infrastructure must be budgeted, requiring strong business cases. Organizational change management and potential workforce resistance are also critical, as implementing digital twins fundamentally shifts work processes. There's also a skills gap in areas like data science and IoT, and significant cybersecurity concerns with connecting OT and IT systems. Finally, a lack of clear strategic vision can hinder successful implementation."

The "newness" of digital twins is also an obstacle. For many airlines and their MROs, "This is a new land," Kornberg said. "Since we are in a phase where companies do not want to take many risks, we need to demonstrate the value of technology innovation, and the costs of relying only on legacy IT systems. That said, we are seeing a growing adoption of virtual twin technology across industries. Powered by AI, virtual twin experiences can revolutionize product development, lifecycle management, and supply chains and their operation. Relying on IT legacy systems to bring products and new innovations to market simply cannot be the foundation of a growing business in the age of AI."

"The digital transformation of an airline is a very complex endeavor that can take many years to be completed, but it's worth it for many reasons," added Martens. "Besides efficiency gains it also increases the reliability of an aircraft fleet. This being said, in the process of digital transformation some airlines may face issues with data. Sometimes it's the quality, the format or the accessibility. Legacy IT systems that do not provide industry standard interfaces could also be an obstacle, but many airlines have proven that digital transformation is not only manageable but delivers great results."

The Impact of AI

There is no doubt that AI is transforming every industry it touches. The experts we interviewed expect it to have the same significant impact on digital twins.

"AI and predictive modeling will dramatically evolve digital twins, leading to even more sophisticated capabilities," Colombo predicted. "We'll see enhanced predictive accuracy, moving beyond simple failure prediction to understand how and when components will fail, enabling ultra-precise, condition-based maintenance. Assets will become more self-optimizing, with digital twins suggesting real-time adjustments for efficiency or extended life. Autonomous data collection and initial analysis by drones and robots, guided by AI, will highlight anomalies for human review. These 'cognitive' digital twins will reason through issues and recommend optimal actions. However, the human element will remain absolutely central. AI will serve as a powerful assistant, augmenting the capabilities of technicians and engineers, providing deeper insights and faster information. Their role will evolve from reactive problem-solvers to proactive strategists, leveraging these advanced tools for unprecedented efficiency, safety, and performance."

"AI will assist technicians and engineers for improved quality and efficiency and will not replace them," agreed Kornberg. "We believe that technologies like virtual companions will help humans in their daily work, enabling humans and AI to collaborate safely, intelligently, and at scale on the most complex industrial challenges. While AI companions will empower professionals with new expertise, humans will still make decisions especially in the highly regulated aerospace industry where safety is the number one priority."

Frank Martens believes that nothing is changing the MRO industry and driving the development of new solutions more than digitalization. "It is the only game changer of this decade," he said. "With 50 times more data being generated by new aircraft types and approximately 50% of airline operating costs consisting directly or indirectly of MRO services, further cost reductions can only be accomplished through MRO and operational optimization through technology."

But don't count the humans out quite yet. "Especially in technical operations, the aviation industry will always depend on highly trained and dedicated professionals — no matter how advanced digitalization becomes," Martens concluded. "While new technologies, data-driven tools, and automation continue to enhance efficiency and precision, they can never replace the deep expertise, critical judgment, and hands-on skill of our people. At Lufthansa Technik, our employees remain our greatest asset: their knowledge, experience, and commitment are what keep aircraft flying and our industry moving forward." AVM

GE Aerospace image.

The Engines Capacity Crunch

By Mario Pierobon

The widespread adoption of new generation narrowbody engines has driven significant efficiency improvements across commercial aviation, but the maturation of these fleets is now placing substantial demand on global MRO infrastructure. As these engine programs transition to mature operational phases, operators are encountering the realities of maintaining advanced powerplants at scale: longer turnaround times driven by material constraints, growing shop visit volumes and the need for specialized repair capabilities.

The MRO sector is responding through coordinated infrastructure expansion, with engine manufacturers and their partners investing in new facilities and upgrading existing sites to handle increasing workload complexity. Geographic positioning of repair capacity is shifting closer to fleet concentrations, reducing transportation delays and improving responsiveness to regional operators.

Workforce development has emerged as equally critical as physical infrastructure expansion. The specialized skills required to maintain advanced turbofan architectures demand structured training pipelines and partnerships with technical education institutions. Simultaneously, automation technologies are being deployed selectively to improve process repeatability, reduce risk of injury and free experienced technicians for higher-complexity diagnostic and assembly tasks that require human judgment.

This article examines how capacity expansion strategies, workforce development initiatives and automation integration are shaping the MRO response to demand growth driven by the operational success of new generation narrowbody engine programs.

Turnaround Time Increases

GE Aerospace points out that customers have selected CFM LEAP-1A engines to power more than 60% of Airbus A320neo aircraft (for which they have selected engines). "And this is just part of the engine program's extraordinary success. With over 3,700 LEAP-powered aircraft in service with more than 150 operators worldwide, 60 million flight hours logged, and over 10,000 engine orders in hand, the company

Pratt & Whitney image.

With 3,700 LEAP-powered aircraft in service, 150 operators worldwide and 10,000 engine orders in hand, GE Aerospace faces a growing challenge to keep all those engines in peak condition. GE Aerospace image.

Rob Griffiths

Iain Rodger

faces a growing challenge, how to keep all these engines in peak condition, they say. "Indeed, due to the large number of engines in service, LEAP engine overhauls are expected to increase significantly by the end of this decade."

Pratt & Whitney continues to see strong demand for the GTF engine, with more than 13,000 engine orders and commitments from 90+ customers worldwide, and over 1,500 orders in 2025. The fleet size is now over 2,600 aircraft across the Airbus A320neo family and A220, and Embraer E2, with 50 million hours flown.

Pratt & Whitney

Material constraints remain the primary driver of lead times, but significant progress is being made, Rob Griffiths, senior vice president commercial engines operations at Pratt & Whitney, observes. "MRO production of the PW1100G-JM GTF increased 26% in 2025 compared to 2024, despite a 40% year-over-year increase in heavy shop visits for more complex repairs. We ended the year particularly strongly, with MRO production increasing 39% in the fourth quarter, thanks in part to a 16% reduction in lead times and a significant increase in component repair volumes, which relieves pressure on the need for new materials, he says. "This puts us in a position to increase MRO production to a similar level in 2026. We are also integrating durability upgrades into the GTF engine that increase in-flight uptime, thus reducing the need for shop visits."

Closing the Capacity Gap

GE Aerospace has announced a $300 million, multi-year investment plan to enhance its engine component repair capabilities in Singapore by 2029, reaffirming the company's commitment to strengthening its presence in the Asia-Pacific region. "Supported by the Singapore Economic Development Board, the investment will transform engine repair operations, enabling faster response times, improved connectivity, and a more seamless customer service experience. We plan to establish an AI Center of Excellence to develop automated, AI-enhanced digital inspection solutions, as well as a new registration, evaluation, and authorisation of chemicals (REACH), compliant coatings facility and for the industrialization of such coatings, and a regional centre for critical shaft repair, GE Aerospace says. "The company's multi-year investment plan is already taking shape with the opening of a new module repair facility at Seletar Aerospace Park. The facility is dedicated to supporting the growth of operations for CFM LEAP-1A and LEAP-1B high-pressure turbine (HPT) modules. This investment is significant for the global engine fleet, allowing the company to perform service closer to operators in the Asia-Pacific and Middle East regions."

GE Aerospace Component Repair

By expanding the repair of LEAP engine HPT modules locally, GE Aerospace expects to reduce downtime and improve engine flow within its global MRO network. "With the addition of Building 8 to our Seletar campus, we are not only expanding our physical presence but also our capabilities, moving from individual engine component repair to engine module repair on LEAP-1A/1B high-pressure turbine modules, says Iain Rodger, managing director of GE Aerospace Component Repair in Singapore. "As the first of our specialized module repair shops, this facility offers improved connectivity within our engine overhaul supply chains, initially for MRO activities in Asia and the Middle East. Many of the components currently repaired in Singapore will be used in these modules, and the shaft repair capability announced later will also be integrated into these modules, significantly reducing downtime for our customers."

In early 2026, Pratt & Whitney announced a memorandum of understanding with the Singapore Economic Development Board to add GTF fan drive gear system (FDGS) repair capacity in Singapore, affirms Griffiths. "Additionally, the recent opening of a USD 70 million 81,000-square-foot GTF MRO expansion at our Columbus Engine Center in Georgia that will increase that facility's annual capacity by more than 25%. We anticipate further expansion of the GTF engine MRO network with the commissioning of the Christchurch and KHI engine centres expected later this year, he says. "In addition to our global engine centres, we have approximately 40 component repair facilities in the GTF engine MRO network. The ability to develop and execute innovative repairs at the individual component level is critical to optimising material flow."

Over the past decade, CFM and GE Aerospace have continued to expand their MRO shop network worldwide, both by increasing the number and size of their own facilities and by partnering with other top-tier MRO providers, according to GE Aerospace. "Now, with the opening of a shop in Poland and a new partnership with MTU Maintenance in Texas, they are doing the same again. GE Aerospace announced its most recent MRO capacity increase two weeks before MRO Americas, with the inauguration of XEOS, a 35,000-square-meter (375,000-square-foot) facility near Wroclaw, Poland. GE Aerospace operates the facility in a joint venture with Lufthansa Technik, GE Aerospace says. "MTU Maintenance Fort Worth will also service GEnx engines under a GE Aerospace-branded service agreement (GBSA). Thanks to this new partnership, MTU Maintenance will perform

MTU Maintenance Fort Worth is being expanded from an on-site service center to a full-fledged maintenance facility — with full disassembly, assembly and testing capabilities for LEAP-1A/-1B and GEnx engines. MTU Maintenance image.

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Pratt & Whintey announced an expanded agreement with Delta TechOps for a more than 30% increase in annual GTF overhaul capacity for the PW1500G engine powering the A220. Delta TechOps image.

performance restoration work and industrialize extensive repair capabilities for the CFM LEAP-1A and -1B engines, as well as for the GEnx-1B engines."

In Germany, MTU Maintenance Berlin-Brandenburg has expanded its PW800 engine program from a focus on low-pressure turbines to a comprehensive engine MRO service, explains MTU Maintenance. "Additionally, the Ludwigsfelde location is expanding its capacity in the industrial gas turbine (IGT) segment, building a new production facility to achieve its goal of a 30% increase in workshop volume over the coming years. EME Aero, MTU's joint venture with Lufthansa Technik specializing in the MRO of the GTF engine family, delivered its 1,000th engine to its plant in Jasionka, Poland and inaugurated a second test cell, with plans to increase its operating volume to 500 maintenance interventions per year starting in 2028, MTU Maintenance says. "In the Asia-Pacific region, MTU Maintenance Zhuhai opened a second production facility in nearby Jinwan for MRO of the PW1100G-JM program, creating greater overall maintenance capacity for its portfolio, which also includes the CFM56, LEAP, and V2500 engines at the original Zhuhai site. Once the Jinwan workshop is fully operational, the two sites will have a combined annual capacity of more than 700 maintenance interventions. In São Paulo, MTU Maintenance do Brasil has moved to a larger facility to meet the growing demand for on-site maintenance of aircraft engines and IGTs in South America."

Pratt & Whitney and its network of workshops continue to invest in the GTF MRO network, consisting of 21 global service centers, to support the growing GTF fleet, and the network will continue to expand, Griffiths affirms. "In 2025, we announced the addition of Sanad to the GTF MRO network, representing the first GTF workshop in the South Asia, Middle East, and North Africa region, with the first induction scheduled for 2028. This workshop will be able to overhaul all three GTF models. In addition, we announced an expanded agreement with Delta TechOps for a more than 30% increase in annual GTF overhaul capacity for the PW1500G engine powering the A220, he says. "Also in 2025, we finalized an agreement to expand GTF overhaul capacity at MTU facilities, increasing MTU's annual capacity to 600 repairs on all GTF models; ITP joined the GTF MRO network as our 21st workshop and EME Aero announced a USD 37 million expansion of its facility in Poland to service more than 500 GTF engines annually starting in 2028."

Workforce Pipeline and AI-Assisted Diagnostics

Celma's new MRO facility in Três Rios in Brazil is expected to usher in a new chapter, nearly doubling its maintenance capacity from 600 to 1,000 engines per year, GE Aerospace points out. "This new growth is expected to create another 400 jobs, bringing the total number of employees at the Brazilian operation to nearly 4,000 in the state of Rio de Janeiro. Many of these new hires will be MRO technicians. This represents many positions to fill, but Celma management is confident in their approach," GE Aerospace says. "The Celma team's partnership with the Serviço Nacional de Aprendizagem Industrial (SENAI), a training academy established by Brazilian industrial companies, has been crucial to Celma' success. The continued collaboration with SENAI will ensure that GE Aerospace employees are well-prepared to address new technical needs."

"GE Aerospace has historically hired a high percentage of SENAI graduates, affirms Julio Talon, GE Aerospace's MRO leader for Brazil. "The program provides students with a solid foundation in aerospace technology, and we offer opportunities to develop advanced skills as our

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technicians gain experience. LEAP engine maintenance will be one of these important career growth opportunities."

Pratt & Whitney is investing in automation support to improve safety, efficiency and productivity. "Key benefits include safer operations with lower risk of injury, greater repeatability and reliability, reduced rework, shorter process times, and less waste, as well as customized equipment that integrates software and hardware while minimising space requirements, says Griffiths. "In addition to expanding our footprint, we are equipping our MRO facilities with cutting-edge technologies, including automation and robotics, to meet demand while increasing the speed and productivity of MRO operations. For example, at our Eagle Services Asia (ESA) MRO facility in Singapore, our 'Alfred' robotic system assembles the rotors of the GTF's high-pressure compressor, maintaining tight assembly tolerances in a repetitive manner, while recording and analysing key process quality data."

'Alfred' has allowed ESA to halve process times and reduce man-hours by 85%, freeing up three operators for more complex tasks such as rotor balancing, according to Griffiths. "In addition, ESA also uses a collaborative robot (cobot) to assist technicians in photographically documenting external engine components, demonstrating their condition before and after overhaul, he says. "This system replaces the photographic documentation routine previously performed by ESA technicians and enhances their operational skills. At the same time, it has helped ensure process integrity, reducing man-hours by 90%. This level of MRO automation is industry-leading, and we are evaluating the possibility of implementing ESA's robotic innovations in other shops within the GTF MRO network."

Summing Up

The narrowbody engine MRO sector is responding to increased demand through coordinated capacity expansion, workforce development, and selective automation deployment. Geographic repositioning of MRO capacity closer to concentrated fleets in Asia-Pacific and Middle East regions reflects strategic infrastructure investment, while network expansion through partnerships continues to broaden overhaul capability distribution. Component repair volume increases and lead time reductions are addressing material constraints that have historically driven turnaround delays.

The GE Aerospace Celma facility in Três Rios, Brazil provides MRO services to more than 30 commercial airlines. GE Aerospace image

Workforce pipeline development remains critical to capacity execution, with established partnerships between MRO providers and technical training institutions supporting planned expansion requirements. Automation integration at advanced facilities demonstrates measurable efficiency improvements in repetitive assembly processes and documentation tasks, prioritising repeatability, safety improvement, and operator reallocation to higher-complexity work rather than workforce reduction.

The industry trajectory points toward continued MRO network expansion through the remainder of the decade. Material flow optimisation through component-level repair capability development and durability upgrades designed to reduce shop visit frequency will influence whether capacity additions keep pace with projected overhaul demand as installed fleets mature. The combination of geographic network expansion, process automation, and workforce development represents the sector's integrated response to demand growth driven by the operational success of new generation narrowbody engine programs. AVM

Pratt & Whitney says MRO automation is reducing man-hours dramatically and is investing in automation support to improve safety, efficiency and productivity. Shown here is the Pratt & Whitney GTF. Pratt & Whitney image.

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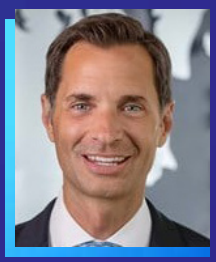

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10

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11

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N-S Hall/1960

12

MK TEST SYSTEMS

N-S Hall/5264

13

BARFIELD

N-S Hall/4326

14

SONIC tools

N-S Hall/2574

15

DMC DANIELS MANUFACTURING CORPORATION

N-S Hall/3152

16

AIRBUS

N-S Hall/4307

17

Perform Air International

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18

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Liebherr-Aerospace is a leading global system, component and solution provider of environmental control and thermal management systems, flight control and actuation systems, landing gears as well as on-board electronics.

Liebherr Aerospace Saline, Inc. is Liebherr's dedicated service center for the Americas providing component and landing gear repair, overhaul, modification, material sales, technical support, and customer service. The organization is certified by FAA/EASA/TCCA/Anac and maintains a broad capabilities portfolio.

Lifecycle support

Committed to high customer satisfaction, Liebherr provides best-in-class lifecycle support from the design and development phase, over the complete service life, up to enhancements for the next product generation.

Design and development

Liebherr leverages extensive system knowledge from millions of operational hours to create reliable, cost-optimized equipment that is easy to test and to maintain. Customer support and engineering teams collaborate to combine innovative ideas with field experience, delivering systems designed for:

- Low cost of ownership
- High reliability
- Easy operation, testing, and maintenance
- Reduced environmental impact

Manufacturing

Production methods are continuously expanded and improved to meet future demands while maintaining the tools, machinery, and expertise needed to support aircraft operations long after production ends. Manufacturing processes prioritize flexibility, quality, reactivity, and efficiency, with each site committed to ambitious environmental targets. Close collaboration with customers ensures the ability to anticipate needs and deliver services promptly and effectively.

Entry-into-service

Entry-into-service encompasses the transition from aircraft development to its first operation by an operator, regardless of the aircraft's age.

The entry-into-service package includes:

- Training for maintenance personnel and familiarization with the global field service network
- Distribution of technical documentation
- Recommendations for initial provisioning and strategic asset placement
- Suggestions for tools and parts to maintain systems
- Monitoring component behavior during operation

These steps are part of a structured framework, ensuring efficient and reliable support during the aircraft's initial operational phase.

Operations

Hundreds of customer service employees in a global network provide local support through regional Service Centers offering a wide range of services. These Service Centers serve as the first point of contact for any needs. In-service engineers focus on developing innovative repair solutions and product enhancements to reduce maintenance costs and meet evolving airworthiness requirements.

Repair and re-use

Products are designed to be repairable and re-usable, reducing waste and minimizing "scrap and replace" practices. As aircraft reach their end-of-life, Liebherr actively participates in returning equipment removed from dismantled aircraft into service by:

- Re-using parts during the repair process based on their life potential
- Offering spares through the "USM by Liebherr" service The Used Serviceable Material (USM) program provides global access to OEM-quality serviceable parts at fair market value, helping to optimize operating costs.

Take MRO to the next level

In-service engineers focus on innovative repair solutions and product enhancements to reduce maintenance costs, meet evolving airworthiness requirements, and address operational needs. As a Design Organization Approved (DOA) company, with access to extensive test capabilities, Liebherr can develop and implement such enhancements quickly.

Dedicated teams support airlines thanks to innovative analytical solutions improving reliability and helping prevent flight interruptions. Decades of system performance knowledge and OEM expertise, combined with MRO activities data science, drive continuous improvement in solutions such as troubleshooting tools and predictive maintenance models:

- Visualizers: These solutions aim to support A/C troubleshooting activities
- Trend Monitors: They provide computed degradation patterns graphics to improve aircraft maintenance scheduling
- Predictors: They predict and alert in a range from 4 to 20 calendar days before a component's failure

Airbus Americas, Inc.

N-S HALL/4307

Airbus is a global leader in aeronautics, space and related services. Airbus offers a comprehensive range of passenger airliners, tanker, combat, transport and mission aircraft, as well as one of the world's leading space companies. Airbus provides the most efficient civil and military rotorcraft solutions worldwide. Airbus employs more than 134000 people of over 100 different nationalities in facilities in the U.S., Europe, China, Japan and the Middle East. Airbus also operates spare parts and training centers around the word and provides round-the-clock support services to all Airbus operators.

CTS Engines

N-S HALL/2700

CTS Engines is a global leader in mature jet engine maintenance. Our mission is to provide the highest quality and most reliable repair and overhaul services for mature jet engines, while maintaining a commitment to safety, innovation, and customer satisfaction. We strive to be the industry leader in providing efficient and cost-effective solutions that exceed our customers' expectations and ensure the safety and reliability of their aircraft. CTS Engines supports test, repair and overhaul of the following engines: CF6-50, CF6-80A, CF6-80C2, CF6-80E1, PW2000, and GP7200.

Vapormatt

N-S HALL/4955

Vapormatt is a specialist solutions provider dedicated to wet blasting technology. In the aerospace industry, we have to be able to offer highly controlled and automated systems that can reliably and repeatedly provide the standard of finish that is demanded by MRO companies. We have extensive experience in a range of aerospace applications across the globe with installations at both OEM and MRO levels. Our ability to control the process using patented technologies has made us an approved supplier for several blue-chip firms. The quality of surface finishing we can provide is not only consistent but always improving. This is why Vapormatt wet blasting machines are able to stay ahead of the competition and offer great advantages.

Aviation Component Solutions

N-S HALL/3528

Aviation Component Solutions is a principal in the OEM alternate product industry. A world-class PMA company, ACS designs, certifies and manufactures PMA parts for every major MRO and airline worldwide. Our forte includes: HMU/FMU fuel, vacuum generator, hydraulic pumps/actuation, pneumatic valves and air conditioning components.

AJW Group

N-S HALL/1714

Transforming aviation efficiency for over 90 years, AJW Group is a world-leading independent component parts, repair, lease, engine, flight hour program and supply chain solutions integrator. Our business ethos of quality and flexibility permeates all aspects of the customer experience offering 24/7/365 support to over 1,000 airlines across 100 countries. AJW Technique, our state-of-the-art component MRO facilities in Canada and Europe, is joined by inventory hubs and offices on every continent delivering an award-winning package of global services, including end-to-end, tailored solutions for interior needs. The company has an extensive global vendor supply chain and is focused on service excellence. Nose to tail, we've got you covered.

TAT Technologies Ltd.

N-S HALL/5114

TAT Technologies is a leading provider of thermal management solutions, APU and landing gear MRO Services to the aerospace industry. TAT's reliability, expertise, and commitment to meeting customers' needs and requirements have positioned them as a trusted partner to some of the world's leading OEMs, airlines, maintenance organizations, air forces and defense organizations.

Airmark Components, Inc.
N-S HALL/1660
Airmark Components has been providing reliable accessory repairs to airlines since 1985. Airmark offers cost-effective quality and dependability, while providing the highest level of customer service and support. Airmark Components is FAA/EASA certificated for Class 1, 2, and 3 accessories. Our capabilities include pneumatic, heat transfer, hydraulic, and electro-mechanical components for commercial, regional, and corporate aircraft.

Transport Workers Union of America
N-S HALL/4474

PAG
N-S HALL/2328
Precision Aviation Group (PAG) is a leading provider of products and value-added services to the aerospace and defense industries worldwide. With 20 repair stations and over 850,000 square feet of sales and service facilities in the United States, Canada, Australia, Singapore, and Brazil — PAG's 23 locations and customer-focused business model serve aviation customers through supply chain and inventory supported maintenance, repair, and overhaul (ISMRO®) services. PAG provides MRO and supply chain solutions for fixed- and rotary-wing aircraft. PAG has MRO and manufacturing capabilities on over 100,000 product lines in four MRO segments — avionics, components, engines, and manufacturing/ DER services.

Jet Parts Engineering, Inc.
N-S HALL/4121
As a leader in the development of FAA-PMA parts and engineered repairs, Jet Parts Engineering is devoted to providing spare part solutions to our global network of airline and MRO partners. We specialize in over 25 ATA chapters across most aircraft systems with capabilities to develop a wide range of part-types. Our ecommerce portal gives immediate access to pricing, availability, technical information, and the ease of order placement and tracking. Jet Parts Engineering's staff is comprised of some of the best and brightest in the industry — our people are the best part. Visit www.jetpartsengineering.com to learn more.

DAS Aviation
N-S HALL/1960
DAS Aviation is an FAA Part 145 repair station specializing in engineering, airframe structural repairs, sheet metal fabrication, component overhaul and repair, composite structures, and and parts support. With facilities in TX, OH, and IL and 100,000+ sq ft of shop space plus 44,000+ sq ft of inventory, we deliver industry-leading return to service for business, commercial and military operators.

MK Test Systems.
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Barfield, Inc
N-S HALL/4326
Barfield is part of the AFI KLM E&M network, a major MRO provider. With 400 employees across its facilities located in Miami, Phoenix, Louisville and Atlanta, Barfield can satisfy the needs of customers operating commercial or regional aircraft in North, Central and South America. From MRO services to distribution and Ground Support Test Equipment (GSTE), Barfield provides complete tailor-made support programs for Airbus, Boeing, Bombardier, ATR and Embraer aircraft to operators in need of inventory, repair management, engineering and fleet support programs, and logistics solutions.

SONIC Tools
N-S HALL/2574
SONIC is a market leader in the design and manufacturing of premium hand tools and toolbox solutions. SONIC products are found in the world's most progressive automotive enterprises, service centers, race shops, aftermarket businesses and personal garages. Our goal is to design and manufacture equipment that meets and exceeds all standards. For nearly 50 years, we've accomplished that goal. Faster pace of work, increased efficiency, the best value — that's what we're all about. SONIC is a Dutch-based company with facilities in the Netherlands, Germany and the United States.

Daniels Manufacturing Corp.
N-S HALL/3152
Daniels Manufacturing Corporation is the leading manufacturer of mil-qualified crimp termination tools, EWIS maintenance kits, insertion/removal tools, and connector assembly tools. Additional product lines include Safe-T-Cable, the time-saving substitute for lockwire, Alphatron crimp pull testers, and Twist-Strip, an outer jacket stripper for multiconductor cable. DMC's newest product, LaceLok, will debut at the AMC skills contest. LaceLok provides a superior, safer, and consistent solution for secondary wire bundle support that replaces zip ties and hand-tied lace. DMC continues to support the latest in aviation technology and is proud to offer custom-engineered tools to fit your needs. ISO 9100:2008 and AS9100:2004 Registered, ROHS Compliant.

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N-S HALL/5137
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DAC Engineered Products
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DAC-Engineered Products delivers best value solutions to the worldwide aviation aftermarket. Specializing in DER repairs, PMA components, and PMA brakes, we add value to our customers by prioritizing high-quality standards, meaningful cost savings, exceptional customer service, and improved reliability.

Iberia Maintenance
N-S HALL/2738
Iberia Maintenance delivers premium MRO services for A320ceo/neo family and 330. All operators can benefit from our component repair and overhaul expertise covering a wide service spectrum of components assembled in these fleets. Iberia Maintenance offers engine process on CFM56-5B, CFM56-7B, V2500, RB211-535E4 and PW1100, but also power generation systems, associated accessories and thrust reversers. More than 95 years and its solid international customer portfolio habilitates to Iberia Maintenance being an MRO with the highest quality and safety standards combined with a flexible and competitive commercial approach. An example of its adaptability is the recent incorporation of 5% sustainable aviation fuel in its engine test bench in Madrid.

Air France Industries KLM Engineering & Maintenance
N-S HALL/4125
Air France Industries KLM Engineering & Maintenance is a major multiproduct MRO provider. With a workforce of over 14,000, AFI KLM E&M offers comprehensive technical support for airlines, ranging from predictive maintenance, engineering, GSTE, and line maintenance to engine & APUs overhaul, as well as the management, repair and supply of aircraft components structured around a powerful logistics network. Adaptiveness® is our response to the changing MRO business environment. It means listening to and understanding the key technical priorities of our customers' operations, building unique solutions meeting their specific requirements, and staying at their side as a partner to support them through their daily challenges.

The Power of Extended Reality (XR) Training for MROs

By James Careless

Aviation maintenance is complex yet precise work, requiring extensive training for those who perform it. This is why airlines and MROs alike are looking for new and better ways to train aviation technicians, such as extended reality (XR). Encompassing the three IT-driven technologies known as virtual reality (VR), augmented reality (AR), and mixed reality (MR), XR makes it possible to train technicians faster, more accurately, and without the need for a physical classroom.

Before we examine the detailed benefits of XR for MRO training, let's begin by defining terms with the help of TJ Moser. He is Varjo's USAF account executive and a former USAF officer/aviator. Varjo Technologies is a Finnish company that specializes in industrial-grade VR/MR headsets.

"VR is a fully digital environment, where the technician is completely immersed in a virtual hangar or engine room," said Moser. "This is ideal for procedure familiarization where physical hardware is unavailable. AR uses digital overlays, like text or 2D diagrams. It provides 'just-in-time' information but typically lacks deep spatial integration, realistic shadows, and struggles with contrast in bright, outdoor conditions. MR is the most advanced form of XR. It blends the physical and digital worlds, so they seamlessly interact. For example, a technician can see their real hands and physical tools while interacting with a virtual aircraft engine. It combines the immersion of VR with the tactile utility of the real world."

TJ Moser Varjo

David Bienvenu CAE

Why XR is So Useful for MRO Training

Talk to the experts, and you'll soon learn the many ways in which XR is so useful for training MRO technicians.

Take CAE: "VR, especially when it comes to aircraft technician training, is proving to be a high-value solution, especially when it comes to offering our customers flexibility," said David Bienvenu, the company's global leader of maintenance training. "VR offers multiple benefits including a reduced need for physical equipment, minimized downtime for the aircraft, cost-effective repetitive practice, and the VR modules' adaptability to new aircraft."

Airbus Helicopters' training academy is similarly impressed by XR. "We believe that these technologies contribute to improving the trainee experience in order to bridge between classroom theory and hangar floor practice," said Melchior Kaag, the company's VP head of training and flight operation services. For instance, XR training helps technicians to develop risk-free muscle memory by practicing high-stakes procedures, such as a complex engine removal, dozens of times without consequences in a virtual environment. "They build the necessary 'muscle memory' and procedural confidence without any risk of damaging flight-critical components or expensive tooling," he said.

Meanwhile, AR training lets trainees "see inside" physical aircraft systems. "We can overlay electrical currents or hydraulic flows onto the aircraft, helping technicians understand the 'why' behind a failure, rather than just following a 'how-to' checklist," said Kaag. "We can also simulate critical situations in XR that are impossible to replicate safely in real life, such as localized fires, structural cracks, or specific bird-strike damage. This prepares technicians for rare but high-impact maintenance scenarios in a controlled, safe setting."

Sanddeep Sinha is head of global strategies at Qvolv Technologies, a developer of XR software for training, safety simulations, and digital twin applications. In addition to the benefits outlined above, he cites AR for effectively supporting ad hoc training on the job site. "In the real-world scenario even, experienced technicians sometimes face unfamiliar equipment, where manuals are thick, and time pressure is high," Sinha told Aviation Maintenance. "With augmented reality smart glasses, instructions appear directly on the equipment through immersive manuals. One plant manager told us their downtime dropped significantly because technicians no longer spent hours searching manuals."

XR can also be used to capture the skills of experienced

Melchior Kaag, Airbus Helicopters

Sanddeep Sinha, Qvolv

technicians about to retire, so that this knowledge remains in the organization. "Within a VR module, a master welder demonstrates techniques," said Sinha. "Young learners can observe, practice, and get feedback on accuracy. As well, in a VR/MR environment, we can measure how long a tech takes, where they hesitate, and what errors they make. This allows us to tailor training. If a trainee finds safety procedures difficult, they can practice just that section until they get it right. Training becomes smarter, not longer."

Finally, XR supports training anywhere, anytime. "Immersive tech can provide top-class training in small towns and Industrial Training Institutes," he said. "The trainee in a rural training center can learn to maintain turbines used in global industries. This provides equal opportunities for all."

How These Companies are Using XR in MRO Technician Training

We began this article by having the experts talk about the use of XR in MRO technician training in general. Now we will dig deeper, by asking each of them how they use it.

Airbus Helicopters' training academy uses XR training on an incremental basis. They start with basic applications and then move into XR more deeply as the trainees become comfortable with it.

"The first steps consist in using a digital mock-up of the helicopters and the simulation of helicopter behavior," said Kaag. These tools include Virtual Maintenance Trainers, where technicians can move around a realistic virtual helicopter to identify components and practice procedural tasks. The Helionix Advanced Tool Simulator (HATS) also falls into this category. HATS is a desktop or touch-panel training device that replicates the Helionix avionics suite. "Specifically designed for our Helionix-equipped aircraft—like the H135, H145, H175 and H160—technicians use this troubleshooting simulator to make the transition from theory to practical cockpit management," he said.

CAE is using XR to accelerate a student's progress to becoming an effective MRO technician. To make this happen, "CAE has integrated advanced VR technology into some of our maintenance technician training programs, which allows us to create detailed digital twins of aircraft," said Bienvenu. "This VR capability enables technicians to engage with aircraft systems, components, and procedures in a fully immersive, simulated environment. By doing so, they can build their skills and confidence in a safe setting before handling the actual aircraft. This approach is transforming the aviation maintenance industry, fostering greater competency, adaptability, and safety."

CAE has deployed cloud-based VR simulations to support its latest Gulfstream and Dassault maintenance programs for the G500/600, G650, and Falcon 6X. "Technicians can perform maintenance tasks in this virtual environment in several teaching modes, including an evaluation mode that allows technicians to measure their skills independently," Bienvenu said. "An instructor-led mode also exists that will guide students through the various steps to perform certain troubleshooting tasks. As we gather feedback from our customers on VR, the intent is to roll out across other aircraft platforms."

Qvolv Technologies is using VR, AR, and MR for MRO technician training. In the VR realm, "we create virtual twins of machines and perform simulations of maintenance activities," said Sinha. "They support aviation training sessions where a technician is able to perform simulations of dismantling parts of an aircraft, troubleshooting hydraulic issues, and conducting inspections within a virtual environment before working on an actual plane. This approach provides no risk of damaging equipment, no loss of time due to errors, and the opportunity for unlimited repetitions by the student until they get it right."

In the MR realm, Qvolv allows senior engineers to guide field technicians remotely. "A field technician at a plant can share his/her view with a senior engineer who is located in another city," Sinha explained. "The senior engineer can then draw arrows on the view of the field technician to show them what to do. We achieve this through immersive collaboration platforms like Q Connect,

With Qvolv's augmented reality smart glasses, instructions appear directly on the equipment through immersive manuals. Qvolv image.


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CAE says VR capabilities enable technicians to engage with aircraft systems, components and procedures in a fully immersive, simulated environment. Technicians can build their skills and confidence in a safe setting before handling the actual aircraft the company says. CAE image.

which enable teams to interact with digital twins and share live annotations."

As for Varjo? According to Moser, "We work with industry leaders like Lockheed Martin, Boeing, and FlightSafety International-Defense. While our technology is primarily used for more complex and demanding aviation training use cases, our partner AXIS Flight Simulation has developed a mixed reality training solution using Varjo technology for 'Virtual Cockpit Procedure and Walkaround Trainers." Technicians can perform pre-flight inspections and external maintenance checks in a high-fidelity virtual environment. Additionally, through our partner Lockheed Martin's Prepar3D platform, maintenance crews can rehearse complex system diagnostics. By using the Varjo XR-4 Series headsets, they can read tiny labels and identify hair-thin cracks in virtual components that are invisible in lower-resolution headsets."

Benefits for Everyone

Ask the experts to detail the benefits of XR for MRO technician training, and chances are you'll get a list.

Here is one from Varjo's TJ Moser. "For MROs: Cost savings. A physical engine simulator can cost millions; an XR-based station costs tens of thousands and can be updated instantly via software when a new engine variant is released," he said. "For clients (Airlines/Military Operators): Faster turnaround times. Better-trained technicians work more efficiently and make fewer errors, leading to higher fleet reliability. Finally, for technicians (MRO employees): Increased confidence. Data shows that XR training can increase student confidence by up to 275% compared to traditional classroom settings. It also provides a more engaging, modern work environment that helps with talent retention, as especially new, younger trainees are already familiar with tech and XR."

Airbus Helicopters is currently conducting studies to quantify the actual impact of XR on technician training. "Nevertheless, Airbus Helicopters' feedback is the following," Kaag said, citing his own list. "For trainees: Increased engagement, motivation, concentration and memorization, plus increased confidence and safety. Technicians can 'fail' safely in a digital environment,

CAE has deployed cloud-based VR simulations to support its latest Gulfstream and Dassault maintenance programs for the G500/600, G650, and Falcon 6X. CAE image

Using Varjo's XR-4 Series headsets, mechanics can identify hair-thin cracks in virtual components that are invisible in lower-resolution headsets. With their partner Lockheed Martin's Prepar3D platform, maintenance crews can rehearse complex system diagnostics, Varjo says. Varjo images.

which reduces the stress and anxiety associated with high-stakes maintenance.

Training to manage unusual situations. Technicians can be immersed in rare scenarios thanks to realistic simulations. Finally, for training centers: On one hand, limited training space for real scale 1:1 physical mock-ups, while on the other hand less costly development and recurring costs for XR-based systems. XR also offers the ability to modify the scenario depending on the trainee evolution, and immediate feedback thanks to virtual trainer voice communications."

CAE's list of benefits is less list-like. "Utilizing VR in MRO training and operations provides significant benefits across the board," said Bienvenu. "Customers love being able to bring an aircraft inside the classroom environment, where VR, in particular, allows for special orientations that make learning objectives — such as identifying component locations or performing removal and installation tasks — much easier to deliver. Students can access parts of the aircraft they would not normally see during routine maintenance, explore onboard maintenance computers, and evaluate faults that may not exist on their own aircraft, providing hands-on experience in a risk-free environment."

For MROs, using XR technology improves training efficiency and standardization, he noted, reducing the need for on-aircraft instruction while accelerating skill development. "Employees gain confidence and deeper understanding by practicing complex procedures virtually before performing them in the hangar,"

Young learners can observe, practice and get feedback on accuracy. In a VR/MR environment how long a tech takes, where they hesitate and what errors they make can be measured and then training can be tailored to the technician. Qvolv image.

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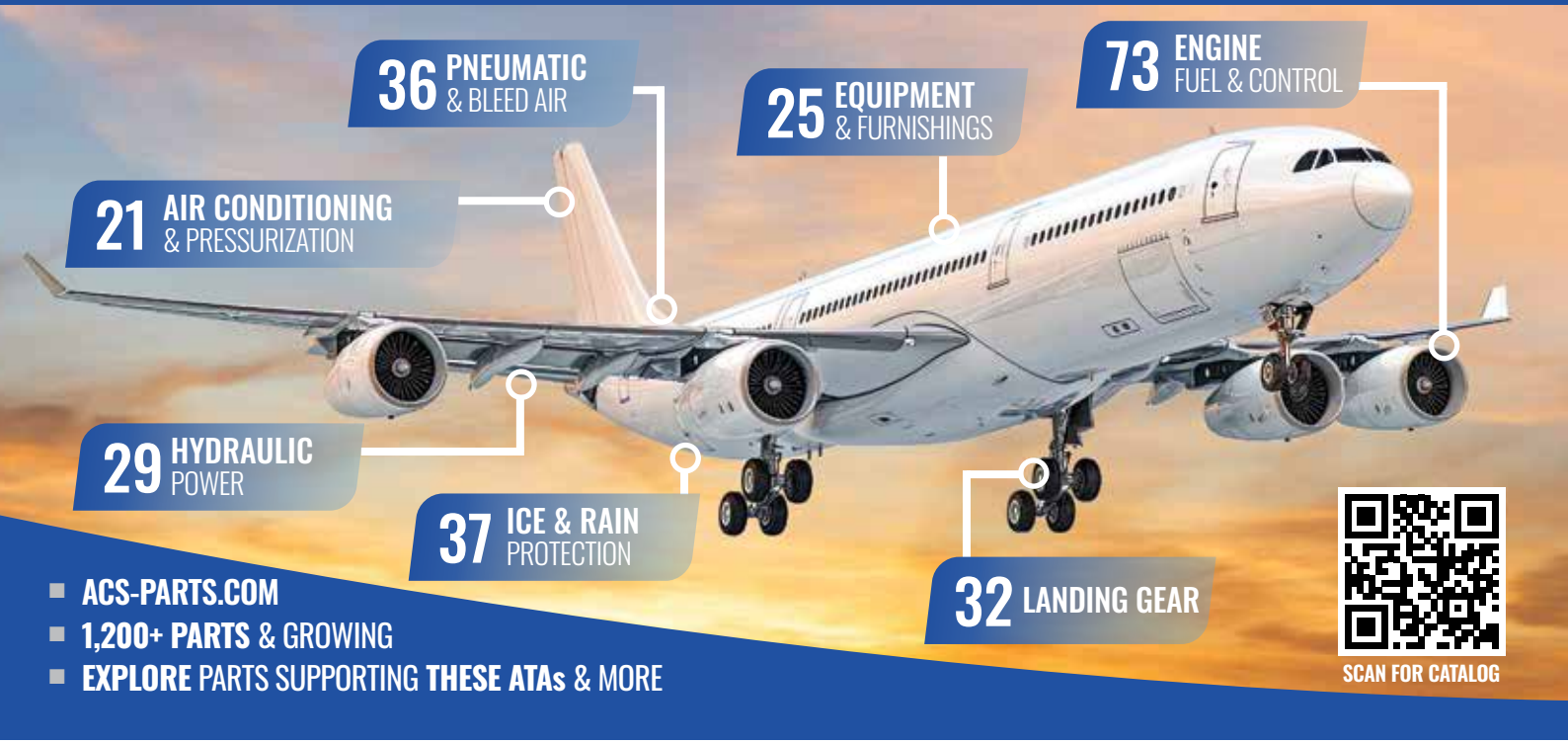

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Bienvenu told Aviation Maintenance. "For clients, these tools ensure higher-quality maintenance, as technicians are better prepared and familiar with their aircraft systems. OEMs have come to expect this level of advanced training technology and often collaborate to push the development of new VR applications, keeping the entire MRO ecosystem at the cutting edge of safety, efficiency, and operational readiness."

Over at Qvolv Technologies, Sanddeep Sinha fielded the benefits question by saying, "Let me answer this the way we often explain it to partners — not in numbers first, but in people. One evening, after a long training session, a young technician told us, 'Sir, today I was not scared to touch the machine.' That single sentence captures the real benefit of immersive training. When AR, VR, and MR are used thoughtfully, they don't just improve processes — they change how people feel about their work. And that impact spreads across MRO companies, their clients and the technicians themselves."

The Limits of XR Training

Even with the many benefits outlined above, there is only so much that XR-based training can do. "Despite the leaps in technology, for certain elements XR is a supplement, not a replacement," said Moser. "For instance, it is not a substitute for tactile feedback (haptics). While we can simulate visuals and some sound, the specific 'feel, of a rusted bolt breaking loose or the resistance of a hydraulic line is difficult to replicate perfectly without high-end, expensive haptic rigs. Similarly, the smell of jet fuel or the physical exhaustion of working in a cramped crawlspace with high and low temperature extremes are real-world variables that still require hands-on experience. Finally, leadership, team communication during a 'hangar floor' crisis, and the ethical responsibility of signing off on a repair are nuances best taught by human mentors."

Sinha replied to this question with another list: "What Must Still Be Taught by Humans." This includes:

- How to handle tools and be precise.
- How to be safe and have a safety culture and discipline.
- How to troubleshoot and have intuition.
- How to be responsible and have a sense of ethics.
- How to have pride in one's work.

He closed the list by saying, "A wise technician's advice, 'Listen to the machine, it will tell you what's wrong', is something that software cannot teach."

David Bienvenu agrees with this caveat. "At CAE, we believe that people learn from people," he said. "AR, VR, and MR are tools which supplement learning, create opportunities for self-practice and can help ramp up basic skills. But they will never fully replace a person-to-person interaction. People can better gauge the nonverbal cues of students to new materials, adjust the pace of training, or deep dive on a particular subject to help with the student's specific situation. This is why CAE instructors are the most important element of our training operation. Rarely are AR and VR quoted as elements that have significantly improved a student's understanding of the aircraft, yet CAE instructors are consistently lauded in our customer experience surveys. In summary, a course with AR/VR/MR capabilities creates new learning opportunities, which the full value is only realized with an experienced, qualified and dedicated instructor."

What's Coming Next

Today's XR-based training is impressive in its own right. But what's on the horizon may well be mind-blowing. Here are some predictions, some on the verge of coming true.

"We are seeing the integration of AI-driven instructors within the XR environment that can provide real-time feedback," said Moser. "And while it may never completely eliminate the need to touch a real airplane before a technician is certified, there are expectations that 90% of a technician's curriculum will eventually move to XR."

"Future systems will use artificial intelligence to track a student's gaze and hand movements in VR, instantly identifying where they are hesitant and adjusting the lesson in real time." Kaag said. Meanwhile, AI-powered training modules "will be able to adapt to the individual technician's errors and learning pace," said Sinha. In fact, AI is already being used to create adaptive training and digital twins to help technicians train faster and reduce errors.

In terms of coming advances, "the future convergence of AI and VR represents a transformative synergy which will revolutionize how we build immersive training and skills-development solutions within the aviation industry," said Bienvenu. "As these technologies continue to evolve in tandem, the convergence of AI and VR is poised to redefine the boundaries of human interaction and pave the way for new and innovative applications across diverse domains within the aviation industry."

Despite their far-ranging predictions, none of the experts expect humans to be eliminated from the MRO technician training loop.

"I do not believe that VR, AR or MR will take over human instruction," Bienvenu said. "I — and my colleagues at CAE — believe these are tools to help, but the human experience and expertise are absolutely fundamental in teaching. Although younger generations enjoy learning via technology, the human element will always be fundamental to an adequate, complete, and safe teaching experience — meaning the human element will always be paramount to an adequate, complete and safe aircraft."

"At Qvolv, we believe that the future of MRO training is not technology versus the human," concluded Sinha. "Rather, the future of MRO training is technology and the human." AVM

Shown in this image is a technician viewing a digital twin using Qvolv's MR headset. Qvolv image.

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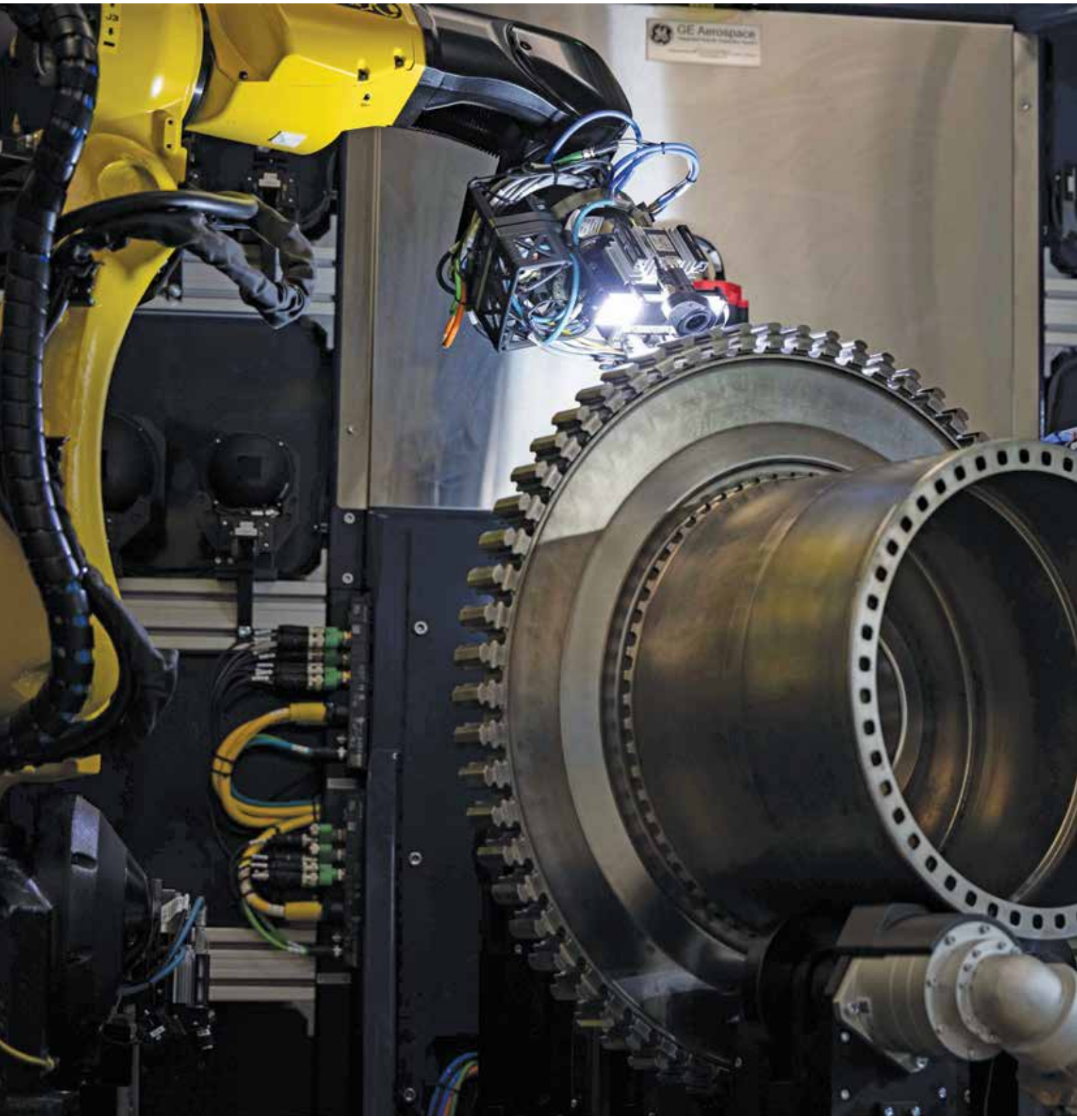

All About Aircraft Smart Tools

Embedded intelligence is smartly revolutionizing aviation maintenance tools

By Mark Robins

Standing in a universal workstation, two articulated industrial robots outfitted with white light optical scanners move closely over the entire surface of the high-precision part — in this case, a turbine disk for a GE90 engine. Like two ballroom dancers, the robots' movements are carefully choreographed by human operators and use AI to capture and analyze data with optimal accuracy, speed, and consistency, simultaneously creating a digital record of each part's condition. GE Aerospace image.

Aviation tools — the guardians of the sky — are fundamental to maintaining the high safety standards and operational efficiency demanded by the aviation industry. It's advanced technology integration that's been the driving force behind the innovation and evolution of these aviation tools. The emergence of smart tools powered by Internet of Things (IoT), artificial intelligence (AI) and automation is at the forefront of this. Smart tools open up new opportunities for data-driven decision-making and optimization in aircraft maintenance enhancing efficiency, productivity and overall performance.

Work Smarter, Not Harder

Smart tools combine traditional functions with sensors, processors and connectivity to automate data collection. Smart tools give greater control over data and reduce mistakes by taking human error largely out of the equation. Data entered by hand increases the risk of mistakes, especially when inputting long identification codes.

Gathering massive amounts of data that can be used for quality control and quality assurance, smart tools can communicate this data to other systems, such as a mobile app or software, where team members can access it. This data can be recorded in real time, then processed using advanced algorithms and analytics tools, which can identify patterns, trends and insights. By sending data directly to a software program, physical manuals and logs can be eliminated. The integration and connectivity of multiple devices and systems enable seamless communication, which significantly improves overall efficiency.

With traditional tools, users may not know when they need maintenance, leading to them breaking down unexpectedly. This breakdown often causes downtime, as a replacement tool needs to be found and tool repair needs to be scheduled. Smart tools reduce downtime by keeping track of when they need maintenance and providing alerts. Remaining tool life can be predicted based on machine signals correlated with wear. Repairs can be scheduled more efficiently so they don't affect downtime and productivity.

Smart tools can warn users if they're using them improperly, thus preventing mistakes. Their accuracy facilitates better quality results, leading to greater client and customer satisfaction. Smart tools can identify required maintenance tasks and verify a tool is needed for a particular job.

A Growing Market

According to a research report titled, "Smart Tools Market" (2025 - 2035) by the research firm Future Market Insights, the global smart tools market is projected to grow from USD 1.29 billion in 2025 to approximately USD 2.18 billion by 2035, marking an absolute increase of USD 890 million over the decade. This growth reflects a total expansion of 68.9%, with the market forecast to advance at a compound annual growth rate (CAGR) of 5.4% during the 2025 to 2035 period. The total market size is expected to grow by nearly 1.7 times its current size by the end of the forecast window, supported by the integration of sensor-based diagnostics, predictive analytics and IoT connectivity.

The report goes on to say that growth in the smart tools

Smart inspection tools such as digital dent-mapping systems allow technicians to quickly measure damage on complex surfaces like wing leading edges, delivering accurate results through intuitive, easy-to-use workflows. 8tree image.

market is being supported by the convergence of Industry 4.0 deployment, demand for operator safety and the rising importance of traceable maintenance operations. Labor shortages in skilled trades are also encouraging adoption of programmable tools that reduce operator error and simplify complex procedures.

Smartly Reducing Downtime

Smart inspection tools reduce downtime by shortening the time required to inspect, document and communicate findings. Aishah Yahya, marketing coordinator at 8tree, Rancho Cucamonga, California, says traditional dent-mapping or fastener-checking methods often involve multiple manual steps, repeated measurements, and handwritten or separately entered documentation, all of which slow the workflow and introduce variability.

"Digital tools replace those steps with automated measurement, instant visualization and standardized outputs," Yahya explains. "For example, dentCHECK allows technicians to capture dent measurements in seconds and immediately generate digital, SRM-compliant reports that can be shared with engineering teams for rapid assessment. Industry case studies have shown that digital dent-mapping tools can dramatically reduce inspection time. For example, data collected during Aerospace Maintenance Council (AMC) maintenance competitions demonstrated that technicians using dentCHECK completed dent-mapping tasks up to 90% faster than with traditional manual measurement methods. In addition, studies have shown that dentCHECK can reduce false-positive detections by up to 32%, helping maintenance teams avoid unnecessary repairs and the associated downtime. Similarly, fastCHECK helps operators evaluate large numbers of fasteners in a single click, delivering immediate go/no-go feedback directly on the surface and reducing the time spent on repetitive, manual checks."

Another area where smart tools have seen significant advancements in recent years are digital non-destructive inspection tools that help aviation teams work faster, more consistently and with greater traceability. Yahya cites common examples of this as digital borescopes for internal visual inspections, ultrasonic and eddy-current equipment for subsurface defect detection and optical scanning systems for surface damage assessment.

"These technologies reduce subjectivity and help replace manual methods that can vary depending on the technician's skill and interpretation," Yahya says. "Two examples from 8tree that are relevant to this trend are dentCHECK and fastCHECK. dentCHECK is an augmented reality (AR)-enabled handheld 3D inspection tool used to measure dents and other surface defects on aircraft surfaces and generate instant, SRM-compliant digital reports. fastCHECK is an all-in-one fastener-flushness measurement solution that enables operators to inspect 100 fasteners or more in a single click, providing instant go/no-go results for quality control in aircraft assembly and maintenance environments. Together, these tools support faster and more standardized airframe inspection workflows."

Technology in the Tool

According to the Smart Tools Market Research Report, other smart tools aiding aviation maintenance include drills and drivers, saws, sanders and grinders, and measuring tools. Smart measuring tools process surroundings with vision algorithms and can retrieve acceptable measurement values from a database. Digital calipers allow users to determine the exact size of small objects. They display measurements on a screen rather than having the user look at the ruler. Electric torque wrenches can be programmed to properly tighten nuts and bolts at the best number of turns. Smart drills typically come with a touchscreen and sensors to help guide users as they drill holes and sense the angle the user is holding it at. Many can update cutting conditions at each material layer and even monitor the drilling depth. Smart screwdrivers use tightening configurations to improve a screwdriver's performance and reduce its torque reaction. Ingersoll Rand's IQi Series, transducerized low-torque electric screwdriver uses real-time torque feedback and advanced error-proofing. The IQi Series measures actual torque applied, ensuring every fastener is secured correctly.

Digital inclinometers can use electronic sensors to measure the angle of an object relative to the earth's surface. Unlike traditional analog inclinometers, which rely on mechanical components and gravity, digital versions offer enhanced accuracy, ease of use and additional functionalities. Operating with up to 0.1° of repeatable accuracy, they provide digital readouts of angular reading instantly with no interpretation or guesswork needed. They can measure and display any angle through 360° and readings can be relative to any angle. These qualities make them ideal for many aviation maintenance applications.

Image Recognition and Classification

AI-enabled smart tools for image recognition and classification in avionics repair, testing and inspection are becoming an important part of modern aviation maintenance, repair and overhaul (MRO). Tom Heiser, CEO of Orama.AOI, Lilburn, Georgia, says they help technicians inspect aircraft surfaces, avionics hardware, and structural components more efficiently and consistently.

AI inspection tools are called smart because they have capabilities beyond simple imaging systems. AI-enabled avionics inspection tools combine computer vision, machine

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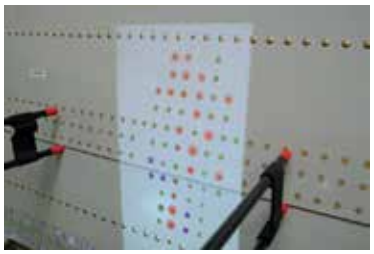
learning and automated diagnostics to detect and classify defects on aircraft surfaces and electronic systems. They are considered smart because they learn from data, recognize complex patterns, provide automated decisions and continuously improve over time, making aircraft maintenance safer, faster and more reliable.

"AI vision systems analyze images of aircraft surfaces (fuselage, wings, radomes, avionics housings) to detect defects such as cracks, corrosion, dents, paint degradation and lightning strike damage," Heiser adds. "Often these systems are mounted on handheld inspection devices, drones, robotic crawlers and hangar scanning systems. Image analysis can detect hidden defects in composite materials, internal delamination and structural fatigue. This supports predictive maintenance, reducing unexpected failures."

Orama.AOI's recent initiative in drone-based aircraft inspection used in aircraft MRO significantly reduces both inspection time and operational cost compared with traditional manual inspections. The main savings come from automation, faster data collection and reduced labor requirements. Traditional aircraft inspection requires technicians to move scaffolding or lifts, visually inspect large surfaces manually and take photos and document findings. "This process can take several hours or even days," Heiser says. "However, smart drone systems fly around the aircraft automatically, capture thousands of high-resolution images, and can scan the entire fuselage, wings and tail. This typically reduces inspection from 6-to-12 manual hours, to 1-to-2 drone inspection hours. This dramatically reduces aircraft ground time."

The IQi Series Transducerized Screwdriver is an intelligent fastening solution that combines advanced technology, precision engineering and intuitive design providing real-time torque feedback and advanced error-proofing. Ingersoll Rand image.



An augmented reality-enabled fastener inspection tool highlights fastener flushness conditions in real time, instantly identifying which fasteners are within tolerance and which require attention. 8tree image.

The future of smart power tool use in aircraft maintenance looks promising. As technology continues to evolve, smart power tools will become even more sophisticated, offering advanced features. AVM

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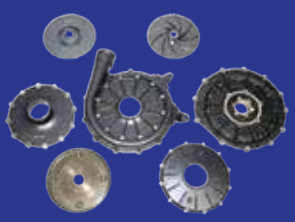

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- Jointly developing and deploying an AI-assisted commercial engine borescope solution with Waygate Technologies to GE Aerospace's MRO network to be used for High Pressure Compressor (HPC) inspections for its GEnx and CFM LEAP engines. The integration of cutting-edge AI techniques has been shown to reduce overall inspection times while helping to increase detection rates by ~34%, while reducing false alerts by >13% vs. previous Gas Power-assist model version 4.1. Additional details can be found in the following press release here.

Along with deploying advanced tools to reduce inspection times, we're integrating AI to bolster our predictive maintenance capabilities to identify issues sooner and tailor maintenance work scopes to further prevent instances of unplanned downtime in our MRO shops. For example, we have deployed an AI-Material Assistant that accurately assesses workscope needs and replacement components required for CFM LEAP engines weeks ahead of their induction date for service to avoid unnecessary delays. As a result, our Celma and Malaysia facilities are seeing a 5- to 7-day turnaround time improvement with the service of these engines. Overall, we continue to improve our predictive maintenance capabilities to gain earlier visibility to engine service needs that allow for more optimal maintenance planning with our airline customers to further minimize unplanned downtime.

An inspection engineer performs an inspection using Waygate Technologies' Mentor Visual iQ+ borescope. Waygate Technologies and GE Aerospace have jointly developed a new AI-enhanced version that will be made available to customers through an upcoming software update for the Mentor Visual iQ+ video borescope later this year. GE Aerospace image.

Information provided by Nicole Jenkins, chief MRO engineer, GE Aerospace, Evendale, Ohio.

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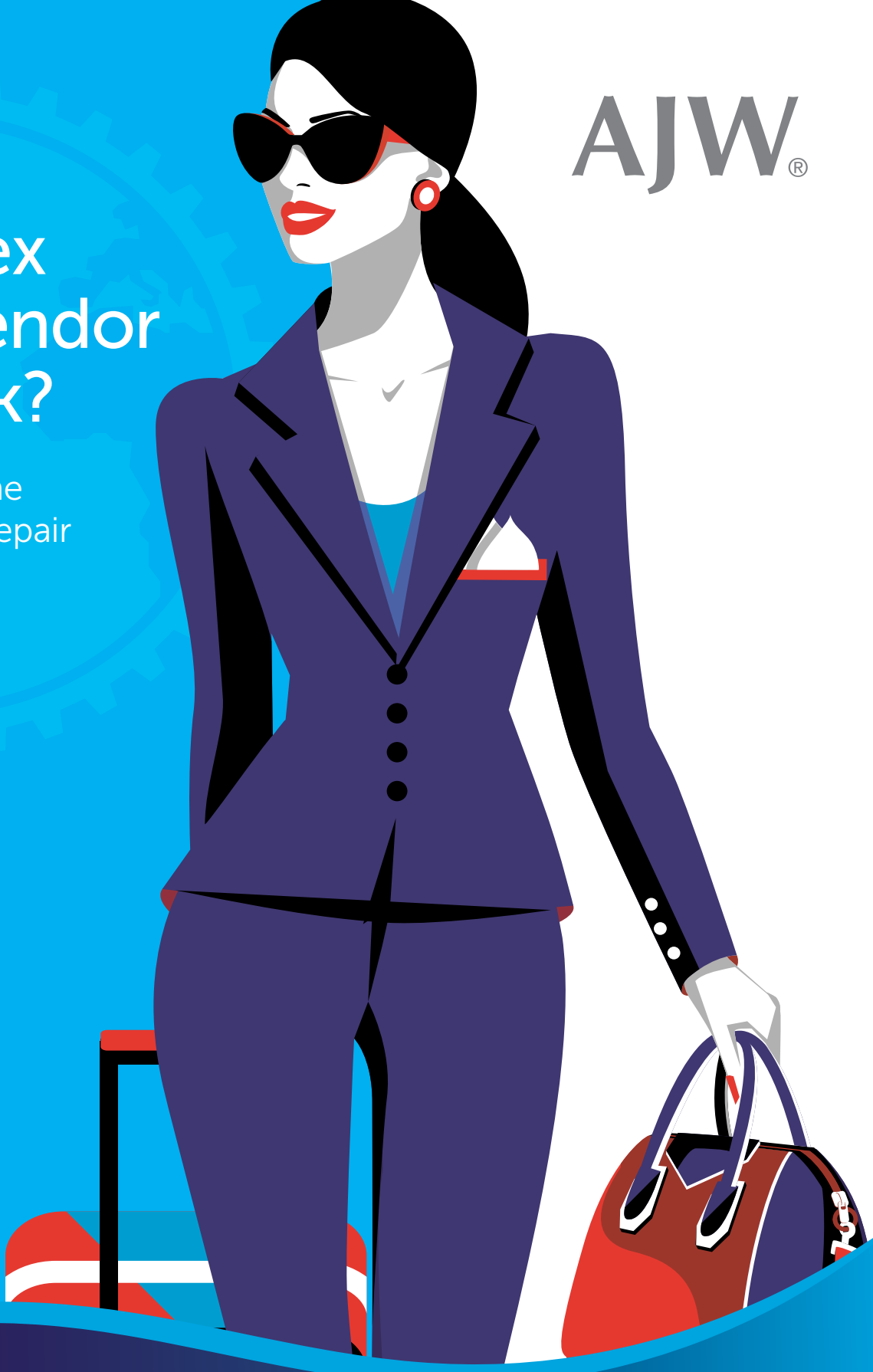

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Heat Exchanger Management: A Better Model for Commercial Operators

By Paul Maness, General Manager, TAT Technologies

As fleets age and MRO demand reaches record levels, thermal component availability is becoming a strategic planning discipline — not a procurement afterthought. Here is a practical framework for getting ahead of it.

The global commercial fleet is aging. According to Oliver Wyman's 2025 Global Fleet and MRO Market Forecast, the average age of commercial aircraft in service has risen to 13.4 years — the highest it has been in decades — driven by production shortfalls at both major airframe manufacturers and sustained passenger demand that is keeping older aircraft flying longer than originally planned.

Within that environment, heat exchangers occupy a specific and frequently underestimated position. They are among the most frequently removed components in commercial line and base maintenance. They are platform-specific — the unit that services a 737 does not transfer to an A320 or a Q-400. They require a level of manufacturing expertise that most component shops cannot perform in-house. And when a serviceable unit is not available at the moment it is needed, the operational consequences arrive quickly and compound through the maintenance schedule.

For operators managing thermal components reactively — sourcing units as demand arises — the current environment is creating pressure that a transactional approach was not designed to absorb. For operators managing them proactively — with rotable pools and supplier relationships — the complexity of maintaining that model is growing. In both cases, the question worth asking is the same: is the current approach optimized for what the next five years of maintenance demand is going to require?

Before arriving at a strategy, it is worth identifying which operational situation actually applies. Not every operator faces the same heat exchanger challenge, and a solution that addresses the wrong problem delivers no value.

The first question applies to operators with planned heavy maintenance events: when your aircraft enter scheduled base maintenance, do you have serviceable heat exchanger units staged and ready to install? The time between when units are removed and when they return from overhaul is a predictable gap. Operators who have not pre-positioned exchange units against their maintenance schedule absorb that gap as schedule risk every cycle.

A closely related but distinct question applies to what happens during that same maintenance event. An aircraft enters the hangar on a planned schedule. Inspection reveals heat exchanger units that are not serviceable — a finding that is not uncommon on aging airframes. If that happens, does your operation have the inventory to keep the aircraft on its return-to-service schedule, or does it wait? The cost of an aircraft sitting on the hangar floor past its planned release date does not appear on a parts invoice. It appears in utilization data and schedule performance at the end of the

Heat exchangers are among the most frequently removed components in commercial line and base maintenance and require a level of manufacturing expertise that most component shops cannot perform in-house. TAT image.

Operators who have not pre-positioned exchange units against their maintenance schedule absorb that gap as schedule risk every cycle. TAT image.

quarter.

For operators who do maintain rotable pools, the questions shift in character: Are the units in your pool in serviceable condition when you need them? Are they positioned where your maintenance events actually occur? And is the overhead of managing that pool — tracking serviceable status, managing core returns, coordinating overhaul cycles across multiple platforms — consuming resources your team would rather direct elsewhere?

These questions do not carry a right or wrong answer. They are a diagnostic framework. The operators who have worked through them honestly are the ones who have moved from reactive heat exchanger management to a planned program — and who consistently find that the shift changed their maintenance cost structure in ways that were not visible when they were managing transactions one unit at a time.

Why Heat Exchangers Deserve a Dedicated Strategy

Heat exchangers are not a uniform commodity. Each platform uses specific configurations that are not interchangeable across types. The core of a heat exchanger — the internal structure that transfers thermal energy between fluid streams — must be manufactured to precise tolerances and assembled through a process, vacuum brazing, that requires specialized capital equipment and process certification. A shop that does not manufacture its own cores is dependent on external supply for the most lead-time-sensitive element of the repair cycle.

This manufacturing dependency is the reason heat exchanger turnaround times vary so significantly across the market. Shops that control their own core production can move a unit from induction to test without waiting on a supplier network. Shops that do not control it cannot. For operators, that difference — measured in days, not hours — compounds across every removal event in a maintenance year and has a direct effect on how much rotable inventory is required to achieve a given level of availability.

For operators, the supply chain architecture becomes relevant when there are handoff points between the initial repair shop and the recore capability. A heat exchanger that requires recoring but enters a shop without that capability must move to a second facility for that work before it can return to service. That handoff — receiving, inspection, manufacturing, and return logistics between two facilities — adds time to the overall cycle that is not inherent to the repair itself but is inherent to the structure of the relationship. Operators who contract directly with vertically integrated manufacturers eliminate that handoff. Operators who contract with intermediate shops accept it as part of the supply chain model. Neither approach is categorically right or wrong — but the lead time implications are structurally different, and operators managing tight maintenance schedules benefit from understanding which model they are working within.

The implication is that the choice of heat exchanger MRO partner is not primarily a price decision. It is a supply chain architecture decision. The right partner reduces both the inventory requirement and the schedule risk simultaneously. The wrong partner, regardless of unit price, increases both.

A Better Model: Direct Partnerships with Manufacturing Capability

The operational situations described above share a common requirement: availability when it matters. The question is not whether an MRO provider can repair the unit — most credible shops can. The question is whether they can deliver the unit, in serviceable condition, at the moment the operator's maintenance schedule demands it.

That capability is not primarily a function of inventory depth. It is a function of manufacturing agility. An MRO partner that manufactures its own cores in-house can build and stage units ahead of scheduled maintenance events when agreements are structured that way. For operators with planned heavy maintenance, this means serviceable units can be pre-positioned before the aircraft enters the hangar — the planned return-to-service date is not dependent on a repair cycle that begins the day the aircraft arrives.

For unscheduled events — when inspection reveals units that are not serviceable — the same manufacturing capability enables faster response. A vertically integrated shop can prioritize that repair without waiting on a supplier for the core, which means turnaround measured in days rather than weeks. For operators, that difference is the margin between a maintenance event that stays on schedule and one that does not.

The distinction worth understanding is this: transactional MRO relationships are structured around units already in the system — cores already received, repairs already in process. Direct partnerships with manufacturing capability are structured around availability planning — units built ahead of demand, turnaround

Vertically integrated shops can prioritize repairs without waiting on a supplier for the core, which means turnaround measured in days rather than weeks. For operators, that difference is the margin between a maintenance event that stays on schedule and one that does not. TAT image.

TAT Technologies designs and produces its own heat exchanger cores, fin forming, certified welding and precision machining within their facility. TAT says that vertical integration insulates them from the material shortages and supplier backlogs currently extending industry-wide lead times. TAT image.

optimized for the operator's schedule, and exchange arrangements negotiated as part of the agreement rather than activated as an emergency accommodation.

What TAT Technologies Brings to the Partnership

TAT Technologies brings more than 75 years of thermal management heritage to the aerospace industry. That history is not incidental — it is the foundation of the engineering depth and manufacturing capability that makes flexible exchange arrangements operationally credible rather than commercially aspirational.

The foundation of that capability is in-house manufacturing. TAT Technologies designs and produces its own heat exchanger cores — fin forming, certified welding, precision machining — within our facility. That vertical integration insulates TAT from the material shortages and supplier backlogs currently extending industry-wide lead times. While shops dependent on external core suppliers wait for production capacity or material availability, TAT controls its own manufacturing process from start to finish. That supply chain control is the operational foundation of turnaround reliability — not just capability, but certainty. It is the reason TAT can structure agreements with exchange provisions, build units ahead of scheduled maintenance, and respond to unscheduled demand when other shops are waiting on their supply networks.

TAT Technologies currently has exchange capability on select platforms and is actively investing to expand that coverage across the Boeing 737 family and 777, De Havilland Q-400, and Airbus A320 family — platforms that represent the core of mid-size and larger commercial operator fleets. The expansion is intentional and customer-driven, built around actual removal frequencies and maintenance schedules rather than around what is convenient to stock.

TAT Technologies holds FAA, EASA, and CAAC certification — meaning that regardless of an operator's regulatory environment or the international routes their fleet flies, the documentation that accompanies every unit from our facility meets the applicable airworthiness standard and provides complete chain-of-custody traceability from repair through return to service.

The agreements we structure with operators are direct partnerships — availability planning built into the contract before removal events occur, not reactive sourcing after they happen. Operators who have structured relationships this way report that the most significant change is not in cost or turnaround time individually, but in the predictability of both across a full maintenance year. Planning against known capability changes the heat exchanger conversation at the program level, not just the transaction level.

Planning for What the Next Decade Requires

The dynamics driving current MRO demand are not short-cycle phenomena. Oliver Wyman projects the MRO market to grow steadily through 2035, with component maintenance representing a meaningful and expanding share of total industry spend. Heat exchangers, as a high-frequency removal category tied directly to platform age and utilization, will track that growth or exceed it.

The operators best positioned to manage that environment are those who have already moved heat exchanger availability from a transactional function to a planned program — with direct relationships to manufacturing partners who can build ahead of demand, stage units for scheduled maintenance, and respond to unscheduled events without dependency on external supplier networks.

The shift from reactive to planned is not a large operational change. It begins with the questions outlined here. It continues with a direct conversation about what an operator's platform profile, maintenance schedule, and availability requirements actually look like — and what a partnership structured around manufacturing capability and exchange flexibility would mean for their maintenance cost structure and schedule performance.

That conversation is one TAT Technologies is built to have.

ABOUT THE AUTHOR

Paul Maness is the General Manager of TAT Technologies, a global leader in thermal management solutions for the aerospace and defense industries with more than 75 years of operational heritage. TAT Technologies operates one of the largest heat exchanger MRO facilities in America, with in-house core manufacturing, FAA, EASA, and CAAC certification, and growing exchange capability across Boeing, De Havilland, and Airbus platforms. He can be reached at paulm@tat-technologies.com or visited at Booth 5114 during MRO Americas, April 21–23, 2026, in Orlando, Florida.

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West Star Aviation announced a major expansion at its Chattanooga Airport campus, growing the site to approximately 400,000 square feet by February 2027. The project includes a new 40,000-square-foot Hangar 26 with 15,000 square feet of support space, along with a 30,000-square-foot expansion to Hangar 27 to enhance service, accessories, composites, and sheet metal operations. Designed to strengthen safety, workflow, and turnaround times, the development reinforces full-service capabilities under one roof. The expansion is expected to create up to 200 new jobs, underscoring West Star's long-term commitment to customers, workforce development, and the Chattanooga region.

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Knowledge Management

By Marijan Jozic

In the beginning, I didn't pay much attention to knowledge management after Covid, but now we are already four-to-five years into the process, and it has become a serious issue. Let me explain.

During Covid, many MROs (maintenance, repair and overhaul organizations) decided to retire older and experienced engineers/mechanics. They knew this would create problems for themselves. However, at a certain moment, due to financial pressure, they simply retired experienced personnel and decided to deal with the potential consequences later, after the Covid situation improved.

Soon after the Covid crisis, I began to hear rumors that some companies were complaining that the new generation of engineers was not operating efficiently. They simply did not know what to do. They did not know the "tricks" that older and experienced engineers had applied for years, which allowed MROs to operate smoothly. Normally, such a situation could be considered temporary, and the

new generation would eventually catch up and perform better. Unfortunately, even now — five years later — the situation has not improved significantly. The main reason is that there were no good mentors to pass on the knowledge. Some MROs are now even hiring retired engineers to help bring new engineers back on track.

Let me explain how this works in the real world and why I came up with the theory of the "three knows."

The first know is know-how. Know-how can be learned to a certain extent. Most of this type of knowledge can be acquired through self-study of the CMM, AMM and SRM, online courses and numerous books and drawings. Generally speaking, an engineer will be able to maintain and even modify an aircraft and keep it flying. Know-how is transferred from engineer to engineer, and all details can be found in educational resources. This type of knowledge is relatively easy to acquire, and most new engineers can master it.

More important is the second know: know-why. Know-why is usually stored only in people's heads. Only those who know-why also know where this information is documented or recorded. The ability to find it is crucial. Let me give you an example:

Many ARINC documents mention the 200 ms rule for power interruption duration. But why 200 ms? Why not 300 ms or 100 ms? A power supply that can maintain voltage for 300 ms after a power interruption can be designed, just as one can be designed to maintain voltage for only 100 ms. So why was 200 ms chosen? It would be interesting to know-why. Try to find out for yourself. It is not easy.

If you are designing a new aircraft, system or LRU, it is crucial to understand why regulations and requirements are defined the way they are. Even when modifying an aircraft (such as the 737 MAX or A320neo), it is essential to know-why certain design decisions were made. Over the lifetime of aircraft like the 737 and A320, there will be upgrades where design engineers will scratch their heads and wonder why things were done in a particular way. Knowing the reason can be critically important, but the answer may be hidden in the minds of a select few. If they never take the time to write it down and share this knowledge, it will be lost forever. Every MRO has such "secrets" hidden in the heads of experienced engineers.

If you are designing a new aircraft, system or LRU, it is crucial to understand why regulations and requirements are defined the way they are.

The third know is know-where. Know-where means exactly that: where can the information be found? Know-where is of paramount importance. When you forget the past, you are doomed to repeat it. This is also the point at which we must discuss how data is stored. If you cannot find where something is documented, you are doomed to redesign it — to reinvent something that may have been invented many years ago.

Today, essential information is often stored in ways that allow keyword searches using computers, which is a huge improvement over years past. However, we still rely on a limited number of people who possess vital knowledge and also know where the information is stored. When they are gone — due to retirement, winning the lottery, Covid RIFs or other reasons — no one will know-where their documents are. Without that, it may be impossible to know-why something is done the way it is done.

I am convinced that know-how, know-why, and know-where can be preserved using the internet and intranets. Unfortunately, during the coronavirus pandemic, many companies pushed people out to reduce costs. Three years later — or even sooner —those people and their knowledge were sorely missed. We are still experiencing the consequences, even five years on. A culture of transferring know-how, know-why and know-where should be established in every industry to prevent the loss of institutional knowledge and the high cost of re-creating it.

The value of the individual and the knowledge embedded within that individual is generally underestimated, and capture measures are often taken too late — or not at all. When someone leaves an organization for any reason, replacing them without losing critical knowledge can be extremely difficult. Therefore, knowledge transfer becomes essential. The level of risk depends on how each company maintains and stores its critical knowledge. Know-how, often referred to as tribal knowledge, resides in people's heads and must be preserved to ensure continuity. Equally important is knowing where the information is stored and how it can be accessed.

There are two main aspects to consider. The first concerns maintaining the level of knowledge and skills individuals need to perform their tasks as technology evolves. One example is line maintenance, where the increasing use of built-in tests, diagnostics and operational software requires mechanics to be fully proficient in these technologies. The second aspect of people obsolescence concerns the transfer of knowledge from one generation to the next. In many countries, industries, and companies, the workforce is aging. Critical knowledge that makes an organization successful often resides with older workers, and too often there is no structured method for transferring this knowledge to younger employees. When experienced workers retire, the knowledge walks out the door with them.

The loss of this knowledge can cause significant disruption when a task must be performed, and no one knows how to do it. To effectively address "people obsolescence," knowledge must be managed. Knowledge Management is the deliberate and systematic management of vital knowledge, along with its associated processes of creation, organization, dissemination, and exploitation. A key aspect of any knowledge management program must be the acquisition, preservation and distribution of knowledge residing within employees.

Now, back to the beginning of the story. We are currently seeing some well-intentioned managers hiring MScs and PhDs, hoping they will solve these problems. While these individuals can deliver excellent presentations and lead meetings, they often lack the specialized technical knowledge required to truly understand the problems. Worse still, nobody can even provide a correct description of the problem if know-how, know-why, and know-where have already been lost.

It will take time for MROs to operate as efficiently and cost-effectively as they did before Covid. In many cases, they will have to start from scratch. What can I say? If you do not preserve knowledge — which can be costly — you are doomed to start all over again, which is even more costly. AVM

By Jason Dickstein

Examining 8130-3 Tags

People often joke that the paperwork is more important than the part. While this is obvious hyperbole, the importance of documentation as evidence of airworthiness has steadily increased over the past 30 years. A corollary to the important role that documentation plays, today, is the importance of understanding what is — and what is not — acceptable in the documentation. A key element of this is understanding the FAA's Form 8130-3.

One of the issues we've seen is 8130-3 tags that are not appropriate to the underlying component. One of the most obvious examples of this is Airbus parts with FAA Form 8130-3 tags.

Left Side Signature

Generally speaking, the FAA only permits 8130-3 tags to be issued as airworthiness approvals for new parts that were produced under an FAA production approval. A Boeing aircraft, for example, is typically produced under the Boeing's FAA-issued production certificate, and the replacement parts that Boeing produces for that same aircraft are also subject to the FAA production approval. Because the components are produced under an FAA production approval, the production approval holder is authorized to issue 8130-3 tags for those new components.

When the production approval holder issues an 8130-3 tag for a new replacement part, it is typically signing the 8130-3 tag on the left side. This signifies that the part is in an airworthy condition at the time of the signature. The production approval holder is typically able to rely on its own production quality assurance system to ensure this current airworthy condition at the time of release from the manufacturer's production quality assurance system.

Airbus typically produces its aircraft and replacement parts under its European production organization authorization (POA). This is different from the FAA production certificate. Airbus is authorized to issue EASA Form 1 (the European form), but it is not authorized to issue 8130-3 tags for new parts.

We often hear about requests for 8130-3 tags on Airbus parts (or other foreign-produced parts) that are directed to FAA designees. FAA designees who receive this sort of request should first inquire whether there is any FAA production approval associated with the component in question.

- If the answer is "yes," then the FAA-designee should rely on the FAA production approval as the basis for considering whether to issue an 8130-3 tag to document the airworthiness of the component (more on this, later);
- If the answer is "no," then the component is likely ineligible for an airworthiness approval that is issued on an 8130-3 tag.

Is there ever a circumstance where a part for an Airbus aircraft could be accompanied by an 8130-3 tag? Yes: if the part was produced under a U.S. FAA production approval. Two main examples of this would be parts produced under an FAA PMA and parts produced under an FAA TSOA. Both FAA-PMA and FAA-TSOA are FAA production approvals.

The first of these categories — parts produced under an FAA PMA — could be replacement parts produced for installation on an Airbus aircraft. The PMA company might be fully independent of Airbus, or it might be a supplier to Airbus that sought PMA in order to be able to support the aftermarket. Either way, to the extent the PMA parts are produced under FAA production approval, they are eligible for an 8130-3 tag issued by the production approval holder, as well as a subsequent tag issued by an FAA employee or designee who is able to confirm the conformity to approved design and current airworthiness of the article.

Similarly, a component produced under an FAA TSOA could also be intended for installation on an Airbus aircraft. Such a part would be eligible for an 8130-3 airworthiness approval because it was produced under an FAA production approval, and conformed to the parameters of the approved design.

In each case — FAA PMA or FAA TSOA — an 8130-3 might be issued by either the manufacturer (under 14 CFR 21.137(o)) or by an FAA employee or designee who confirms that the component was produced under an FAA production approval, and that the component has not suffered damage nor degradation that would cause it to no longer meet the design parameters.

An Example

Imagine that a manufacturer in the United States

("Partsco") produces widgets for Airbus. The manufacturer produces the widgets solely for Airbus, for installation on their aircraft, and produces them for no other customer. These parts are produced (solely) under the Airbus POA. Such parts are not eligible for an 8130-3 but Airbus may be able to issue an EASA Form 1 (the European form) for the parts when they are released from the Airbus production quality assurance system.

Now imagine that Partsco decides to obtain parts manufacturer approval, or "FAA-PMA," from the FAA. They can do it by submitting their own data to demonstrate compliance to the FAA regulations, or they can apply under PMA assist letter from Airbus that allows them to obtain a PMA by licensing agreement. It is not uncommon for a component manufacturer to design an article that is installed in an aircraft or engine, transfer the intellectual property to the type certificate holder for the aircraft or engine, and then as part of the supply contract, the type certificate holder licenses the recently transferred intellectual property back to the supplier (Partsco). The data will have been approved in the context of the type certificate. When that approved data is licensed to Partsco, then Partsco is able to identify it as already-approved data and take a short-cut to FAA-PMA by applying under a licensing agreement from the type certificate holder. Once the FAA issues the FAA-PMA to Partsco, then Partsco is eligible to issue 8130-3 tags for new parts that are released from the production quality assurance system. While it would be legal for the Partsco 8130-3 tag to remain on the part while it is shipped to a final destination, Airbus has no independent power to issue an 8130-3 tag for that same component (but, again, Airbus may be able to issue an EASA Form 1 for the component when it is released from Airbus' own European production organization authorization (POA) system).

Right Side Signature

Don't get confused by the FAA form 8130-3 tag when it is used as an approval for return to service (right side signature). The signature rights for this usage are derived from the maintenance regulations in 14 C.F.R. Part 43.

An FAA-approved repair station could inspect or overhaul an Airbus component and then document the work with an FAA Form 8130-3. In this situation the 8130-3 tag is used as an approval for return to service. (You can distinguish this usage visually because the form is signed on the right side, and not on the left side.) AVM

It's All There

By Brett Levanto, Vice President of Operations, Aeronautical Repair Station Association

In March, ARSA hosted its 2026 Annual Conference. The association proudly claims the four days of regulatory content and legislative advocacy paired with collegial engagement among and between the industry's most engaged quality professionals to be the aerospace maintenance community's premier substantive event.

The event provides a thorough overview of the current aerospace technical needs. For anyone with interest in international aviation safety regulation, it's all there.

In his pre-Conference message to ARSA membership, association president John Riggs called the state of the association address regularly given during the end-of-week member meeting "perfunctory."

"Anyone applying critical thinking during the member breakfast will realize that the 'president's address' contains a recitation of the same topics and details covered during the previous three days of the Conference," Riggs said in the February edition of the members-only hotline newsletter. "Taking a step back, members should realize that those days of focused, useful discussion are a continuation of the daily work by ARSA's team reported in its communications."

Reviewing what happened on each of "those days" shows where the industry has been over the past year and where it is going.

Executive-to-Executive Briefings – March 17

The first and smallest day of the Conference brings in handpicked participants from sponsoring organizations for a series of high-level, closed-door meetings. The day's agenda takes focus away from the FAA to engage other areas impacting aerospace business. This year's "E2E" heavily centered on trade and supply chain issues. A briefing on tariff impacts (and refund options) and a visit from the office of the U.S. Trade Representative highlighted the day, with an economic briefing from ARSA partner Oliver Wyman Vector bringing home both business and workforce issues.

Legislative Day – March 18

What was once a day reserved for a golf tournament has become a staple of the annual event. Dozens of maintenance professionals catch up on key policy issues before putting a personal face on their industry's story before their members of Congress. The association's priorities are to fully invest in career development programs while addressing resonating problems from the legislator's prior reauthorizations of the FAA. The message to Capitol Hill is that 300,000 maintenance technicians need consistent resources and reliable oversight to continue supporting the world fleet.

Annual Repair Symposium – March 19

The "around the world" nature of ARSA's work was evident as civil aviation authorities from three continents took center stage. After general updates participants engaged in new maintenance organization mandates and the long-term bilateral interests of the FAA, the U.K. CAA, ANAC Brazil, and the European Union Aviation Safety Agency. Major issues like Safety Management Systems integration and the expansion of unnecessary drug and alcohol testing program requirements globally attracted considerable attention. There was also time for reports on rulemaking priorities like reciprocal acceptance and the elimination of the "current data burden" placed on repair stations. A wrap-up on career development returned focus to the needs of individuals required by the rules to perform maintenance.

Member Meeting and Breakouts – March 20

ARSA president Riggs handed the member meeting reins to the ARSA team. The recap session highlighted the association's service to the industry and actions to be taken by its members'. A pair of concluding breakout sessions covered the major SMS and D&A issues in a practical and direct manner; each provided a chance for instruction to participants as well as learning by ARSA's team (with agency personnel sitting in on the drug and alcohol session to gather information for continuing guidance development).

Overall, the 2026 Annual Conference showcased ARSA's leadership and its members engagement. Between the event's four days and the continual communications from the association's team — internal and external — there is no compliance or advocacy matter of interest to international maintenance providers not covered. No matter where you're looking for support, it really is all there.

Brett Levanto is vice president of operations of Obadal, Filler, MacLeod & Klein, P.L.C., managing firm and client communications in conjunction with regulatory and legislative policy initiatives. He provides strategic and logistical support for the Aeronautical Repair Station Association. AVM

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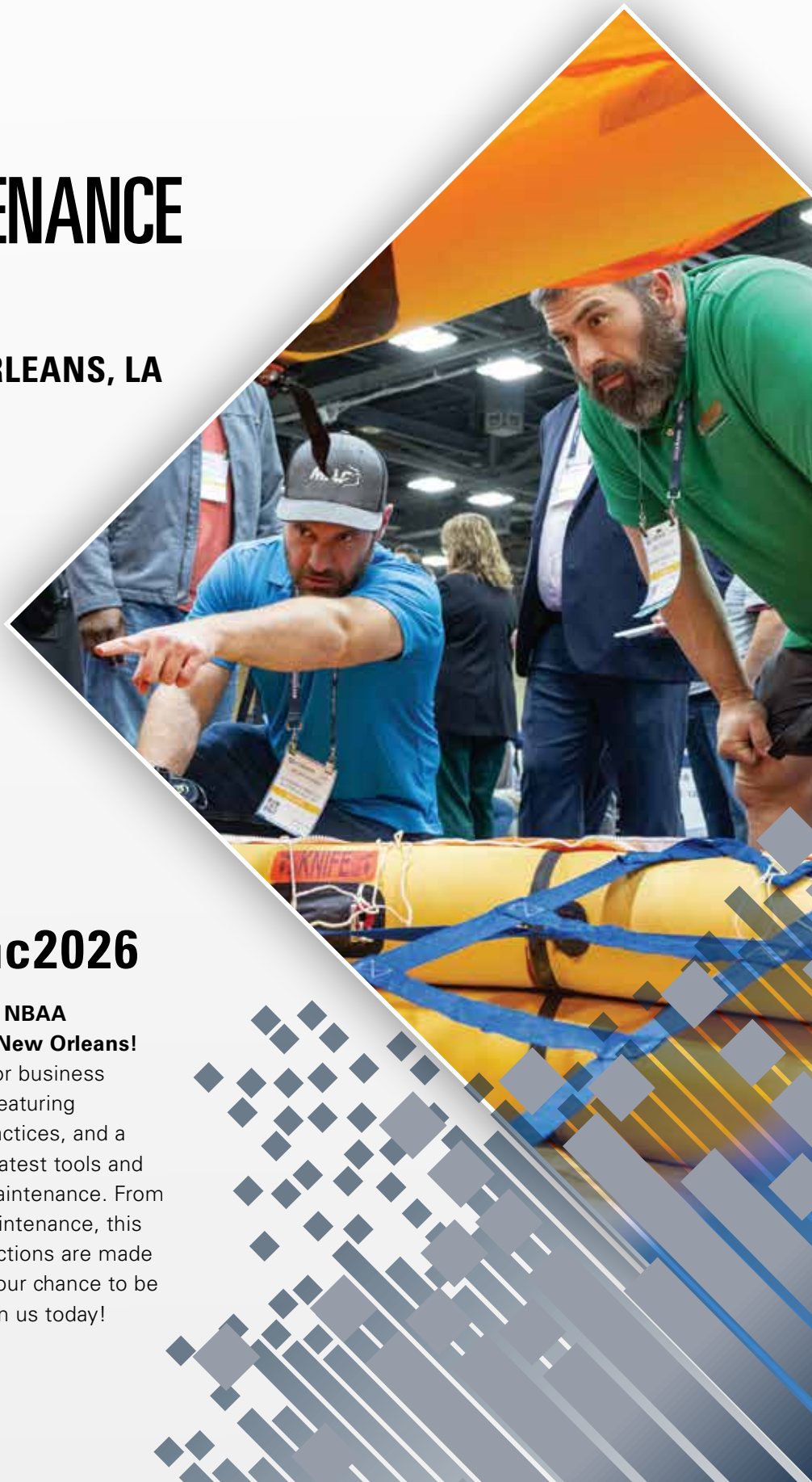
NBAA MAINTENANCE CONFERENCE

MAY 5-7, 2026 ◆ NEW ORLEANS, LA



LEARN MORE
nbaa.org/mc2026

Let the good times roll as the 2026 NBAA Maintenance Conference heads to New Orleans! This is the industry's premier event for business aviation maintenance professionals, featuring expert-led sessions, industry best practices, and a dynamic exhibit hall showcasing the latest tools and technologies shaping the future of maintenance. From aircraft technicians to directors of maintenance, this is where careers are elevated, connections are made and momentum is built. Don't miss your chance to be part of what's next. Make plans to join us today!

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