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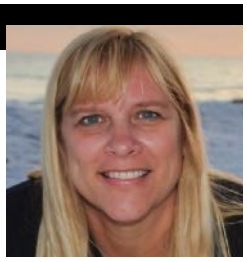

BY JOY FINNEGAN
EDITOR-IN-CHIEF

Supply chain issues continue to persist as a meaningful risk and cost driver in the aerospace industry. According to experts, shortages of raw materials and critical components including metals like titanium, specialized alloys, composites, high-temperature materials used in engine parts, landing gear and avionics, continue. OEM price escalations may also feed into parts pricing. Lead times for parts procurement have increased significantly, both for final parts and for subcomponents, according to IATA.

Shipping delays, export certifications, and even tariffs are amplifying disruptions. Because new aircraft deliveries have been impacted by these supply chain issues, airlines are keeping older aircraft in service longer. Older aircraft often have parts that are no longer produced, with regulatory or certification complexities which makes sourcing and repair more challenging.

Labor issues due to a dearth of experienced technicians in some areas and continued retirements may be adding pressure as well. Some reports say labor costs are rising and that wage inflation is adding cost pressure.

These supply chain issues are driving demand for alternative sourcing such as used serviceable materials (USM), PMA parts, digital tools, predictive maintenance and others as adaptive responses.

The Oliver Wyman 2025 supply chain risk and resilience survey, "Navigating Supply Chain Resilience Through An Uncertain Future" revealed a worrisome paradox. The report says organizations have maintained a strong focus on supply chain risk and resilience and that has helped. "Eighty percent of respondents now consider their supply chains to be very resilient," the report says. "Yet despite this confidence, only 4% plan to increase their resilience budgets, and more than a third expect to reduce them." This hardly seems wise.

Many in the industry believe that some of these supply constraints will continue for several years. Check out Ian Harbison's report on the supply chain situation that goes into more detail about the many complexities impacting it. That story starts on page 60.

Several of the feature stories in this issue of Aviation Maintenance take a look at ways to help alleviate some of those supply chain pressures. One of those is our cover story about predictive maintenance for engines. While predictive maintenance has been around for a long time, check out what experts like Karine Lavoie-Tremblay, director of commercial engines digital transformation at Pratt & Whitney, and Dr. Christian Keller who oversees the engine trend monitoring program at MTU Maintenance, say about taking predictive maintenance to the next level. That story begins on page 20.

Next, we take a look at the PMA parts market. The use of PMA parts continues to grow. Jason Dickstein, who heads up the Modification and Replacement Parts Association (MARPA) is seeing yet another trend in the PMA market. He says cooperation between the OEM type certificate holders and PMA companies to develop new PMAs is happening more than ever. "But now this OEM/PMA cooperation is becoming a little bit more public. Today, even engine OEMs are buying PMA parts to relieve their supply chain issues," Dickstein says. Read all about the state of the PMA parts market and how it can help with supply chain concerns in the story starting on page 32.

We take a moment to acknowledge a milestone for Barfield. The MRO and maker of ground support test equipment company is celebrating its 80th year in business — an impressive feat in aviation. We had the opportunity to speak with CEO Gilles Mercier about what this milestone means to the company, what he sees as the current challenges in our business and his outlook on the future. Check out his answers in our executive Q&A starting on page 46.

On page 48 Mario Pierobon delves into human factors. He reports that the aviation maintenance industry is at a juncture where traditional hands-on expertise meets ever-evolving digital technology. Today mechanics on the shop floor must navigate a complex maze of physical dexterity, data interpretation, experience-based intuition and algorithm-generated recommendations. Is human factors training keeping pace with the digitization of the hangar? Experts in human factors like Michael Parrish, president of Elliott Aviation and Jonathan Huff, senior solutions engineer at TeamViewer, give their takes on where we are and where we can improve our human factors focus as technology in maintenance processes increases.

Composite materials have become indispensable in the aerospace world and the ability to repair rather than replace them is a vital skill for the industry. As Mark Robins reports, composite repair sophistication has advanced significantly by using artificial intelligence, machine learning and advanced software tools. These technologies are transforming composite repair from a highly manual craft into a more data-driven, precise and predictive discipline. Learn more starting on page 54.

No matter how high tech the industry gets, nothing gets done in MRO without tools. So, we also take a look at some classic tools that can help any operation be safer, more efficient and more accurate. Check those tools out starting on page 64.

As always, we have our columns, and I want to encourage you to check out the three in this issue. First, Chris Brumitt, managing director at Maine Pointe, shares his thoughts on the demand for special aircraft for intelligence, surveillance and reconnaissance (ISR), electronic warfare (EW), medevac, tactical transport and maritime patrol. He urges new thinking on the development of this type of aircraft program. Check out his call to action on page 70. Avionics expert Marijan Jozic is back this issue with his perspectives on the missing link in accident investigations — cockpit video recorders. See his column on page 72. And finally, ARSA's inimitable Sarah MacLeod's piece asks a seemingly simple question. But if you know Sarah, you will know it's never that simple. Check out her piece on page 74.

Enjoy this issue and hope to see you in the hangar or in London for MRO Europe in October. AVM

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SriLankan Airlines Chooses Lufthansa Technik's Engine Services and Digital MRO

SriLankan Airlines selected Lufthansa Technik to provide comprehensive engine MRO (maintenance, repair and overhaul) services for the CFM56-5B engines fitted on its Airbus A320ceo fleet. Over the next four years, the Sri Lankan flag carrier will entrust these power plants to Lufthansa Technik's renowned engine shop in Hamburg, Germany, where they will receive comprehensive sustainment services up to complete overhauls. The first engines covered by the new agreement are expected to arrive in Hamburg by early 2026 at the latest.

At the site, the newly contracted services will complement the ongoing Quick Turn Shop Visits (QTSVs) for the airline's latest-generation LEAP-1A engines, which are fitted on the A320neo fleet and were already contracted to Lufthansa Technik in 2023. So far, the company has already re-delivered four LEAP-1A engines to SriLankan,and more engines are still in induction.

In addition to the hands-on engine MRO services, SriLankan Airlines has recently opted for AVIATAR Condition Monitoring, a part of Lufthansa Technik's Digital Tech Ops Ecosystem. The software provides the airline with a real-time overview of its entire fleet, offering comprehensive insights into every aircraft's current technical status and components. By merging the fleet's operational data with real-time maintenance records, SriLankan Airlines can thus quickly trace past actions and respond promptly for all affected aircraft types in the case of a critical incident. This supports not only the airline's maintenance control center, but also troubleshooters and engineers in proactively managing the fleet's condition.

"Lufthansa Technik has been a strong support for SriLankan Airlines for decades, and we have constantly broadened our fields of collaboration," said Vipul Mishra, head of engineering at SriLankan Airlines. "While their classic MRO services for our aircraft and our engines have become — and will remain — a backbone in our technical operations, we are also eagerly looking forward to extending our collaboration onto the digital playing field, which has already facilitated many useful insights and improvements for us."

"We know SriLankan Airlines as a very loyal customer, and it's always a big pleasure for us to sign a new contract with the outstanding team in Colombo," said Johanna Koch, vice president corporate sales Southeast Asia and Indian subcontinent at Lufthansa Technik. "Our most recent agreements resemble great continuation stories to previous steps on SriLankan's customer journey: the CFM56 services perfectly complement the LEAP engine services, and the AVIATAR product creates many synergies with other joint activities in the field of digital MRO services."

During around 20 years of cooperation, SriLankan Airlines has opted for a broad spectrum of Lufthansa Technik's MRO service offerings. Recent fields of cooperation, for example, encompass a Total Component Support for the airline's Airbus A330 fleet, as well as the mentioned QTSVs for the CFM LEAP-1A engines the airline has selected to power its Airbus A320neo fleet. SriLankan Airlines has moreover successfully implemented the AMOS maintenance and engineering software, which is also an integral part of Lufthansa Technik's Digital Tech Ops Ecosystem.

Taiwan-Based China Airlines and Lufthansa Technik Strengthen Cooperation

China Airlines (CAL) and Lufthansa Technik have once again expanded their cooperation in the field of maintenance, repair and overhaul (MRO), this time with a particularly long-term focus. The two companies signed a new contract that will secure the parts supply for China Airlines' existing Boeing 777 and future Boeing 787 fleets over the next two decades.

With Total Component Support (TCS) for the 787, Lufthansa Technik will also become an important partner for the airline in its fleet expansion. The new contract complements an existing TCS agreement for China Airlines' Airbus A330 and A350 fleets. It adds a total of ten Boeing 777-300ER and ten 777F aircraft, as well as 18 787-9 and six 787-10 joining the fleet in the near future. Through the TCS, the airline will have direct access to Lufthansa Technik's global spare parts pool, which will enable China Airlines to increase the availability of aircraft components and to leverage cost advantages for the mentioned fleets. As such, the agreement not only covers classic component MRO services, but also an AOG (Aircraft On Ground) support and the setup of a dedicated home base parts pool located directly at China Airlines' hub in Taipei.

The TCS for the 777 fleet commenced in August. With the subsequent buildup of its 787 fleet, the airline is not only welcoming a new aircraft type into its operations, it is also pursuing a strategic fleet expansion. Lufthansa Technik says it "aims to support this expansion in the best possible way by leveraging the company's extensive expertise with this modern aircraft type for a seamless

entry-into-service." Currently, the MRO provider supports around 200 Dreamliners worldwide under TCS contracts.

"Lufthansa Technik has been a reliable partner in the past decades, hence we are delighted to write this next chapter in our joint success story," stated China Airlines. "Based off the very good experience we had with the company's component support for our Airbus A330s and A350s, we are more than happy to extend this cooperation onto our entire long-haul fleet now. Lufthansa Technik's expertise with the 787 will moreover help us ensure a smooth entry-into-service of this new type."

"In the aircraft components business, signing long-term agreements is not uncommon, but agreeing on a duration of 20 years still resembles something very special, and we regard this as an outstanding vote of confidence in our services," said Dennis Kohr, senior vice president corporate sales Asia Pacific at Lufthansa Technik.

AFI KLM E&M Signs Long-Term A330 Component Support Contract with Parata Air

Air France Industries KLM Engineering & Maintenance (AFI KLM E&M) announced the signing of a comprehensive component support agreement with Parata Air, Korea's newest airline company and the nation's airline operating a full Airbus fleet.

Owned by the Winix Group, Parata Air will launch operations with a fleet of six Airbus A330ceo aircraft, all to be supported under a six-year Power By the Hour (PBH) components contract with AFI KLM E&M. The agreement marks a significant milestone as it is the first time a Korean airline has signed an Airbus fleet components contract with AFI KLM E&M. Under this long-term partnership, AFI KLM E&M will provide Parata Air with full PBH components support, covering pooling, repair, main base kits, component health monitoring, and logistics services for their entire A330 fleet. As Parata Air grows, the fleet will expand to include four additional A320 aircraft.

Parata Air has chosen AFI KLM E&M as its exclusive component support provider. The support will leverage AFI KLM E&M's Asian hub-and-spoke operations.

"As we are preparing to launch Parata Air with the brand slogan 'Fly New, Fly Happy, Fly Together', we are delighted to partner with AFI KLM E&M for our Airbus fleet," said Yoon Chulmin, CEO of Parata Air. "Their global know-how and regional support capabilities give us the confidence to deliver exceptional service and reliability to our future passengers."

Tommaso Auriemma, vice president sales Asia Pacific at AFI KLM E&M stated: "We are honored to be selected by Parata Air for this landmark agreement. Supporting the first full Airbus fleet in Korea reflects our commitment to innovation and excellence in the region. We look forward to contributing to Parata Air's successful launch and ongoing growth."

ST Engineering Increases Engine MRO Capacity

ST Engineering's commercial aerospace business officially opened a new engine MRO facility in Singapore recently. The ceremony was officiated by Singapore's deputy prime minister and minister for trade and industry Gan Kim Yong.

The new multimillion-dollar facility, an expansion of ST Engineering's engine MRO operations, is located within its existing aerospace compound in Paya Lebar, Singapore. The expansion will allow its commercial aerospace business to progressively double its capacity for CFM56 and LEAP engine maintenance to over 300 engines annually by 2027. When combined with its engine MRO facility in Xiamen, China, the planned capacity across both locations will exceed 400 engine shop visits a year. Concurrent with capacity expansion, ST Engineering is broadening its services to include performance restoration and full overhaul shop visits for both LEAP-1A and LEAP-1B engines to better meet growing demands.

Through this expansion, ST Engineering is expected to create over 300 new jobs for its engine MRO operations in Singapore, while leveraging advanced technologies such as AI-enabled hardware sorters and automated cleaning systems to boost the efficiency of its engine MRO operations.

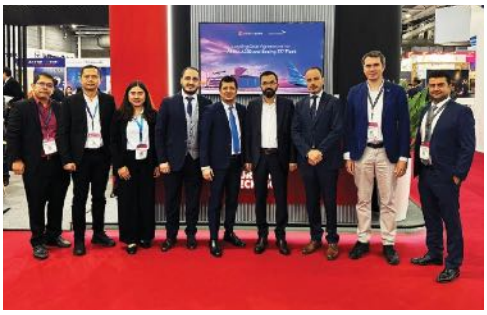
"This expansion reflects our commitment to staying ahead of industry demand and delivering the highest standards in engine MRO, supporting both airline customers and engine OEMs," said Jeffrey Lam, president commercial aerospace, ST Engineering. "As airlines expand and renew their fleets, and with more new-generation LEAP engines entering into service, our new capacity and technology-enabled workforce will position us well to support airline and operator customers worldwide."

"ST Engineering's expansion of its MRO activities for aircraft engines along with the deployment of AI and automation in its facilities will further Singapore's status as Asia's leading aerospace hub. ST Engineering's partnership with local enterprises is also a good example of how leading industry players can leverage Singapore's vibrant and growing aerospace ecosystem to drive innovation as well as to enhance their business resilience and competitiveness," said Jermaine Loy, managing director, Singapore Economic Development Board.

Turkish Technic and Garuda Indonesia Ink Two Landing Gear Overhaul Agreements

Turkish Technic and Garuda Indonesia signed two multi-year agreements covering the landing gear overhaul services of several Airbus A330 and Boeing 777 aircraft of Garuda Indonesia at MRO Asia Pacific 2025 held in Singapore.

The two say this agreement will enable Garuda Indonesia to benefit from Turkish Technic's decades of expertise and know-how in landing gear overhaul services, enhancing the carrier's operational efficiency and reliability. It also further strengthens the partnership the two established with component pool service agreements last year.



"We are pleased to strengthen our collaboration with Garuda Indonesia,"said Fikret Koç, SVP of sales of Turkish Technic. "Our close cooperation in recent years has paved the way for new agreements, which not only expand the scope of our partnership but also create greater value for both companies moving forward. We look forward to continuing our successful partnership and remaining a trusted partner to Garuda Indonesia in the years ahead."

Regarding the continuation of the partnership, Mukhtaris Aris, director of maintenance at Garuda Indonesia, said: "Garuda Indonesia is delighted to expand the longstanding partnership with Turkish Technic. ... This collaboration aligns with the flag carrier's ongoing efforts to uphold the highest level of safety standards while also increasing the operational efficiency to maintain the customers' satisfaction."

New Aviation Program at SAIT Takes Flight Fueled by Lufthansa Technik Canada

The Southern Alberta Institute of Technology (SAIT) will offer a new Gas Turbin Technician certificate with support from Lufthansa Technik Canada's (LTCA) Fuel the Future initiative.

Through a collaborative approach to diversifying Alberta's skilled workforce, the two organizations say they hope to transform the journey from education to employment. As SAIT launches a new opportunity for hands-on training, LTCA is opening new doors for students passionate about aviation yet facing financial barriers.

Set to launch May 2026, the new certificate program will prepare graduates with the technical skills and regulatory awareness needed to meet increasing demand for gas turbine expertise. Elevating the program through its Fuel the Future initiative, LTCA will offer at least 10 students in each 32-student cohort an unprecedented sponsorship opportunity.

"Built as a direct response to industry needs for specialists in this field, this certificate is another indicator of the value of applied education," says Dr. David Ross, president and CEO, SAIT. "By offering practical, hands-on education, we're addressing the need for a higher education credential achieved through enhanced training and aligned with emerging industry trends."

As Alberta's first post-secondary institution to offer a program of this kind, SAIT will be positioned to meet the needs of a growing aviation sector across Calgary, Alberta, and western Canada, and create a skilled talent pipeline. Students entering the program through Fuel the Future will receive financial support to cover tuition costs and tools, a salary during their studies and be guaranteed job placement with LTCA following completion of the program — ensuring equitable access to training in aviation maintenance. "Fuel the Future is about opening doors to possibilities. For those students selected, there are no program costs — everything is covered," says Max Schramm, president and CEO of Lufthansa Technik Canada. "At LTCA, creating opportunity is at the heart of this first-of-its-kind initiative for the Alberta aviation industry that removes barriers, so every student has the chance to build a lasting career. Our partnership with SAIT also reflects our wider commitment to Calgary, to Alberta and to Canada's leadership in global aviation. We're creating pathways for generational jobs that strengthen families, communities, and the future of the sector."

Developed in collaboration with the British Columbia Institute of Technology (BCIT) as an adaption of their successful industry-aligned program, the new certificate program is modified to reflect the credential framework and institutional strength and expertise held by SAIT's School of Transportation "Gas turbines are a crucial component in both aviation and industrial energy production sectors, powering everything from commercial airplanes to power plants and natural gas facilities," says Lynda Holden, dean, School of Transportation and School of Manufacturing and Automation, SAIT. "An aging workforce and fewer younger workers entering the skilled trades means the gap between available talent and industry demand is widening. SAIT is ready to train skilled technicians to maintain and repair these sophisticated engines."

From positions with aerospace maintenance organizations and gas turbine repair facilities to jobs in the energy sector with companies utilizing industrial gas turbines, the new program's curriculum will prepare learners for employment in and across sectors where gas turbines are integral to operations.

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Acron Aviation Announces New MRO Repair Center in India

Acron Aviation announced the launch of its new maintenance, repair, and overhaul (MRO) center in Bangalore, India, reinforcing its commitment to the Asia-Pacific region.

Strategically located in Bangalore, the company says the new facility will offer regional operators faster turnaround times and localized support, reducing dependence on overseas repair channels. The center launches with repair and test capability for the SRVIVR25, a critical onboard safety system, and will expand over the next three years to include recorders, TCAS, and advanced display systems.

The company is currently in the process of securing DGCA CAR 145 approval, with plans to pursue FAA, EASA, and CAAC certifications. These approvals will enable the Bangalore site to

serve both regional and global customers with the same level of compliance and quality that Acron Aviation's repair stations and licensed centers are known for.

"Our Bangalore facility is fully integrated with Acron Aviation's global repair network, ensuring consistent standards, processes, and IP protection across every location," said Ronald Nye, VP and GM aftermarket, Acron Aviation. "This investment is a direct response to our customers' need for lower logistics costs, faster repair cycles, and enhanced local support."

Safran Signs Long-Term Partnership with Singapore Airlines for its Airbus A380 Component Support

Safran Electrical & Power and Singapore Airlines have signed a seven-year (with an option to extend another five years) component maintenance contract for the airline's Airbus A380 fleet. The two companies say the agreement underscores Singapore Airlines' continued confidence in Safran Electrical & Power's technical expertise, global support network and commitment to operational excellence "This agreement is a strong testimony to the depth of our relationship and reflects the trust we have built with Singapore Airlines over many years," said Amans Defossez, vice president customer support & services at Safran Electrical & Power. "Safran Electrical & Power is proud to continue supporting one of the world's most prestigious airlines with tailored solutions that enhance operational performance and optimize lifecycle costs."

Alvin Liew, vice president strategic sourcing at Singapore Airlines said, "We are pleased to continue working with Safran Electrical & Power under this renewed agreement that will provide component support services for Singapore Airlines' Airbus A380 fleet to help maintain safe and reliable operations."

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Trax Announces Air Europa Express' Successful Deployment of Expanded eMobility Suite

Trax announced Air Europa Express has successfully implemented an expanded suite of Trax's eMobility applications. Air Europa Express currently uses multiple Trax eMobility apps to access real-time information for line maintenance functions. However, until recently, the airline relied on a paper-based technical and cabin logbook. Expanding the airline's selection of eMobility solutions to include the apps in Trax's Electronic Logbook solution has delivered enhancements to Air Europa Express' operational efficiency, data accuracy and maintenance processes across their fleet of 737 aircraft, Trax says.

The deployment also marks the inaugural operator to implement Trax's Electronic Logbook under EASA regulations, further signifying regulatory confidence in Trax's digital solutions and the opportunity for significant adoption of mobile maintenance solutions across European operators. Trax's Electronic Logbook suite has been in use by FAA and UK CAA-regulated operators for many years.

"The intuitive design of the Electronic Logbook apps has ensured seamless adoption by our crews, bolstering operational safety through real-time, reliable, and accessible data," said Francisco Borja Mas Boned, head of innovation maintenance department at Air Europa. "By leveraging these advanced tools, we are optimizing and modernizing our maintenance operations, setting a new standard for innovation in the aviation industry."

"Trax appreciates Air Europa Express' continued enthusiasm for our solutions, including the recent expansion of their selected eMobility apps. We are proud to continue to collaborate with the airline by replacing their previously paper-intensive flight deck and cabin-based processes with a fully digital approach," said Nelson Perea, regional director of EMEA at Trax. "It is incredibly rewarding helping customers implement additional Trax solutions to magnify the benefit we provide to their operations."

Air Niugini Signs Flight Hour Services Contract for A220 Fleet

Air Niugini has selected Airbus Flight Hour Services (FHS) to support its new fleet of 11 A220 aircraft. The long-term power-by-the-hour contract covers integrated component services, including on-site stock, pool access and repair services.

The agreement was signed in Port Moresby by Anand Stanley, president Airbus Asia-Pacific and Captain Samiu Taufa, officer-in-charge and acting COO, Air Niugini, at a ceremony to mark the arrival of the airline's first aircraft from the A220 main assembly facility in Mirabel, Canada.

"We are pleased to sign this agreement with Airbus as part of our comprehensive preparations for our new A220 fleet," said Captain Samiu Taufa. "The arrival of the A220 marks a milestone in our long history and for the whole nation of Papua New Guinea. Working together with Airbus and our other partners, we are working at every level not only to meet but to exceed the expectations of our customers and the nation with the best products and services the industry has to offer."

"We are delighted to welcome Air Niugini to the Airbus FHS family. This agreement underlines our commitment to provide Air Niugini with world-class maintenance solutions to optimize efficiency and ensure a smooth operation of their new fleet. We look forward to supporting Air Niugini in bringing the full potential of the A220 to their passengers and markets," said Anand Stanley.

Airbus FHS provides airlines with a flexible, power-by-the-hour model designed to maximize aircraft availability while reducing overall operating costs. Leveraging Airbus' engineering expertise, predictive maintenance tools, and global logistics network, FHS ensures operators are well placed to achieve best-in-class fleet performance and reliability.

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HAECO Achieves Milestone with 500th Aircraft Input for ANA

HAECO announced the completion of its 500th aircraft input for All Nippon Airways (ANA) at the maintenance, repair and overhaul (MRO) organization's facility at Xiamen Gaoqi International Airport. This achievement marks a milestone in the longstanding collaboration between HAECO and ANA which began in 1997.

HAECO offers airframe maintenance capabilities for ANA's wide range of aircraft types, including the Boeing 767, 777 and 787 and the Airbus A380, and line services at various airports in the Chinese Mainland and Hong Kong.

"We are honored to celebrate this significant milestone with ANA, our valued partner since 1997," said Ben Scheidel, group director airframe services of HAECO. "This achievement is a testament to nearly 30 years of dedication, innovation and teamwork. We greatly appreciate ANA's trust and confidence placed in our long-term relationship and industry leading services. We look forward to growing our successful collaboration."

"As an international airline that is built on security and trust, ANA has enjoyed safe and reliable maintenance services from HAECO over the years. The perseverance and professionalism at HAECO have been a welcoming drive for us to fulfil the hopes and dreams of an interconnected world. We are excited about more aircraft inputs ahead and are dedicated to continuing this journey safely together for many more decades," said Kohei Tsuji, ANA's executive vice president, engineering and maintenance center.

GE Aerospace Names Chief Mechanic for Open Fan

GE Aerospace has named Craig Higgins as chief mechanic and architect for open fan technology, prioritizing the producibility, durability and maintainability of next-generation engine designs still in development.

In the newly created role, Higgins will lead strategies for a simple, lightweight engine concept that emphasizes durability by leveraging the CFM RISE program's advanced technologies, architectures and materials. This includes working with technicians and other experts across GE Aerospace's global assembly and maintenance, repair and overhaul (MRO) shops to incorporate the latest techniques for enabling more on-wing repairs and part replacements.

"With the RISE program, we're advancing a suite of pioneering technologies to meet our customers' needs for the future of flight," Arjan Hegeman, vice president for future of flight at GE Aerospace, said. "This marks the first time we've named a chief mechanic during technology development, making durability and maintainability a top priority in engine design with an uncompromising commitment to safety."

Higgins has more than 40 years' experience in the aerospace

industry, joining GE Aerospace in 1997 as a design engineer. In his most recent role, he was a consulting engineer for the RISE program.

Unveiled in 2021, the CFM RISE program is one of the aviation industry's most comprehensive technology demonstrators with more than 350 tests and more than 3,000 cycles of endurance tests completed to date, including tests on advanced engine architectures like open fan, compact core and hybrid electric systems. The RISE program prioritizes safety, durability and efficiency, targeting more than 20% better fuel burn compared to commercial engines in service today.

CFM RISE program technologies are maturing toward ground and flight tests this decade with work underway on aircraft and engine integration in collaboration with partners, GE Aerospace says.

Boeing Opens New Engineering Center at Embry Riddle Research Park

A ribbon-cutting ceremony was held to celebrate the opening of the new Boeing Engineering Center in the Cici & Hyatt Brown Center for Aerospace Technology at Embry Riddle's Research Park. The facility is now operational and is anticipated to create approximately 400 high-paying jobs in Daytona Beach and Volusia County as hiring continues. Embry Riddle/Daryl Labello image.

Boeing opened its new Boeing Engineering Center in the Cici & Hyatt Brown Center for Aerospace Technology at Embry Riddle Aeronautical University's Research Park. The facility is now operational, expanding the company's commitment to the region.

"This day represents an important milestone for Boeing, Embry Riddle and the broader Daytona Beach community," said Dan Gillian, vice president and general manager, Boeing Air Dominance. "This engineering center will accelerate Boeing's work on critical defense programs and deepen our partnership with Embry Riddle, giving us access to an exceptional talent pipeline and enabling collaboration to drive aerospace innovation."

The Boeing Engineering Center spans 65,000 square feet

and supports engineering design, research, development and prototyping for Boeing Defense, Space & Security Air Dominance programs, as well as advanced technology efforts. The center is anticipated to create approximately 400 high-paying jobs in Daytona Beach and Volusia County as hiring continues.

"In addition to creating high-paying jobs, these collaborations cultivate a dynamic exchange between students, faculty and industry leaders, ensuring innovation thrives at the intersection of education and enterprise," said P. Barry Butler, Embry-Riddle Aeronautical University president. "We are delighted that Boeing's new facility will draw on the rich pool of local talent and strengthen the vital pipeline between academic achievement and industry success — a partnership forged by the forward-thinking policies and steadfast support of both higher education and aerospace by the leadership of the state of Florida."

Mori Hosseini, chairman of Embry Riddle's Board of Trustees, also described the opening of the center as a milestone — not only for Embry Riddle and the city of Daytona Beach but for all of Florida. "We are delighted to welcome Boeing to our community, where their commitment to advancing aerospace technology strengthens our position at the top of the space triangle," he said. "With Boeing's partnership, hundreds of talented individuals and their families will now have opportunities to live, work and thrive here, investing in our local economy and supporting the future of aviation and aerospace. The impact — made possible by local philanthropists Cici and Hyatt Brown, Florida governor Ron DeSantis and the legislature — is immeasurable. We applaud Boeing's vital support in shaping innovation for generations to come."

The Boeing Engineering Center spans 65,000 square feet and will support engineering design, research, development and prototyping for Boeing Defense, Space & Security Air Dominance programs, as well as advanced technology efforts. The center is anticipated to create approximately 400 high-paying jobs in Daytona Beach and Volusia County as hiring continues.

Boeing is also investing $100,000 to support new STEM programing for the Boys & Girls Club of Volusia/Flagler counties, as well as to provide food for students in need through the Second Harvest Food Bank of Central Florida.

The Embry Riddle Research Park has been a significant driver of economic activity for the state, creating nearly 2,000 direct, indirect and induced jobs to date and generating more than $372 million in total economic impact in Florida. The addition of Boeing further strengthens the Research Park's technology ecosystem, which brings university researchers and students together with businesses, entrepreneurs and start-ups across aviation, aerospace, cybersecurity, commercial space and other STEM fields.

Textron Aviation Expands ProAdvantage Portfolio with Launch of ProParts+ for Cessna Citation 525 Series

Textron Aviation announced the launch of ProParts+, a new addition to the company's industry-leading ProAdvantage support programs, designed specifically for Cessna Citation 525 series operators. ProParts+ builds on the trusted foundation of the ProParts program, offering expanded coverage to address key customer identified priorities and enhance operational predictability.

"Expanding our ProAdvantage portfolio with ProParts+ reflects our continued investment in the long-term support of the Citation 525 Series," said Brad White, senior vice president, Global Parts Distribution. "ProParts+ is a direct response to customer feedback. We've designed this program to provide greater peace of mind and value by covering high-cost components and consumables that matter most to our operators."

ProParts+ introduces several new benefits for the 525 series, including landing gear coverage, consumables, standard freight coverage and a contract buy-out option.

Textron Aviation's ProParts program is a fixed-cost ProAdvantage initiative that simplifies maintenance planning by covering airframe systems and avionics parts required for line, scheduled and unscheduled maintenance. With predictable monthly payments based on reported flight hours, ProParts helps operators manage expenses consistently while benefiting from OEM original or authorized parts.

Pilatus to Take On Major Renovation of Headquarters

Pilatus says it is committed to its site in Stans, Switzerland, and is planning a comprehensive modernization of their outdated, rudimentary and energy-inefficient buildings at its headquarters. The new buildings will allow the company to consolidate and optimize its production and administration areas, thereby contributing to sustainable development and safeguarding around 2,500 jobs. Planning will go ahead in close consultation with the municipality of Stans and Canton Nidwalden.

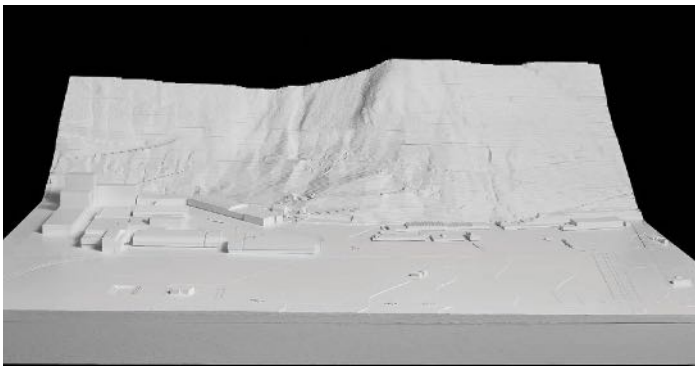
The dimensions of the planned new buildings are carefully aligned with the topography and local landscape. Vertical construction will facilitate better use of the land available. As a result, further extension of the site is unlikely to be required.

The locations of the office buildings, with heights of 32, 36 and maximum 56 meters, were approved as suitable for high-rise buildings in the Cantonal Development Plan of 2014. The buildings will be planned with due consideration for the nearby area of moorland.

Pilatus says it is focused on sustainability in all its buildings: the majority are built with local timber and recycled concrete, meet international standards for sustainable construction (LEED) and are designed to ensure low energy consumption. The buildings blend discreetly and harmoniously with the natural surroundings. Large-scale photovoltaic systems support the company's own power production.

The project will also bring significant optimization in terms of access and mobility. The bus stop will be relocated from Kantonsstrasse to Pilatusstrasse. At the same time, Pilatus will encourage its employees to use environmentally-friendly public transport with financial contributions of up to 1,000 Swiss francs a year.

The people of Stans will be invited to vote on an amendment to the Land Use Plan on November 26, 2025. At this early stage, Pilatus and its staff of around 2,500 employees wish to thank citizens for voting "yes" — and thus for supporting the sustainable further development of its site in Stans.



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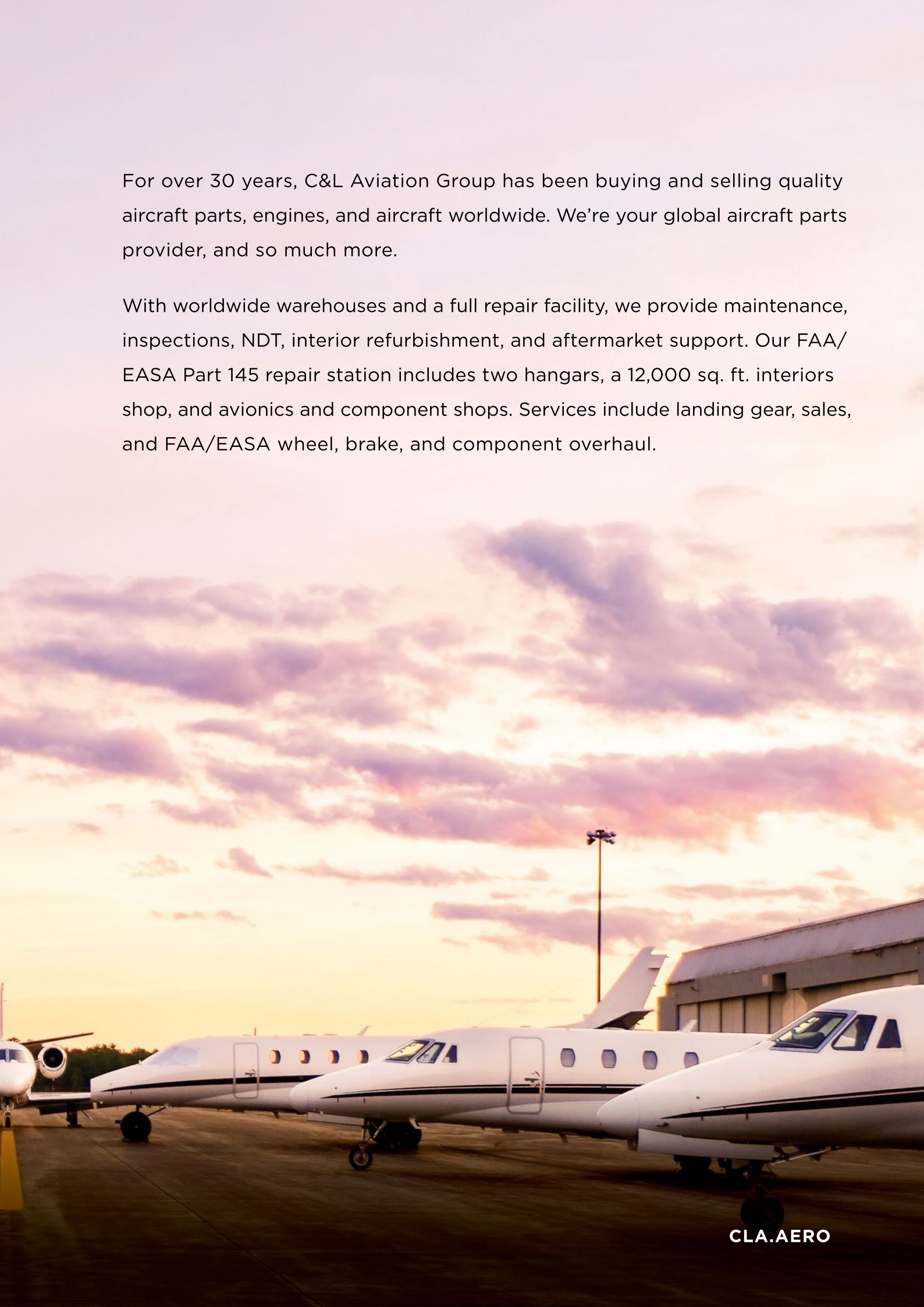

By James Careless

Predictive Engine Maintenance: Fix It Before It's Broke

"If it ain't broke, don't fix it" is a timeworn expression of maintenance common sense. However, this phrase was created before the concept of predictive engine maintenance was introduced. Now that predictive engine maintenance exists, aviation technicians can fix parts before they're broke.

What is Predictive Maintenance?

Let's start with a definition to set the context for this story. "Predictive maintenance is a modern strategy that uses real-time data, historical trends, machine learning and advanced analytics to predict when a component or system on an aircraft is likely to fail or require servicing," said Karine Lavoie-Tremblay, director of commercial engines digital transformation at Pratt & Whitney, an RTX business. "This allows airlines and operators to perform maintenance 'just in time', improving safety, reducing unscheduled downtime, minimizing costs and extending the life of parts."

"Predictive maintenance is the proactive approach to get ahead of the point of failure of an engine component, and to either repair or replace it so that an operator can keep flying their engines with minimal interruptions," added Dr. Christian Keller. (He oversees the engine trend monitoring program at MTU Maintenance.) "It can be broken down further into on-wing and in-shop predictive maintenance, depending on the workscope."

Karine Lavoie-Tremblay, Pratt & Whitney

MTU image.

The Evolution of Predictive Maintenance

The history of predictive engine maintenance began more than five decades ago. This was the time that airlines and manufacturers began collecting more structured maintenance data through early aircraft level health monitoring systems. Still, the insights provided by this data were pretty basic in nature, which is why MROs continued to focus on scheduled preventive maintenance.

"It wasn't until the digital age in the 2000s that engine health monitoring was introduced and engine OEMs began to offer these services," said Lavoie-Tremblay. "With the introduction and widespread adoption of big data, cloud computing and the Internet of Things, it has evolved to a more advanced state to enable real-time predictive capabilities. Today, we are using machine learning and cutting-edge analytics to bring predictive maintenance to the next level."

By moving from a preventive to a predictive maintenance model, MROs are now able to service aircraft engines on an individual basis based on their actual needs, rather than bringing them into the shop for scheduled appointments whether they need it or not. This is why "predictive maintenance has grown steadily over the years with increasing demand for proactive maintenance planning in order to keep engines on-wing for as long as possible," Dr. Keller said. However, "while the focus was initially on-wing predictive maintenance, recent market challenges, such as the drop in demand due to the pandemic, have increased the demand for maintenance planning optimization. Because of that, there is now an increased emphasis on the prediction and optimization in the scheduling of shop visit events to make them as cost effective as possible."

AI's Impact on Predictive Maintenance

Artificial intelligence (AI) is the game-changer of the current digital age, and it is having a big impact on predictive maintenance.

A case in point: "Pratt & Whitney is already utilizing artificial intelligence and machine learning to improve the design,

development and testing of products, making our systems smarter, easier to use and more capable than ever, with enhanced safety," said Lavoie-Tremblay. The company is currently developing and deploying advanced AI-enabled MRO capabilities via its Singapore and North America technology accelerators.

Here are three ways Pratt & Whitney (P&W) is using AI to enhance predictive maintenance. First, "engineers at our Singapore engine center, Eagle Services Asia, have developed a collaborative robot (cobot) to assist technicians to capture photo documentation of the engine's external components, showing the pre- and post-overhaul condition of an engine," Lavoie-Tremblay said. "This system replaces the routine photo-documentation task previously performed by technicians and elevates the skillset of the technicians to operate the system."

Next, in collaboration with the Indian start-up Awiros, P&W has launched "Percept," an AI-based tool for real-time aircraft engine inspections. This tool leverages computer vision and AI to speed up the inspection process, reducing the time taken by nearly 90% compared to traditional methods. It can be used in both pre- and post-lease inspections of aircraft engines.

Finally, P&W is using digital twins to visualize, animate and

MTU's Dr. Christian Keller says myEFM requires artificial intelligence to drive its algorithms. AI can be used to support the diagnosis of engine faults or knowledge management supported by large language models. MTU Aero Engines image.

simulate the current and future operational state of a product cell or factory. "The software creates a digital model of the shop and sets important baseline targets for metrics such as TAT and throughput, enabling equipment and manpower optimization," said Lavoie-Tremblay.

MTU is also deeply involved in AI-enhanced engine maintenance. "As in other industries, artificial intelligence promises a revolution in how work is conducted and this is no different in predictive maintenance," Dr. Keller said. "Some of the recent prediction and optimization capabilities have only been made efficient enough by the use of AI. Where conventional methods sometimes struggle with long compute times or high compute resource requirements, AI and specifically machine learning help speed these up so they become manageable. MTU's myEFM requires artificial intelligence to drive its algorithms. Furthermore, AI can be used to support the work of experts, for instance, in the diagnosis of engine faults or knowledge management supported by large language models."

Anca Mihalache is the managing director of AERO CARE, a Romanian company focused on aircraft engines. She said that AERO CARE has yet to take the AI plunge. "I believe the future will show a greater reliance on AI for predictive maintenance, and maintenance in general," Mihalache observed. "But we are not quite there yet."

Anca Mihalache, AERO CARE

Predictive Maintenance Solutions

Now that we have considered the general evolution of predictive maintenance — and AI's increasing role in this approach — it is time to get specific about actual available solutions.

Pratt & Whitney has been evolving and enhancing its predictive engine maintenance programs for some time now. "Over the years as wireless technology and data storage technology improved, the ability for airlines to get full-flight data from the aircraft automatically has changed," explained Lavoie-Tremblay. "With the ease and convenience of newer technologies, we as the OEM are able to access this data much sooner and more regularly. This includes actual flight performance data and expected physics-based performance, along with some artificial intelligence and machine learning which provides trends, alerts and inspection recommendations."

As a company, (P&W) has put considerable effort into capturing operational data from their entire portfolio of engines, from the day each engine is made to its last day of service. This comprehensive database has allowed this firm to substantially advance the quality of its engine health management analysis. Moreover, P&W's ongoing investments in Industry 4.0 technologies has made it possible to capture, consolidate and automate the flow of product-related data from the design phase through manufacturing, delivery, maintenance, repair and overhaul.

As well, "Pratt & Whitney is running several key initiatives related to product-specific digital twins and the digital thread for the flow of connected data from Enterprise resource planning (ERP), product lifecycle management (PLM) and manufacturing execution system (MES) platforms," Lavoie-Tremblay told *Aviation Maintenance* magazine. "For our clients, Pratt & Whitney offers a range of solutions from data services to expert analysis of engine operational data. With the data digitally connected and centralized, engineers can have significantly better visibility into performance and wear of parts, potentially increasing engine availability and optimization of maintenance operations."

MTU's progress into predictive engine maintenance has been incorporated into the MRO's Engine Fleet Management (myEFM) and Engine Trend Monitoring (myETM) proprietary maintenance platforms. "Both of these services are available via our customer portal myMTU, which offers a range of additional

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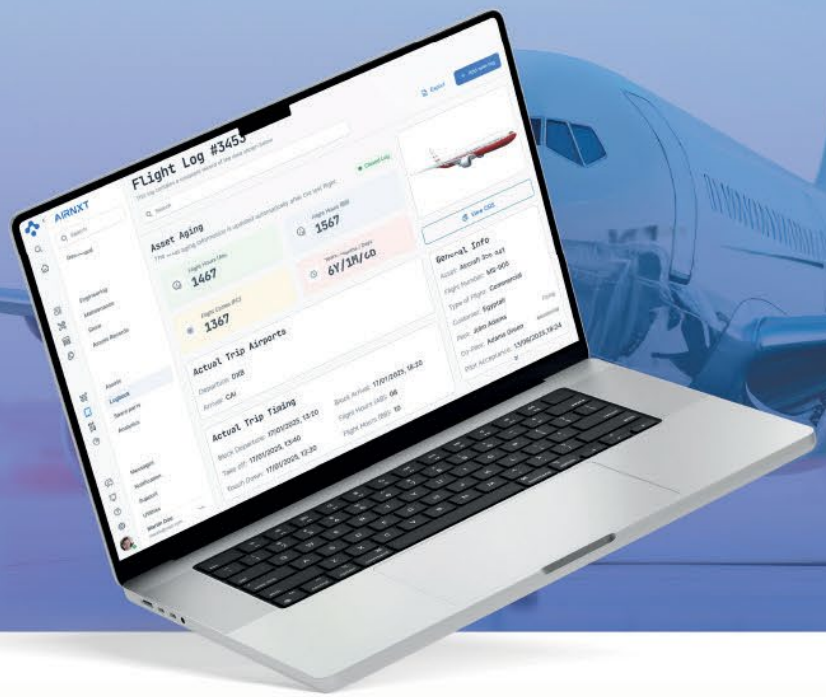

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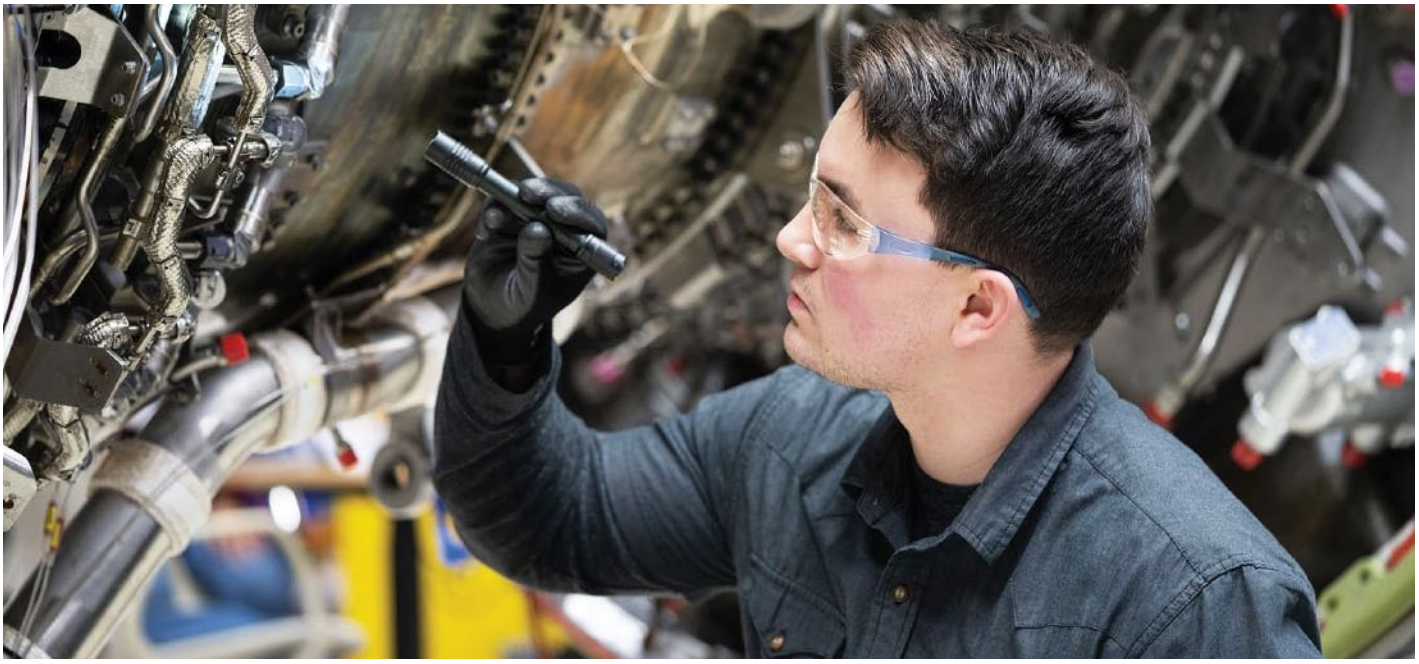

GE Aerospace says it is providing MROs with advanced AI-enhanced predictive maintenance tools that allow the MROs to forecast final work scopes and parts required for a repair months before an engine's induction date. GE Aerospace image.

applications supporting our customers' operations and engine maintenance," said Dr. Keller. "myEFM calculates optimal maintenance scenarios using a series of factors such as fleet composition, the engine's health and operational environment, cost structures of the operator, parts availability, and others. With the help of AI-powered algorithms, we calculate the optimal timing and workscope for a shop visit, which thus reduces overall operating cost and maximizes on-wing time. Meanwhile, myETM is geared towards on-wing performance monitoring and predictive maintenance. Triggered maintenance actions can typically be performed by line maintenance crews, with help from MTU's ON-SITEPlus service experts whenever our customers need

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Pictured here is the tip of a borescope that is part of an AI-enabled Blade Inspection Tool (BIT). GE Aerospace technicians use this to inspect critical jet engine parts. The AI guides the selection of part images to help technicians perform faster, more accurate inspections. BIT can be anchored into position to capture images of items like the high-pressure turbine blades during an on-wing inspection. The BIT counts and indexes each blade as it rotates into view, enabling technicians to compare and measure what they're seeing, determine whether a blade is serviceable or not, and troubleshoot potential issues. BIT has helped reduce processing time from 3 to 1.5 hours vs. a standard Borescope Inspection (BSI), the company says. GE Aeropace image.

specialized equipment or support."

GE Aerospace's fleet support teams are currently moving from condition-based to predictive-based maintenance. According to the company, this shift is enabling faster turnaround times (TATs) and enhanced time-on-wing (TOW) for its fleet of 49K+ commercial engines currently in service.

"For the past ten-plus years, we have been developing and applying AI technologies with great impact to support this revolutionary shift," said a GE Aerospace spokesperson. "Today, we're seeing 60% earlier lead times for identifying predictive maintenance measures, a 45% increase in detection rates, and a reduction in the number of false alerts in half over the past decade. Additionally, we have been able to expand the number of conditions that can be monitored 24/7 on our engines with greater accuracy and consistency."

GE Aerospace is providing MROs with advanced AI-enhanced predictive maintenance tools. These tools allow the MROs to forecast final work scopes and parts required for a repair months before an engine's induction date. "It's not unusual to see an escalation in the scope of work and what an engine ends up needing," the spokesperson said. "Using AI, we're able to foresee and plan for it so that our MRO shops are not caught off guard and don't incur any undue delays in repairing and returning an engine to service."

Long term, GE Aerospace is looking to enable the next big leap from predictive to more personalized maintenance, so that its MRO services can be tailored specifically to each airline customer's fleet. "With the rapid advancements we're seeing in AI and the development of a robust digital thread of data and analytics happening across our MRO value chain, we're developing the fundamental building blocks required to set up this next shift," said the spokesperson.

As for AERO CARE? According to Mihalache, her company supports predictive maintenance "by having in-stock parts ready to go, in my opinion, the biggest current problem is that the BER [beyond economical repair] rates are higher than ever and the risk of selling a unit to meet a TAT and then discovering it to be non-repairable is very high. As such, the shop visit of the engine gets delayed. Our approach to this problem is having an agreement with the repair shops for a shorter TAT which allows us to have a constant flow of parts. We are also trying, as much as possible, to keep modules in stock that we prefer to use as exchanges. It might end up a bit more expensive for the customer but the shorter turnaround time to have the engine back flying helps recoup the extra cost."

Predictive Maintenance That Stands Out

Aviation maintenance is a multi-billion-dollar business, with many vendors competing for clients. This is why we asked the companies interviewed for this story what makes their predictive maintenance platforms stand out.

We started with the engine manufacturer P&W. "Using Pratt & Whitney EngineWise Data by ADEM (advanced diagnostics and engine monitoring), we manage our customers' engine health and maintenance planning requirements, helping them achieve world-class reliability and controlled maintenance costs over the life of their engines," said Lavoie-Tremblay. "Through these services, we deliver greater insights on maintenance planning requirements, superior reliability and controlled maintenance costs over the life of more than 11,000 in-service engines for more than 140 customers. We have invested significantly in upgrades to ADEM to improve our ability to efficiently capture, store and analyze data from multiple sources."

Pratt & Whitney uses the Agile project development approach to collaborate, adapt and modify its service quickly to meet its customers' needs and support their fleets. As a result, "customers now have instant, global access to state-of-the-art visualization and analytics, including full-flight data capabilities, from any desktop or mobile device," Lavoie-Tremblay said. "With access to millions of data points per engine flight cycle, coupled with investments in data and analytical capabilities, we have improved our ability to get better insights into our engines' as-flown behaviors and communicate recommended actions to our customers from a turnaround of weeks to hours, with access to near real-time flight data and state-of-the-art analytics. This plays a critical role in the optimization of engine removal forecasts and the customer's fleet operational availability."

As for MTU Maintenance? "What sets MTU Maintenance apart is its more than 45 years of MRO experience on all types of engines, which, thanks to increasing digitalization, we can feed into our optimization algorithms," said Dr. Keller. "MTU Maintenance also draws upon technical knowledge and reinforces its MRO activities from OEM experience via our parent company MTU Aero Engines. The result is an unrivaled ability to tailor maintenance services to individual customer needs. Our tools and services are used by a wide range of customers. From small airlines that may need our specialized engineering support through myETM to large operators with hundreds of aircraft, which profit significantly from our holistic fleet management

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MTU's engine trend monitoring (myETM) is an intelligent tool for predictive maintenance planning and condition-based engine maintenance. It measures and monitors important engine parameters during flight. The insights it gains, coupled with empirical data, allow MTU to identify and resolve the first signs of engine wear early on, the company says. MTU Aero Engines image.

approach through myEFM."

From AERO CARE's perspective, what sets them apart from the competition is this company's focus on personalized customer service. "If we are talking about an airline, for example, we probably know details about the engine fleet and we expect a shop visit to happen in a certain quarter," Mihalache said. "As such, we will have stock, ready to go, of the units we know are most impacted for that particular type of engine and area of operations. If we are talking about an MRO customer, we know the number of shop visits expected for a type of engine and we either hold stock or we propose consignment agreements, with preapproved prices, to make the process as seamless as possible.

We are highly specialized in certain types of engines (CFM56 and CF6), and our experience helps to reduce TATs for our customers' shop visits. For the lessors, we do our best to have in stock, ready to go, the so-called 'hot parts' to help them save time and get their assets back in the air as quickly as possible."

What's Next in Predictive Maintenance

What will be the "Next Big Things" in predictive engine maintenance, and when will they arrive? That's a question we put to our experts. Here's what they told us.

"Since predictive maintenance is not a new topic, there will likely be a steady evolution with increased capabilities, possibly accompanied by regulation that allows more flexible maintenance intervals on more and more parts," said Dr. Keller. "AI will continue to be a useful tool and facilitate integration of diverse data sources to improve capabilities overall. We already have most of the tools and technologies ready, so I expect many future improvements to come from increased data availability and data sharing between operators and service providers."

"Increasing the connectivity of our digital thread across the entire product life cycle will enable real-time visibility into our products, optimizing our speed to respond to, and even predict our customer needs," Lavoie-Tremblay said. "We continue to build upon lessons learned, expand use cases and scale across the business to accelerate predictability and operational efficiency for our customers. As data quality is further refined and AI continues to advance, predictive maintenance models will move into the next phase to prescriptive and autonomous maintenance."

Pratt & Whitney image.

"I think once all the records of aircraft engines are digital (not scanned) we will see a big change in how we interpret the data — and for sure AI will be the one helping us with the results," said Mihalache. "For example, I think, just like in the medical field, results will be interpreted by the AI and tell us at part-out what non-repairable rate we can expect."

All told, the impressive results delivered by predictive maintenance today will likely be significantly more exceptional and far-reaching as digital technology advances. Granted, we may never see the day where unexpected engine failures cease entirely, but we will be much, much closer to achieving that goal in the years to come.

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By James Careless

PMA Parts Surge Ahead: Availability and Innovation Drive Growth in 2025

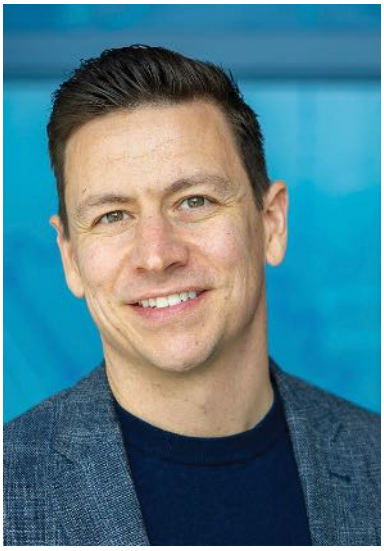
With OEM supply chains strained, airlines and MROs are embracing FAA-approved PMA parts for cost, speed, and reliability — and the market is growing fast.

In 2023 and 2024, Aviation Maintenance's annual report on PMA (Parts Manufacturer Approval) sales reported solid growth. This brings us to 2025: Is the PMA production industry — which provides FAA-approved third-party parts for Original Equipment Manufacturer (OEM) aircraft made by Airbus, Boeing, and others — still doing well? The answer is an unequivocal "Yes!"

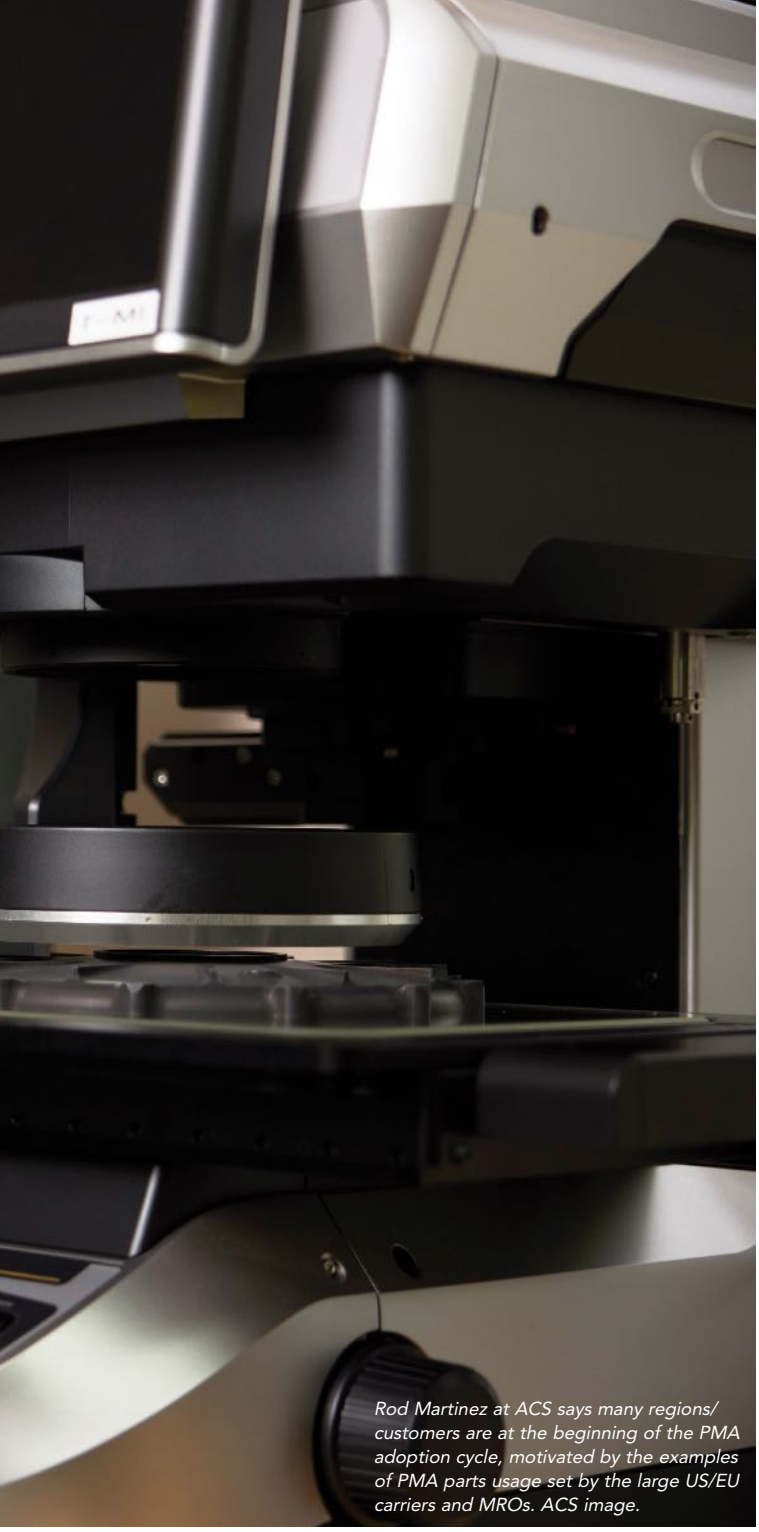
Market Health

"The PMA market remains strong and continues to grow," said John Benscheidt, president of Jet Parts Engineering. "Airlines globally recognize the value PMA brings in not just in cost savings, but in strengthening the supply chain with part availability. Over the past year, we've seen steady expansion from long-time PMA users and adoption from first-time customers who are turning to PMA out of necessity due to the challenges they're having with the OEMs."

"We continue to see tailwinds in this market as more and more operators and MROs adopt PMA to shorten lead times, improve supply chain parts availability metrics, and reduce costs," said Dennis Santare, Aviation Technical Services' (ATS) senior vice president of component & engineering solutions. "This market is specifically driven by adoption and approvals — more of that will drive more consumption, along with the usual drivers like aircraft utilization and age, which are also favorable fundamentals for the market right now."



John Benscheidt, Jet Parts Engineering



Rod Martinez at ACS says many regions/ customers are at the beginning of the PMA adoption cycle, motivated by the examples of PMA parts usage set by the large US/EU carriers and MROs. ACS image.

More Than Just Price

Historically, airlines and other aircraft operators have purchased FAA-approved PMA parts because they offer the same quality as OEM parts, but usually at a lower price. This remains a factor in PMA sales today. "However, post-Covid, FAA-PMA parts development and usage has increased due to supply chain challenges for airlines, MROs and even OEMs looking for part availability solutions," said Patrick Markham, vice president of HEICO Parts Group Technical Services. "Market conditions have increased demand for providing PMA solutions to our customers."

How serious is the shortage of OEM parts? "Parts availability has been a key issue over the past three years," replied Paul Bolton, president/COO of First Aviation Services. "As a result, we have seen customers who were historically OEM-centric change their perspective and open up to alternative solutions." Rod Martinez, president of Aviation Component Solutions (ACS), added that "supply chain constraints continue to challenge the industry, but they've also created opportunities for companies like

Dennis Santare, Aviation Technical Services

Pat Markham, HEICO

ours that can respond quickly and effectively."

The bottom line: "Established PMA companies are aggressively developing new parts to help airlines and MROs strengthen the supply chain — particularly where OEMs cannot meet demand," said Stewart Pope, owner of Fulcrum360. "Airlines that historically avoided PMA adoption are now being forced by supply chain shortages to explore it, often finding great success. So, while cost savings remain the primary reason for airlines to approve PMA use, parts availability is currently the biggest driver."

Key Trends: Availability, Technology, Materials, OEM Partnerships

Based on what the experts tell us, the "need for parts now!" is the dominant trend in the PMA market today. "Part availability is still the biggest driver of PMA adoption," Benscheidt said. "While cost is always important, MROs and operators are increasingly prioritizing who can deliver a quality part now."

Rod Martinez agrees with Benscheidt's assessment, but takes a bigger picture view. "The primary trend driving PMA parts adoption remains specific customer needs," he explained. Yes, availability counts, but so does "the demand for faster lead times, consistent quality and competitive value."

Meeting customer needs is the top trend at HEICO Parts Group Technical Services. In their case, "PMA development is mainly driven by our customers' needs for fleet maintenance," Markham said. "Our use of newer technologies, such as 3D printing, is lagging somewhat behind the OEMs, as we are providing solutions for parts that were designed and developed with older technology and manufacturing processes. Nevertheless, we continually investigate ways to adopt new technologies in design and development to improve our manufacturing lead times and reduce costs."

Aviation Technical Services is certainly interested in the new technology trend, even if modern digital equipment is being employed to make legacy parts. "This is why our ATS engineering team recently invested in an Artec Leo wireless and AI-driven 3D scanners to enhance the processes surrounding both PMA development and our repair engineering offerings," said Santare. "Using these scanners allows our engineers to travel to the customer's facility and scan parts in real time that they are having

issues with, in terms of affordability, reliability, and/or availability. Our engineering team also utilizes 3D FDM printing to validate our test and computation designs. We compare the 3D printed models of our PMA design to the OEM parts to ensure all details and dimensions are comparable."

Materials research and application is a further trend driving the PMA industry. "I'm seeing a lot of older OEM parts that have corrosion issues being materially reengineered by PMA manufacturers," noted Jason Dickstein, president of the Modification and Replacement Parts Association (MARPA). "Where it makes sense, PMA companies are developing new materials for these parts, even though these replacements obviously require test and computation approval by the FAA. That's why these PMA companies are bringing in material science engineers to support those test and computation approval applications."

Dickstein is seeing yet another trend in the PMA market, namely "cooperation between the OEM type certificate holders and PMA companies in the development of new PMAs," he said. "It's quietly always happened in the past, but now this OEM/PMA cooperation is becoming a little bit more public. Today, even engine OEMs are buying PMA parts to relieve their supply chain issues."

The Tariff Factor

Given that the United States is charging tariffs on imported OEM parts, one would think that these charges are a boon for U.S. PMA manufacturers. And one would be right — and wrong as well.

On the "right" side of the equation, "tariffs on certain imported OEM parts have given U.S.-based PMA providers a relative pricing advantage in the domestic market," said Benscheidt. "That said, PMA growth is still primarily driven by performance, reliability, cost, and lead-time advantages; tariffs are just an additional nudge for U.S. customers."

Paul Bolton, First Aviation Services

Rod Martinez, Aviation Component Solutions

"Imported Airbus OEM parts are getting hit with tariffs," Dickstein told Aviation Maintenance magazine. "But even before tariffs, OEM Airbus parts were already more expensive than PMAs. So, for domestic U.S. purchasers, the tariffs just make these OEM parts even more expensive."

On the "wrong" side of the equation, tariffs are affecting PMA providers who have a foot in the U.S. MRO sector. "First Aviation's Piedmont Propulsion Systems propeller MRO facility has been

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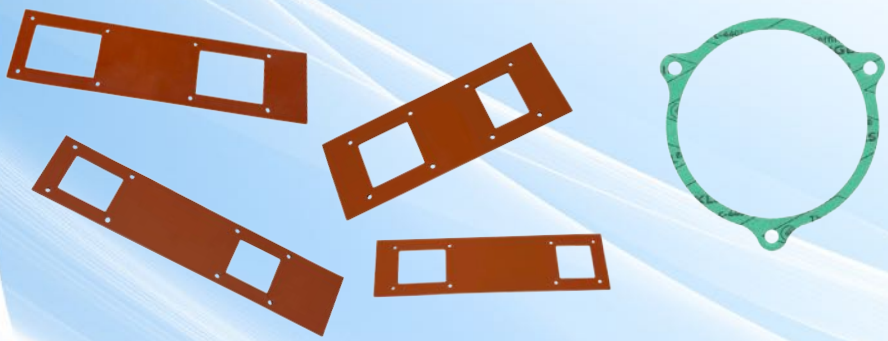

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Jason Dickstein, who leads MARPA, says cooperation between the OEM type certificate holders and PMA companies in the development of new PMAs has quietly always happened, but now this OEM/PMA cooperation is becoming a little bit more public. ACS image.

Jason Dickstein, MARPA

most affected by tariffs as it services both GE Dowty (U.K.) and Collins-Ratier Figeac (France) propeller components," Bolton said. "But as we also offer USA-produced alternative parts, we have been able to realize cost savings."

"Like every industry, the situation with tariffs has been very dynamic and we are working through it," said Markham. "Fortunately for HEICO, a majority of our suppliers are U.S.-based; however, a small percentage of the raw materials and components used in the manufacturing of our parts may be affected by tariffs. Equally fortunately, our sales have been robust throughout the market both domestically and internationally, and maintaining a price advantage over OEMs has always been a key factor in PMA growth."

As for ATS? The company has not experienced any tariff impacts related to its PMA business. "This is because the majority of our current customers are U.S. airlines and most of our supply chain sits inside of the U.S. as well," Santare said. "However, we are increasing the number of exports we do as foreign carriers adopt more and more PMA parts, so tariffs in other countries will become an inevitable challenge for us."

Finally, tariffs have had a general impact on sales in the aviation maintenance space, and not necessarily for the better. "The most notable impact has been a shift in buying behavior — driven less by the direct cost of tariffs and more by the uncertainty they create," said Martinez. "We believe the aerospace industry is resilient and global enough that the long-term impact of tariffs will remain limited. That said, we are continuing to monitor the situation closely and are always ready to support customers who need stable, cost-effective alternatives."

Poised for Growth

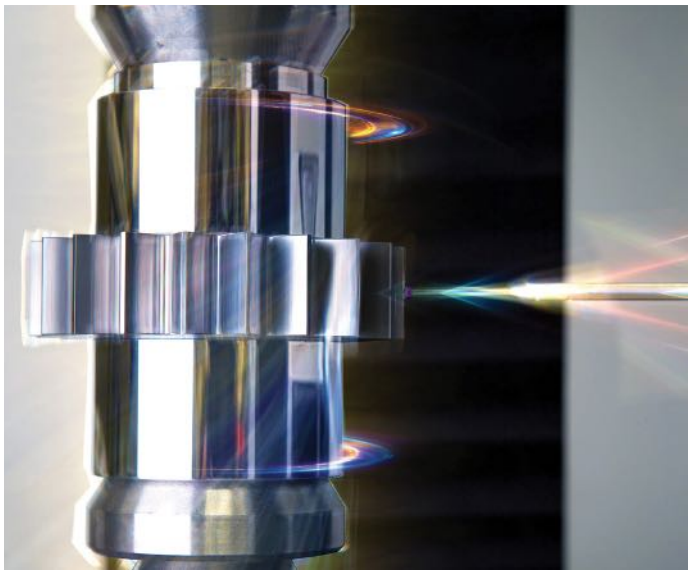
Tariffs notwithstanding, the global PMA market seems poised for continued growth. This is because the combination of PMA parts' lower prices and better availability make them irresistible to a growing number of aviation customers.

"ATS has continued to invest in its PMA business since its 2015 inception and has seen growth from all the U.S. airline majors," said Santare. "We have also seen consistent growth internationally with PMA approvals from airlines in Asia, Europe, the U.K., and Latin America. As well, we see a lot of growth coming from non-critical parts that are under-supported by others in the supply chain. For example, brackets, wear surfaces, hinges, and other hardware receive very little attention, yet those parts could keep an aircraft waiting in the same way it might wait for an engine or landing gear. We also see a lot of demand for doors and panels that are difficult to obtain from other sources."

"ACS continues to see strong growth potential in North and South America, as well as in China, where demand for alternative solutions is rising in response to both cost and supply chain challenges," Martinez said. "From our vantage point, the PMA market is evolving and growing — not shrinking. Many regions/customers are at the beginning of the PMA adoption cycle, motivated by the great examples of PMA parts usage by the large U.S./EU carriers and MROs."

As for where the PMA parts makers will be selling to? "I believe we'll see continued growth in legacy fleets and their critical parts, as OEMs move forward to next-generation support," replied Bolton. "As well, since the deliveries of new aircraft have slowed, older aircraft have to fly longer — and that's good news for us."

"In the normal evolution of airline fleets, the PMA market tends to focus on the mid-life to mature aircraft," Markham agreed. "However, new aircraft delivery delays have forced airlines to keep older fleets in service longer. These delays have given some of the mid-life fleets an extra maintenance cycle. These extra cycles are creating an overlap of the current fleet with the newer



HEICO's Pat Markham says new aircraft delivery delays have forced airlines to keep older fleets in service longer. These delays have given some of the mid-life fleets an extra maintenance cycle. HEICO image.

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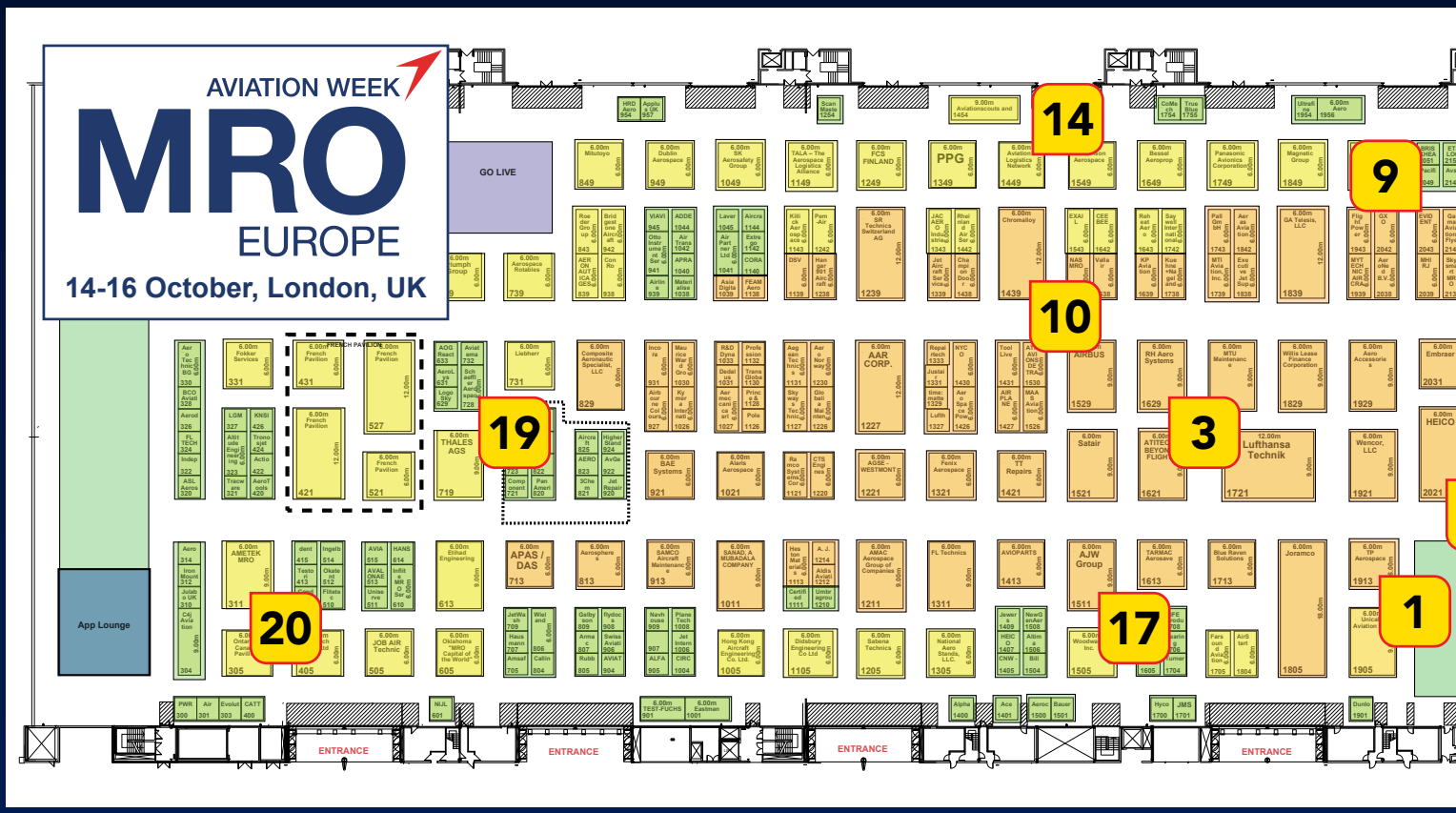

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Air France Industries KLM Engineering & Maintenance

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Air France Industries KLM Engineering & Maintenance is a major multi-product MRO (maintenance, repair, overhaul) provider. With a workforce of over 12,800, AFI KLM E&M offers comprehensive technical support for airlines, ranging from engineering and line maintenance to engine overhaul, aero structure and fan thrust reverser support, as well as the management, repair and supply of aircraft components, structured around a powerful logistics network. AFI KLM E&M supports almost 2,800 aircraft operated by 200 major international and domestic airlines.

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Precision Aviation Group (PAG) is a leading provider of maintenance, repair, and overhaul (MRO) and value-added supply chain services to the aerospace and defense industries. With 25 FAA-approved repair stations, 27 locations worldwide, 1,100+ employees, and over 1.2 million square feet of production/ distribution facilities, PAG offers comprehensive MRO services on over 200,000 product lines.

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Iberia Maintenance is a leading provider of MRO services to worldwide airlines including all IAG OpCos, OEMs and the wider industry. Iberia Maintenance delivers premium MRO services for A320ceo/neo family and A330. All operators can benefit from our component repair and overhaul expertise covering a wide service spectrum of components assembled in these fleets. The Engine Shop is specialised in the V2500, CFM56 and RB211, but also power generation systems, associated accessories and thrust reversers. Last year, Iberia Maintenance obtained the license from Pratt & Whitney to service the GTF PW1100G-JM and received the first engine in the last quarter of the year. In addition, the company is working to introduce the LEAP platform capability.

HEICO

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HEICO Aerospace Corporation is a successful and growing technology-driven aerospace, industrial, defense and electronics company. HEICO provides customers with innovative and cost-saving products and services. HEICO's products are found on large commercial, regional, business and military aircraft, along with a large variety of industrial turbines, targeting systems, missiles and electro-optical devices. HEICO Parts Group (HPG) is the largest independent supplier of FAA-PMA approved engine and component parts. HEICO Repair Group (HRG) supplies flight-critical repair and overhaul services. HEICO Distribution Group (HDG) is a leading provider of FAA-approved component parts, and a leader in distribution for OEM replacement parts.

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provide aviation services and aftermarket support for regional and corporate aircraft, specializing in quality parts, service, component repair, sales, leasing, maintenance, avionics upgrades, interior refurbishment, and aircraft re-marketing. We make aircraft ownership more economical by providing all of our services in one location: our state-of-the-art 200,000-square-foot facility at Bangor International Airport in Maine, where customers have been coming for maintenance and inspections for 30 years. And to make things even more convenient for our customers, we also maintain sales offices and warehouses around the globe.

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Barfield is part of the AFI KLM E& M network, a major MRO provider. With its 500 employees across its facilities located in the U.S., Barfield services customers operating commercial or regional fleets in the Americas. From MRO Services to Distribution and manufacturing of Ground Support Test Equipment (GSTE), Barfield provides complete tailor-made support programs for a wide range of aircraft to operators that need repair management programs, engineering and fleet support, and component reliability management.

Aviation Week Network

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Aviation Week Network's MRO portfolio of products and services enables MRO professionals worldwide to make informed decisions, improve strategic planning, operate more effectively, and capture new business to increase revenue. Our global portfolio empowers you to connect knowledge to opportunity with: intelligence and insight, data, analytics and forecasting, global conferences and exhibitions, digital marketplaces, and custom marketing and advertising solutions.

Aviation Logistics Network

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Aviation Component Solutions (ACS)

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Aviation Component Solutions (ACS) designs, certifies, manufactures and distributes PMA parts for airframe and engine components and accessories for Boeing, Airbus, Bombardier, Embraer, Fokker and Saab aircraft. Leveraging both our OEM heritage and our customer service focus, ACS provides our customers with reliable, high performance aerospace products- on time and at an affordable price. ACS… Delivers the Difference to Keep the World's Most Valuable Fleets in the Air, Supplying Sustainable Growth to our customer and delivering Highly Reliable PMA/Alternate OEM Parts at the Lowest Lifecycle Cost in the Industry.

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AJW Group

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AJW Group is the world-leading independent component parts, repair, lease, engine, flight hour programme, and supply chain solutions integrator. Quality and flexibility drive our 24/7/365 support to over 1,000 airlines across 100 countries. AJW Technique, our state-of-the-art component MRO facilities, joins our worldwide inventory hubs and offices, delivering global services, including end-to-end, tailored interior solutions offered by AJW Technique Interiors. AJW Group utilises its global vendor supply chain and partnerships to transform aviation efficiency.

Ultramain Systems

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Ultramain Systems is a global provider of innovative aviation software solutions, specializing in MRO, electronic logbooks (ELB), and digital transformation for airlines and MRO providers worldwide. We are a proven aviation software provider, with aircraft M&E / MRO customers running paperless, end-to-end, from the cockpit to the ground, with solutions covering the aircraft logbook, line and base maintenance operations and MRO operations. ULTRAMAIN® ELB™ — the market-leading electronic logbook software is in approved paperless use at airlines worldwide. ULTRAMAIN ELB operates mobile or installed devices. Step into the future with a fully paperless organization, by stopping at our booth to learn how using ULTRAMAIN's comprehensive suite of integrated solutions can help you see your aircraft data FAST, ACCURATELY, and in REAL-TIME. With a commitment to operational excellence, ULTRAMAIN solutions help aviation organizations enhance efficiency, reduce costs, and streamline workflows. Come talk to us at our booth and learn how ULTRAMAIN v9, including Mobile Mechanic™ and Mobile Inventory™, to our onboard applications such as ULTRAMAIN ELB can eliminate hassles and increase profitability.

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AMETEK MRO

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AMETEK MRO is a well-respected global provider of MRO services to the commercial, regional, and general aviation aftermarkets. With 14 strategically placed locations around the world, our teams are capable of servicing more than 40,000+ aircraft components. We also offer new build and design programs as well as aircraft component management services.

aircraft, allowing the PMA community a smoother transition into the newer fleets."

John Benscheidt is optimistic about PMA sales opportunities on both sides of the airlines' fleets. "Growth potential exists in both older and newer aircraft platforms," he declared. "OEM production backlogs are extending the operational life of older fleets, and durability issues on some newer platforms are accelerating PMA opportunities there as well. Commonality between generations (such as A320ceo and A320neo) extends the market window even further.

Contraction will likely occur where aircraft are being retired in large numbers with limited interchangeability, but most of these larger fleet shifts already occurred during Covid. Overall, we expect growth to outpace any losses."

The Future Looks Promising

Taken as a whole, the market forces that are boosting the PMA industry today seem likely to keep bolstering its fortunes into the future.

Beyond factors such as price and availability, the industry's improved customer research has made a positive difference. "There was a point in time when PMA companies would design a part and then go out and find customers for it," mused Dickstein. "That still happens, but the PMA business model has since shifted to asking customers about which parts they want to see developed, and then doing it."

This approach is certainly endorsed by HEICO. "By working closely with our diverse customer base, new product lines are being identified based upon their fleet-specific wants and needs," Markham said. "This has been a decades-long, proven process of developing new parts and expanding our product portfolio."

PMA manufacturers truly work together to provide alternative solutions to customers' problems. To achieve this goal, "we come together multiple times a year through conferences hosted by MARPA to discuss idea generation and process change to give customers options when the OEM solution is not available to them due to availability, cost, and lead time," said Santare. "We see an opportunity for PMA providers to collaborate on bringing a wider array of technologies to market for the airlines, rather than just operating inside individual 'sweet spots'."

As well, ATS has enhanced its internal IDEA program that encourages ATS team members ("mainly our wonderful mechanics and technicians") to suggest parts for PMA manufacture to our engineering team. "If the part is approved by the FAA, the employee receives a bonus check from our company," Santare said. "Next year, we are rolling out a program enhancement where employees would get an additional bonus if the part becomes an important part of the supply chain for our customers."

Over at ACS, "we're focused on building upon our current product catalog by expanding into part numbers that align with current fleet mix, ATA chapters and Next Higher Assemblies already in our portfolio," said Martinez. "We're also continuing to strengthen our customer relationships. Being the first to understand their stock requirements, upcoming contracts and day-to-day


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problems gives us a competitive edge in an increasingly complex environment. Finally, as supply chain disruptions persist, we've found that parts availability drives the customer's buying decision-making. We're leaning into this need by optimizing our inventory planning and expanding our eCommerce capabilities to get parts into customers' hands faster."

Clearly, PMA parts are becoming more and more common in OEM aircraft. So just how far can this trend go? "While it is unlikely that an entire aircraft will be built using 100% PMA parts, HEICO parts are used in almost every ATA chapter," Markham said. "There are many LRUs where every or almost every replaceable part has a HEICO PMA approved label on it."

"ATS believes that there are areas of the aircraft where, like automobiles, you could theoretically see 30-50% penetration by PMA," said Santare. "There are also areas of the aircraft that are not likely PMA targets within the life cycle of that aircraft type. Many parts of a typical aircraft either remain available for long portions of the life cycle, generate little demand, or are so low cost that PMA does not make sense.

"As for an all-PMA aircraft? It's unlikely from a regulatory and economic sense," concluded Benscheidt. "PMA works best as a complementary strategy, targeting parts where we can deliver clear advantages in cost, lead time, and performance. That's where the industry will continue to be focused." AVM

Jet Parts Engineering's John Benscheidt says growth potential for PMA parts exists in both older and newer aircraft platforms and expects growth to outpace any losses to fleet retirements. Jet Parts Engineering image.

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By Jim Romeo

Barfield: A World-Class MRO Provider Serving the Aviation Community

A conversation with Gilles Mercier, CEO of Barfield.

Barfield is celebrating its 80th anniversary as a company. Acquired in 2014 by Air France KLM Engineering & Maintenance, the company has grown into a now world-leading multi-product aviation maintenance provider with over 500 customers and supporting nearly 250 aircraft globally. Its services include MRO (maintenance, repair, and overhaul), ground support test equipment (GSTE), distribution, rotable and trading, and drones.

We sat down with Gilles Mercier, CEO of Barfield, to discuss the company's legacy, current challenges in the aviation industry, and his outlook on the future of aviation maintenance.

Aviation Maintenance: It's my understanding that Barfield is celebrating their 80th anniversary. Can you provide an overview of the company, its history, and where it's at today in the aviation industry?

Gilles Mercier: Barfield has been a trusted name in aviation for 80 years now. Mr. James Barfield founded the company as an electronic shop in 1945 with a group of fellow veterans. Remarkably, we still operate in the same building where it all began, near the airport.

Over the decades, Barfield evolved into a key player in the MRO sector, distribution, and ground support test equipment. Today, as part of the Air France KLM Group, we serve airlines, MROs, original equipment manufacturers (OEMs), and military customers together with helicopter and general aviation operators.

We operate from four locations: Miami where we also have our headquarters; Precision Electronics in Atlanta; Phoenix, Arizona; and Louisville, Kentucky.

Aviation Maintenance: From your perspective, what are some of the challenges that you see in the aviation industry and specifically with your customers and prospects who seek out your services?

Mercier: The industry is constantly evolving. Right now, our customers are facing significant supply chain disruptions and are looking to reduce operating costs.

There is also a shortage of skilled labor. Many technicians retired after Covid and more retirement looms in the next years, and the demand for qualified technicians is growing. This labor gap is a major concern for the overall industry.

Gilles Mercier, Barfield CEO

In addition, airlines are integrating newer aircraft while still operating older models, which creates complexity in maintenance strategies.

Aviation Maintenance: Looking forward, how stable do you feel the supply chain is for aviation maintenance in general and what are some of the risks you see on the horizon? How has Barfield approached this facet of the aviation industry?

Mercier: The supply chain remains fragile, though it's improving year over year. Lead times are unpredictable, and parts availability can be affected by obsolescence or shifts in demand.

At Barfield we have built strong relationships with our suppliers and OEMs. We provide them with clear visibility into our needs, which helps with inventory planning and reduces disruptions. Since Covid, we've invested heavily in this approach. Our team of talented engineers also plays a critical role in developing solutions for our airlines and partners when challenges arise.

Aviation Maintenance: Looking forward 3-5 years, what will the aviation maintenance industry look like and be challenged with?

Mercier: Training and retention are critical not only for Barfield, but for the entire industry. Aviation demands high standards and strict processes, and you can't train someone overnight.

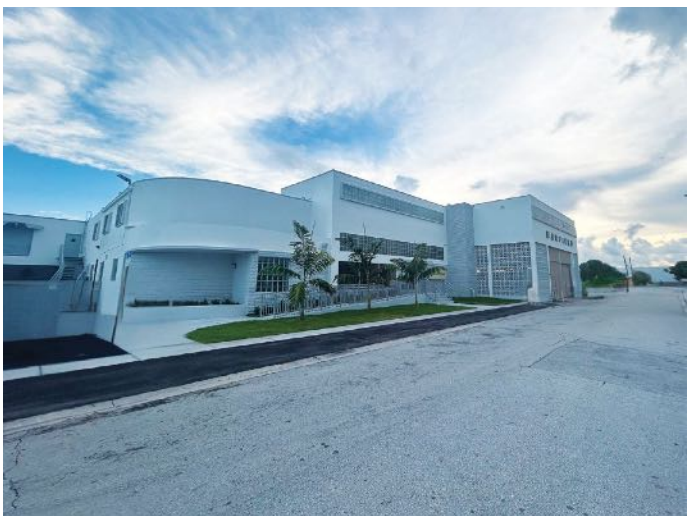
We focus on knowledge transfer at Barfield. We pair younger team members with more experienced employees to ensure continuity and prepare for the future.

Aviation Maintenance: What do you feel is key to success in the aviation industry and are there any stories you can tell that demonstrate such success?

Mercier: I can only speak from my 17 years in the industry. I've learned that success hinges on reliability and relationships. You must do what you say and say what you do. Aviation is global, but it's also a tight-knit community of highly skilled professionals.

One story that stands out to me is from the Covid period. With travel restrictions in place, we wanted to maintain our connection with customers. So, our team created a cookbook featuring recipes from Barfield team members. Each recipe was prefaced by a personal story explaining its special meaning and connection to their families. We sent the cookbooks to our customers as a gift, and it was so well received that we now publish one annually. One customer even asked if they could replicate the idea for their own company and we happily agreed.

I'm proud to be part of Barfield's journey. The company wouldn't exist without our team members, some of whom worked directly with Mr. Barfield many years ago. As we welcome new talent into the company, we remain committed to our values and legacy. We maintain our strong relationships with our customers and partners, and our team is looking forward to serving the aviation community for the next 80 years. AM



Barfield headquarters is located in Miami, Florida. Barfield images.

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By Mario Pierobon

Human Factors for Maintainers in a Digital World

The aviation maintenance industry stands at a particular juncture where traditional hands-on expertise meets ever-evolving digital technology. As aircraft systems become increasingly sophisticated and maintenance operations integrate artificial intelligence, predictive analytics, and automated monitoring systems, the human element remains both the most important asset and ultimate decision maker.

Human factors in aviation maintenance have evolved far beyond the foundational concerns of tool management and procedural compliance. Today's maintenance technicians must navigate a hybrid cognitive landscape where physical dexterity intersects with data interpretation, where experience-based intuition must coexist with algorithm-generated recommendations, and where fatigue management requires both technological sophistication and fundamental human awareness.

The integration of fatigue risk management systems (FRMS) within safety management systems (SMS) represents a paradigm shift towards a predictive safety culture. Simultaneously, the emergence of AI-powered predictive maintenance systems challenges technicians to become interpreters of probabilistic data while maintaining their critical role as decision makers in complex, high-stakes environments.

This convergence of human capability and technological advancement creates new opportunities for safety and efficiency, yet it also introduces cognitive challenges that can have profound implications for aviation safety. Understanding how cognitive biases influence the adoption of AI systems, how shifting workloads affect mental processing, and how automated tools can either support or undermine human judgment is becoming essential for maintenance organizations.

In this feature, we examine these critical intersections, drawing insights from industry experts to illustrate both the promise and the pitfalls of current technological evolutions.

FRMS, SMS, and Technology-Based Fatigue Monitoring

Automated FRMSs are designed to integrate with an organization's SMS, according to Michael Parrish, president of Elliott Aviation. "They can provide information that helps make better planning and staffing decisions within a safety framework. They use data and science to help predict and manage fatigue risk, but they do not replace human judgment," he says. "Fatigue management is ultimately aimed at ensuring the safety and effectiveness of teams. If automated tools can help achieve this goal without adding unnecessary burden, they are worth exploring as part of an overall safety strategy."

Michael Parrish, Elliott Aviation

Dr. Antonio Cortés, GMR Human Performance

Jonathan Huff, TeamViewer

Dr. Antonio Cortés of GMR Human Performance affirms that FRMS seek to prevent one of the most basic factors and causes of human error, i.e., the significant impairment of human performance once a certain level of fatigue has been exceeded. "We know that fatigue directly impacts many of our personal actions, such as increasing the risk of cognitive fixation, sometimes referred to as channelled attention or tunnelling, or distraction. It is no surprise, then, that FRMS are promoted by EASA, FAA, and ICAO, among other agencies. A good FRMS will address the main causes of fatigue, which are sleep loss, circadian misalignment and workload. By integrating fatigue monitoring as a key component of hazard identification and risk assessment into the SMS' systematic safety processes, better performance is achieved," he says. "It is like enhancing our efforts. Furthermore, such anti-fatigue interventions should not be performed only at the technician or inspector level. They require teamwork, close collaboration, and a coordinated approach, many of which should already be present with a good SMS. By integrating this commitment into an SMS, one should aim to also benefit from the established identity protection measures that help foster a Just Culture and encourage voluntary reporting of fatigue-related safety issues."

An FRMS integrated into existing SMS hazard reporting and corrective action processes, rather than being treated as a standalone initiative, fosters overall safety improvements by learning from fatigue alerts, according to Dr. Cortés. "A technician once told me about his wife, a software engineer, who was working herself to the bone and found herself with five days of extra work due to a single typo. In her exhaustion, she had typed the letter 'O' instead of the number '0.' This is exactly the kind of error an FRMS should help us avoid — small oversights that become major headaches when fatigue is left unchecked," he points out. "How would FRMS handle such a situation, if it were self-reported by the individual, if it were managed autonomously, outside of an SMS? Would the system find a Just Culture solution?"

More sophisticated FRMSs can leverage machine learning algorithms to monitor work cycles, circadian rhythms, weather impacts, and even data from wearable sensors to estimate fatigue levels, observes Dr. Cortés. "Such a system can even predict a high fatigue window, recommend postponing non-critical inspections, and assign a second technician in such cases. This growing sophistication and use of technology in FRMSs is also occurring in SMS," he says. "However, low-tech approaches guided by human factors principles should not be overlooked. These approaches can include developing policies for work-rest scheduling practices and promoting healthy habits that become almost automatic, such as listing and verifying steps on a checklist to avoid overlooking an indication or condition, maintaining hydration, double-checking work, or learning to detect mutual fatigue symptoms using a 'buddy' system."

Automated fatigue risk management belongs inside the SMS as an enabler, not as a parallel system, according to Jonathan

TeamViewer says it connects people and technology through AR-powered workflows that transform maintenance, training and aviation operations into a more efficient digital workplace. TeamViewer image.

Huff, senior solutions engineer at TeamViewer. "When paired with TeamViewer Frontline's augmented reality (AR)-enabled workflows, fatigue-related signals become contextual, actionable inputs that strengthen the SMS' core pillars: hazard identification, risk assessment, mitigation, assurance and promotion of a just safety culture," he says. "When fatigue monitoring is implemented through an AR-native platform like TeamViewer Frontline, it becomes a practical safety layer: earlier detection, clearer mitigations, and objective records that support continuous improvement — provided design respects human factors, preserves worker control and avoids creating new cognitive or administrative burdens."

Human factors principles should guide the implementation of technology-based fatigue monitoring to avoid creating additional stressors, including prioritizing situational fit and minimal interruption, affirms Huff. "AR prompts and fatigue alerts should be designed so they appear only when relevant to the task phase, and present concise, actionable guidance rather than lengthy diagnostics. Head-mounted displays and voice control should be used to keep technicians focused on the physical task and reduce the cognitive cost of shifting attention," he says. "Technicians should be allowed to acknowledge an alert, request a remote expert, or follow a defined mitigative workflow rather than enforcing a one-size-fits-all lockout. Using TeamViewer Frontline's guided workflows in training, workers experience the fatigue-mitigation workflows in low-risk settings before relying on them in service. Lastly, routine follow-ups and reporting should be automated to avoid increasing administrative workload, and TeamViewer Frontline dashboards should be used to make

Human factors considerations must evolve alongside technological capabilities. The goal is not to eliminate human judgment but to enhance it through structured verification processes, collaborative interfaces and escalation protocols that honor both algorithmic insights and experiential wisdom.

organizational risk visible without manual collation."

Human factors initiatives not directly related to fatigue prevention also help prevent fatigue-related errors, such as automatic toolboxes that alert about tool shortages at the end of the shift, according to Dr. Cortés. "The more one invests in raising awareness of how it is not possible to simply 'tackle fatigue' with force, and the more one learns about maintenance resource management (MRM) procedures and habits to fatigue-proof tasks, the fewer unwanted maintenance events one will experience," he says. "The current SMS framework can be leveraged for FRMS purposes by defining policies, identifying and managing fatigue-related risks, measuring these factors as part of safety assurance and promoting awareness that fatigue can be lethal."

Cognitive Workload Changing and Digital System Interaction

Parrish points out that with the rise of technology in maintenance processes, the cognitive workload for technicians is changing. "Traditional maintenance relied largely on manual skills and experience, while today's work often involves interacting with digital systems, troubleshooting software and interpreting data, in addition to hands-on tasks. This requires technicians to span different types of thinking. They must move from physical, task-based work to analyzing information and making decisions based on technology reports. To adapt, we focus on training, soft skills, and providing teams with the tools they need to gain confidence in using new systems," he says. "The goal is to ensure that technology supports our technicians rather than creating unnecessary complexity. By providing clear procedures, ongoing training, and access to resources, we help our teams manage these transitions effectively while maintaining the high standards of safety and quality our customers expect."

Dr. Phillip Jasper, J.S. Held

According to Dr. Phillip Jasper, principal on the Human Factors and User Research team at J.S. Held, the current transformation in cognitive workload introduces dual task demands, requiring technicians to seamlessly transition from hands-on, mechanical work to interacting with digital interfaces. "This cognitive switching can lead to increased task fragmentation, increased mental workload, and workflow disruptions. That said, not all impacts are cause for concern, as well-designed automated systems can significantly increase efficiency and ease technicians' workload by taking responsibility for routine tasks, allowing them to focus exclusively on those that truly require their attention. Conversely, poorly designed systems often require constant input or supervision, further increasing technicians' workload rather than alleviating it," he says. "Adapting to these changes requires thoughtful interface design; for example, minimizing cognitive load through intuitive layouts, as well as training that reflects real-world task transitions. Simulation-based training or hands-on scenario exercises that include both digital and manual transitions can help crews develop the mental models needed to operate confidently in hybrid workflows."

AR-assisted maintenance does not eliminate cognitive work, but it redistributes and refines it, according to Huff. "A TeamViewer Frontline's peculiarity is that it shifts routine information handling away from fragile human memory while preserving the technician's role as the critical decision maker. With thoughtful training, interface design, and governance, teams can reduce unnecessary cognitive switching, improve throughput, and raise safety and quality simultaneously," he says.

AI-Powered Predictive Maintenance

AI-based predictive maintenance has the potential to improve efficiency by predicting and reporting problems before they occur, Dr. Jasper affirms. "However, these systems shift the technician's role from problem solver to interpreter of probabilistic data, a cognitively different task. One of the primary challenges of human factors in this context is understanding uncertainty," he says. "AI systems often provide probabilities or confidence levels, which technicians must translate into actionable decisions. Another challenge is overconfidence and under confidence. If AI predictions are accepted without thorough analysis, critical issues may go undetected or, conversely, ignored due to scepticism. Finally, alert fatigue, a well-known challenge that human factors scientists have been discussing for decades, can desensitize users to frequent and ineffective alerts, similar to the problems observed in cockpit warning systems."

AI-powered predictive maintenance systems reduce the mental burden on users by automating data analysis, detecting faults early, simplifying interfaces, and offloading routine decisions, affirms Huff. "However, risks include overreliance on AI, diminished user skills, reduced trust under cognitive overload, and increased mental strain from poorly designed interfaces," he says.

Dr. Cortés believes that too often, when referring to human factors, there is a tendency to discuss obvious and complex topics, like distractions and communication breakdowns, without realizing that there are many smaller, subtle effects that impact human performance in unexpected but significant ways. "For example, the thinking biases all humans have influence the adoption and use of AI-based predictive maintenance systems for decision making. Biases are sometimes difficult to understand, but they can influence human thinking in ways that silently have a significant impact, especially if one's own biases begin to feed back into oneself," he says. "Many people find it flashy to talk about artificial intelligence, the incredible practical insights AI can generate in maintenance, or about how it helps anticipate problems while simultaneously improving safety, reliability, and operational efficiency. But AI proponents themselves often shy away from discussing data, as such conversations lack the brilliance of AI."

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If the goal is to have reliable AI, whether for predictive maintenance or other processes, there must first be a discussion on data quality and completeness, affirms Dr. Cortés. "For AI-based systems, data is essentially the fuel of the system. Poor data quality or an incomplete amount of data can produce inaccurate AI output. This explains the growing emphasis, rightfully so, with the 'certified data' that fuels AI systems. Predictive excellence depends on data quality," he says. "There is a tendency to overlook the quality and completeness of data when talking about AI. Humans are naturally drawn to new and exciting ideas, a tendency some call 'novelty bias'. There is a predisposition to be captivated by the new and shiny, to the detriment of familiar fundamentals. Furthermore, humans fall prey to the availability heuristic, judging importance based on what comes to mind first. Because AI success stories are everywhere, one can overestimate the true effectiveness of AI and pay less attention to hidden factors. Humans may also fall victim to an overconfidence bias, which leads to overestimate the reliability of data and AI systems."

To address current challenges, AI system design should promote transparency, while maintenance organizations may consider investing in training that teaches not only how to use AI but also how to think in concert with it, according to Dr. Jasper. "This builds appropriate trust and preserves the technician's critical thinking role. However, caution is needed, as AI is not yet sufficiently advanced to serve as a completely reliable tool for detecting fatigue or other cognitive states," he says. "More research is needed before we can accurately measure the complex processes of the human brain, let alone rely on AI to interpret that information or generate recommendations based solely on its inputs."

Cognitive Bias and Over-Reliance Issues

When working with AI-generated recommendations, one of the challenges is the potential risk of cognitive bias, observes Parrish. "Technicians may become overly reliant on the system, assuming its recommendations are always correct, or they may underestimate valuable information if it conflicts with their own experience. Confirmation bias and automation bias are common examples that can influence the decision-making process. Balancing human expertise with system recommendations requires a structured approach," he says. "Technicians should be trained to critically evaluate data and use AI insights as one input among many. Clear procedures, cross-checks, and open communication help ensure that human judgment remains central, especially when recommendations conflict with practical experience. The key is to view technology as a tool to enhance the decision-making process, not replace it, so that safety and quality remain the top priorities."

Huff illustrates some other cognitive biases which may be observed when working with AI systems. "The anchoring bias occurs when AI recommendations 'anchor' a user's thinking, making it harder to consider alternative options. The authority bias is when users treat AI systems as authoritative, leading to blind trust in outputs. The framing effect is when the way AI presents information influences decisions, even if the underlying data is the same," he says. "By fostering collaboration rather than competition between AI and human expertise, organizations can unlock the full potential of predictive maintenance while minimizing errors and maximizing trust. AI excels at pattern recognition and data crunching, but it lacks contextual intelligence, i.e., the ability to understand why a machine might behave differently in a specific environment or under unusual conditions. Human experts bring intuition, experience and adaptability that AI simply cannot replicate."

According to Dr. Jasper, organizations should design collaboratively. "Interfaces should present AI data in a way that supports human reasoning; for example, highlighting the reason why a particular prediction was made. Organizations may also consider establishing escalation protocols so that, when AI recommendations conflict with expert judgment, there is a clear and structured way to resolve the discrepancies without fear of repercussions," he says. "Ultimately, the goal is to create human-AI teams, where each supports the other's strengths, so that AI provides speed and scalability, while humans contribute context, experience and judgment."

Summing Up

The future of aviation maintenance lies not in choosing between human expertise and technological capability, but in converging towards their optimal integration. The most significant advances in maintenance safety and efficiency emerge when sophisticated systems enhance rather than replace human judgment, when fatigue management combines scientific rigor with practical awareness, and when cognitive biases are acknowledged and addressed rather than ignored.

The implementation of comprehensive FRMS within existing SMS frameworks demonstrates that effective safety management requires both systematic processes and cultural commitment. Technology can predict fatigue windows and recommend staffing adjustments, but the cultivation of Just Culture principles and voluntary reporting mechanisms depends fundamentally on human leadership and organizational values. The most advanced monitoring systems remain ineffective without the human factors foundation that encourages open communication about safety concerns.

Similarly, the promise of AI-powered predictive maintenance systems will only be realized when organizations invest equally in data quality and the training of human operators. The cognitive shift from problem solver to data interpreter represents a fundamental transformation in the maintenance technician's role, one that requires thoughtful interface design, comprehensive training programs and the development of new models for hybrid workflows. The recognition that data quality has cornerstone importance underscores that technological advancement must be grounded in meticulous attention to foundational elements.

Perhaps most critically, the challenge of cognitive biases, from automation bias to confirmation bias, reveals that human factors considerations must evolve alongside technological capabilities. The goal is not to eliminate human judgment but to enhance it through structured verification processes, collaborative interfaces and escalation protocols that honor both algorithmic insights and experiential wisdom.

Moving forward, maintenance organizations that embrace this integrated approach will find themselves better positioned to navigate the increasing complexity of modern systems. By fostering human-AI teams where each element supports the other's strengths, these organizations can achieve the dual objectives of enhanced safety and efficiency while maintaining the human-centred focus that has always been the main asset of aviation safety.

The path ahead demands investment in the more challenging but ultimately more rewarding work of optimizing human-technology partnerships. In this endeavor, the maintenance technician remains what they have always been: a guardian of flight safety, now equipped with predictive tools to fulfill this critical role. AM

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By Mark Robins

Aviation Composite Repair: An Essential Core Competency

A critical enabler of aviation, composite repair ensures continued airworthiness and aircraft reliability.

Composite materials offer the aerospace industry many benefits because they are stronger, lighter and more durable than metals like aluminum for many components and applications. These materials' repair is a vital part of maintaining today's aircraft. With their increasing use in airframes, control surfaces, nacelles and interiors, the ability to repair rather than replace them helps operators reduce costs, minimize downtime and extend the service life of critical structures, while ensuring safety and regulatory compliance.

"Composite repair is the unsung backbone of the aviation industry," says Nick McDonald, vice president and general manager of Evans Composites, Mansfield, Texas. "As fleets age and shift increasingly toward composite materials, its role has become indispensable. At its core, composite repair ensures that the external components of every aircraft remain safe, reliable and airworthy."

Sunny Mirchandani, general manager at HAECO Composite Services, Greensboro, North Carolina, explains that, "Composite materials now account for more than half of the structure in advanced aircraft such as the Boeing 787 and Airbus A350 … making it a critical enabler of modern aviation. Effective repair solutions are essential not only to restore structural integrity after damage but also to ensure the continued airworthiness and reliability of these aircraft throughout their life cycle. By maintaining safety standards while minimizing downtime and cost, composite repair supports both operational efficiency and the long-term sustainability of the aerospace industry."

Repair Techniques

While there are different composite repair procedures, each has the basic function of restoring a part's structural performance, aerodynamic smoothness and safety certification.

Composite cosmetic repairs are used when the integrity of a part is not affected by the damage. "Cosmetic repairs address surface scratches, paint or erosion without affecting structural integrity," says Nick Weber, regional vice president of Middle East, EXECUJET MRO Services, Johannesburg, South Africa.

Scarf repairs remove damaged material and tapers the edges to bond in new composite layers. "[This] provides structural integrity and restores aerodynamic shape," says Kyle Shoemaker, director

Nick McDonald, Evans Composites

Sunny Mirchandani, HAECO

Nick Weber, EXECUJET MRO Services

Kyle Shoemaker, Coltala Aerospace

of marketing at Coltala Aerospace, Mansfield, Texas. "Bolted/bonded patch repairs add a composite or metallic patch over the damaged area using fasteners or adhesive. [This] provides strength quickly but may not be as aerodynamic."

Wet layup repair is a practical solution for less structurally demanding applications or field-level repairs. "Resin injections fill damaged areas with resin under pressure, or a flush plug patch by removing the damaged section and filling the hole with adhesive material," says François Fermaut, aerostructures operations director at Vallair. "This also includes some temporary wet layup repairs performed on the aircraft through the installation of composite layers impregnated with resin and cured under a vacuum bag with a hot bonding system."

"Wet layup involves saturating dry fiber material, typically fiberglass or carbon fiber, with resin, layering it to restore strength and then curing it under controlled conditions," adds Patrick Meyer, senior vice president and general manager at STS Aviation Services, Shannon, Ireland.

In contrast to wet layup repair, pre-preg repairs use fabric pre-impregnated with resin, requiring controlled temperature and pressure — typically through an autoclave or heat blanket — to cure. "This method offers greater consistency and strength, making it the preferred choice for load-bearing or primary structures," Mirchandani says. "While both techniques aim to restore structural performance and airworthiness, the selection depends on the criticality of the component, repair environment and operational requirements."

"Core replacement focuses on damaged honeycomb or foam structures, which is crushed or moisture-contaminated," Meyer says. "The damaged core is removed and replaced before being sealed with new plies. Vacuum bagging is often used with wet layup and core replacement techniques to eliminate air pockets and excess resin, while controlled heat application ensures uniform curing and a stronger bond. The end goal is always the same: restore the original strength, rigidity and aerodynamic profile of the component."

The taper scarf repair technique for composite structures is where a tapered cavity is machined into the damaged area, replacing the damaged material and providing a large, gradual surface area for bonding a new patch. This technique creates a joint with uniform shear properties, restoring the damaged composite structure to its designed strength and avoiding the need for external, bolted patches. Abaris image.

Difficult to Repair

Some composites are more difficult to repair than others. And, any structures with complex geometries or limited access will be a challenging repair. This includes, "Structures that have integrated (molded) stiffeners such as stringers in composite wing skin and fuselage designs," says Louis C. Dorworth, direct services manager at Abaris Training Resources Inc., Sparks, Nevada. "These are susceptible to high energy, wide area, blunt impact (HEWABI) damage from ground vehicles and other overloading situations, and are hard to detect, inspect and repair. On a smaller scale, parts and structures with compound contoured, aerodynamic requirements can be challenging and often require localized tooling to maintain surfaces."

Meyer explains that large structural components such as fuselage sections, wing skins or internal load-bearing members are particularly challenging because they cannot always be removed from the aircraft. "In those cases, repairs must be performed in situ, often in less-than-ideal environments compared to a clean workshop. This creates added challenges for quality control, health and safety, and environmental conditions like dust, temperature and humidity, all of which directly affect repair outcomes."

At Vallair, Fermaut has witnessed three problematic composite repair scenarios:

- The position of the damage. When Vallair technicians need to repair the lower skin of the fly control, it's not always evident how to properly install the repair patch and the vacuum bag due to gravity.
- The shape of the part to be repaired. If the surface is not flat, the part needs to be removed and Vallair needs to perform some local tooling to support the material during curing process mainly for the belly fairing and radomes.
- The nacelle parts — the composite is exposed to lots of stress, environmental or heat damage. For those units Vallair teams normally need to remove them from the aircraft and send to the shop to perform the defect analyses and repair to the correct condition.

François Fermaut, Vallair

Patrick Meyer, STS Aviation Services

Bag (a vacuum bag) and bonder (a hot bonder device) are components of a hot bonding process, where the vacuum bag seals the repair area, and the hot bonder applies precise heat and vacuum to cure adhesive or resin, ensuring proper compaction, bond strength and restoration of structural integrity to the composite structure. Abaris image.

Weber agrees that composite repairs are more challenging on curved or complex geometries like winglets, nacelles and radomes because achieving correct ply orientation, surface preparation and vacuum bagging can be technically demanding. "Large, bonded structures, such as fuselage skins, can also be difficult due to access, repair size and the need for precise curing conditions."

Composite Repair Evolution

In the last five years, Fermaut says Vallair has increased non-destructive testing (NDT) during composite repairs, at different stages including initial inspection and/or final check. Even if they still use visual and TAP test methods to find disbanding in a sandwich structure, the use of thermographic or ultrasonic inspection is now a key factor. "This process gives us a clear understanding of the condition of the part and we can perform a clear mapping of the damage. In the MRO repair environment, Vallair can see improvements at all stages of a repair. During inspection, advanced NDT methods produce a correct mapping of the damage. During the repair itself new scarfing tools ensure repeatable and accurate repair geometries. During the curing system portable hot bonding systems [have improved]. And there has been improvement of the repair material itself: adhesive and resin."

Composite repair sophistication has advanced significantly via artificial intelligence, machine learning and advanced software tools. Collectively, these technologies are slowly transforming composite repair from a highly manual craft into a more data-driven, precise and predictive discipline, ultimately improving safety, efficiency and sustainability in aviation maintenance.

"At its core, AI involves creating algorithms and models that can analyze data, identify patterns and make decisions based on that analysis," Mirchandani says. "Without quality data, AI models are ineffective. AI adoption for composite repairs would require an AI database of repairs. For this to happen, many MROs, operators and OEMs would need to foster collaboration and promote transparency to contribute repair-data as a source for AI database. Composite repairs are a special skill and require process, materials and tools that are often of competitive advantage and an IP of the organization. There has been adoption of AI and machine learning (ML) and NDT where AI can identify and characterize damage (e.g., delamination, impact cracks) far more consistently than the human eye, thus reducing inspection time and eliminating technician subjectivity."

ML algorithms can analyze large datasets from previous repairs and inspections, helping refine repair strategies and forecast material behavior. It supports continuous improvement by studying thousands of repair outcomes, refining processes and recommending more efficient repair schemes.

McDonald has witnessed the development of complex composite 3-D printing of aircraft components. He says it allows for the production of hard-to-find components at cheaper prices and in some cases higher durability. Also, "A major improvement in our shop is the use of a new cloud-based ERP allowing our technicians to have their data with them when they need it and not having to waste time returning to a workstation."

"Advances in NDI methods and equipment continue to make inspection easier and more precise," Dorworth says. "A technician can do the inspection on the part, on the aircraft, and consult in real time virtually with an offsite ASNT Level III engineer to best understand the damage assessment prior to and after damage removal and repair."

New technologies such as Smart Susceptor heat systems are finding their way into procedures. This equipment plays an active role in heat distribution over the repair area by reducing heat to hotter areas while continuing to heat cooler areas. Dorworth says it helps compensate for underlying heatsinks such as frames and stringers. "Other innovations such as using double vacuum debulk (DVD) processing for near autoclave quality patches to embedded heat sensors, surface-tolerant repair resins and other emerging technologies continue to enhance aviation composite repairs moving forward."

Advanced NDT methods produce more accurate mapping of the damage, new scarfing tools ensure repeatable and accurate repair geometries and portable hot bonding systems have improved, according to Vallair's Francois Fermaut. Abaris image.

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Cloud-based and internal digital platforms, along with hand-held tablets or cell phones allow the technician/mechanic direct access to instructions, drawings, specifications and serialized record-keeping programs where step-by-step photo documentation can be stored. Weber explains that because of cloud testing, remote monitoring, and sharing of repair and curing data allows OEMs and operators to verify repair compliance in real time, enhancing traceability and quality assurance.

Digital transformation is indeed reshaping aviation repair and testing by making maintenance more predictive, data-driven and connected. Cloud-based platforms now store repair records, inspection results and historical data, enabling maintenance teams to access information globally in real time. "Combined with digital twin technology, operators can simulate the performance of components under various conditions, track degradation and anticipate failures before they occur," Mirchandani says. "This supports predictive maintenance, where algorithms analyze fleet-wide trends to forecast repair needs, reduce unscheduled downtime and optimize maintenance planning. Ultimately, digital transformation enhances reliability, efficiency and safety while lowering lifecycle costs."

"Composite repairs are not 'difficult' but they require the technician to follow all the processes without deviation, precise layering, bonding, curing and inspection," Fermaut says. "A single mistake can compromise the entire structure. If the process is properly followed the repair can meet or exceed the strength of the original structure. Most composite repairs are invisible when completed and covered by the paint scheme of the aircraft. A proper follow-up of those repairs and a complete record needs to be kept by the CAMO to warranty the airworthiness of the aircraft."

A Core Competency

Composite structure repair has moved to the forefront of aviation safety and reliability. It is not simply a maintenance task — it is a highly specialized discipline that combines materials science, precision engineering and advanced technologies to ensure structural integrity. It requires a unique combination of technical knowledge, precision and environmental control. Meyer believes that unlike traditional metalwork, mistakes in composite repair can compromise the structure in ways that are difficult to detect until much later. "That is why investment in training, tools and procedures is so critical. As more aircraft move to composite structures, the industry must continue to raise awareness that composite repair is a core competency, not an afterthought."

Acknowledging that composite repair is indeed an essential core competency for modern MROs and no longer a niche capability, Weber stresses that with composite content in new-generation aircraft continuing to rise, "Operators should ensure they partner with MROs that have the facilities, OEM approvals and skilled technicians to handle both minor and complex composite repairs efficiently and safely." AVM

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Supply chain issues have had significant negative impacts on airlines: driving-up leasing costs, increasing the average fleet age to 15 years (from 13 in 2015), cutting the fleet replacement rate to half the 5-6% of 2020, and reducing the efficiency of fleet utilization (using larger aircraft than needed on some routes, for example), IATA said this summer.

By Ian Harbison

Supply Chain Bottlenecks, Shortages, Disruptions Continue

The International Air Transport Association (IATA) expects severe supply chain issues to continue to impact airline performance into 2025, raising costs and limiting growth.

IATA quantified the scale of the challenges facing airlines because of supply chain issues in its latest airline industry outlook:

- Average age of the global fleet has risen to a record 14.8 years, a significant increase from the 13.6 years average for the period 1990-2024.
- Aircraft deliveries have fallen sharply from the peak of 1,813 aircraft in 2018. The estimate for 2024 deliveries is 1,254 aircraft, a 30% shortfall on what was predicted going into the year. In 2025, deliveries are forecast to rise to 1,802, well below earlier expectation for 2,293 deliveries with further downward revisions in 2025 widely seen as quite possible.
- The backlog (cumulative number of unfulfilled orders) for new aircraft has reached 17,000 planes, a record high. At present delivery rates, this would take 14 years to fulfil, double the six-year average backlog for the 2013-2019 period. However, the waiting time is expected to shorten as delivery rates increase.
- The number of "parked" aircraft is 14% (approximately 5,000 aircraft) of the total fleet (35,166 as at December 2024, including Russian-built aircraft). While this has improved recently, parked aircraft remain 4 percentage points higher than pre-pandemic levels (equivalent to some 1,600 aircraft). Of these, 700 (2% of the global fleet) are parked for engine inspections. We expect this situation to persist into 2025.

"Supply chain issues are frustrating every airline with a triple whammy on revenues, costs, and environmental performance. Load factors are at record highs and there is no doubt that if we had more aircraft they could be profitably deployed, so our revenues are being compromised. Meanwhile, the aging fleet that airlines are using has higher maintenance costs, burns more fuel, and takes more capital to keep it flying. And, on top of this, leasing rates have risen more than interest rates as competition among airlines intensified the scramble to find every way possible to expand capacity. This is a time when airlines need to be fixing their battered post-pandemic balance sheets, but progress is effectively capped by supply chain issues that manufacturers need to resolve," said Willie Walsh, IATA's director general.

Specifically, IATA noted that persistent supply chain issues were at least partially responsible for two negative developments:

- Fuel efficiency (excluding the impact of load factors) was unchanged between 2023 and 2024 at 0.23 liters/100 available tonne kilometers (ATK). This is a step back from the long-term (1990-2019) trend of annual fuel efficiency improvements in the range of 1.5-2.0%.
- Exceptional demand for leased aircraft pushed leasing rates for narrow body aircraft to levels 20-30% higher than in 2019.

"The entire aviation sector is united in its commitment to achieving net zero carbon emissions by 2050. But when it comes

Willie Walsh, IATA

Mark Shimizu, AerFin

to the practicality of actually getting there, airlines are left bearing the biggest burden. The supply chain issues are a case in point. Manufacturers are letting down their airline customers and that is having a direct impact of slowing down airlines' efforts to limit their carbon emissions. If the aircraft and engine manufacturers could sort out their issues and keep their promises, we'd have a more fuel-efficient fleet in the air," said Walsh.

One company caught in the middle of this is U.K.-based AerFin. Specializing in aviation asset management, it buys, sells, leases and repairs aircraft, engines and parts to maximize the value for owners and provide a lower-cost supply of material to airline, lessor and MRO customers.

Right now, says Mark Shimizu, SVP EMEA, engine material leads demand — especially hot-section parts and engine LRUs — because OEM lead times and pricing pressure keep operators looking for certified Used Serviceable Material (USM) to keep aircraft flying and to reduce engine shop-visit costs. Life Limited Parts (LLPs) are particularly sought after thanks to the high cost-saving potential from procuring components with specific hours and cycles remaining to help operators align engine build goals.

High-use, flight-critical LRUs on the airframe side — avionics, pneumatics/air systems, hydraulics and flight-control actuators — also remain priority items because of their impact on dispatch reliability.

Landing gear and APU material also see steady pull because they are lifecycle-driven and it is expensive to defer maintenance. USM shortens downtime compared with waiting on new.

In principle, lower-failure structural items and many cabin/interior parts should be more stable because failure rates are lower and maintenance is more predictable. In practice, the opposite can occur. With fewer aircraft disassemblies taking place, these event-driven structural items are becoming harder to source, and new-buy lead times are extreme. Cabin interior items can suffer the same issue. Operators are facing indefinite lead times in some cases for repairs of various flight surfaces, so USM — where available — is key to circumnavigating the delay.

Piece parts from cooler sections of engines, which experience lower levels of scrap exposure due to reduced heat and degradation, are typically more reliable and therefore less exposed to bottlenecks. The greatest pressure remains where turnaround times, OEM pricing and utilization collide — engines and high-failure LRUs. This reinforces the need for a robust, reliable supply chain that can identify and secure these dependable parts ahead of surges in demand, ensuring operators have continuity even when high-stress components face extended lead times.

The most active source of UMS at the moment is from strategic teardowns. In fact, AerFin has just acquired a fifth A320neo, from EMPAviation Trading, with the continued collaboration of a Middle Eastern investor. Like the previous five aircraft, it has completed a six-year maintenance check and full interval shop visits on both engines. The airframe is planned for disassembly in Asia to support existing customer base in the region. The engines are available for purchase.

He says AerFin differentiates itself through acquisition and purchasing at scale, buying whole assets to unlock material in volume. This ability to execute at fleet level sets it apart from much of the market and allows it to feed high-quality USM into the supply chain faster and more predictably. Inventory purchases to build breadth and responsiveness across our hubs.

Repair and refurb

Mark Shimizu continues: "AerFin's repair management is key to turning material faster and stabilizing flow for operators. By leveraging strategic relationships and Tier-1 vendor partnerships, we can launch high-volume repair campaigns that secure favorable pricing and turnaround times. Our scale in repair activity gives us the agility to keep material moving and customers flying when market constraints tighten."

He adds that this is a global issue driven by a supply-led market. AerFin supports a variety of regional, narrowbody and widebody aircraft and their complementary engine types. Engines operated in hot-and-harsh environments can face higher maintenance costs because Exhaust Gas Temperature (EGT) margins degrade faster and OEM manuals can impose stricter limits in these conditions.

AerFin mitigates these pressures with strategically located stock — Gatwick, Newport, Miami and Singapore — to support operators locally and compress lead time.

Of course, short supply and extended lead times have driven higher fair-market values, particularly for engine material and critical LRUs. While USM prices are increasing, they still offer considerable cost savings compared with new. The continually rising price of whole assets inevitably cascades to USM prices.

Those increases have been significant with engine hot-section components and scarce LRUs with long OEM turnaround times showing the most acute inflation, reflecting where downtime risk, and willingness to pay to avoid it, is highest. CFM HPT blade parts are among the highest-demand items on the market, with production delays and high scrap rates intensifying pressure. Engine LRU pricing continues to rise as engine disassembly volumes remain limited. Early teardowns are helping to ease these pinch points by bringing fresher, durable parts into the pool sooner.

He describes the solution to the problem as "use the difficulty": accelerate strategic teardowns across all asset types — from A320neo to A330, E-Jet, 777, 737, CFM56-5B, CFM56-7B, V2500 and CF6 — to unlock high-quality USM earlier, reduce OEM dependence and cut operator downtime. In addition, make supply programmatic by combining teardown-fed USM, repair management and, where appropriate, green-time engine leasing to bridge peaks in demand. Partnering with key strategic customers allows AerFin to provide integrated supply solutions in this constrained market.

Positioning inventory close to the need means AerFin's extensive stock can be spread globally without impacting availability in any specific region, while planning dynamically with customers by sharing live TATs, FMVs, utilization and vendor performance can secure critical material ahead of events.

He believes normality will return progressively as OEM capacity

Boeing says anticipating parts needs by using a tailored approach based on unique mission requirements is the backbone of their total lifecycle management approach. This approach brings efficiencies, cost savings and increased capabilities in everything from parts and repairs to delivery and analysis, the company says. Boeing chart.

improves and as more mid-life assets feed USM through structured teardowns. The aftermarket remains structurally strong for the medium term, so the pragmatic path is to stabilize now with programmatic USM, repair management and targeted leasing rather than waiting for a single step change. IBA released its second engine value update for 2025 in September, and it echoes Shumizi's views.

Values for narrowbody engines increased through 2025. The new generation LEAP-1A and PW1100G are prime examples of engines showing strong market value performance despite well-publicized engine performance-related issues. Most discussed are Pratt & Whitney and aircraft-on-ground (AOG) occurrences related to powdered metal issues on their GTF engines. However, recent reports point towards increased material availability aimed at improving AOGs.

The current generation of engines, such as the CFM56-5B/-7B and V2500-A5, have benefited from showing year-on-year market value increase as operators continue to acquire and lease engines to maintain their flight schedules. This year has been one of both increased transaction pricing and lease rates. The CFM56-7B market finds itself in a situation with a distinct lack of availability, and both market values and lease rates are above the long-term trend. This is partly due to elevated levels of operator retention of the 737NG amid variant delays and FAA production ramp-up restrictions on the LEAP-1B powered MAX. There is a similar situation with 777-300ER due to 777X delays.

Moving to the regional engine market, this is seen as relatively stable for turbofans and turboprops. However, the instability can have serious consequences for smaller operators.

The U.K. Civil Aviation Authority recently published its 2Q2025 Aviation Trends report, which showed that, of 20 airlines surveyed, Blue Islands was the least reliable, with only 55% of flights arriving on time or less than 15 minutes late.

The airline operates a fleet of four ATR 72-200s and one ATR72-600. It had been forced to restrict operations in late May after the ATR 72-600 arrived that month, almost four months late due to an extended lease transition maintenance turnaround time. In addition, a newly installed Pratt & Whitney Canada PW124B engine on one of the 72-200s experienced FOD problems. Extended delays in accessing the required parts and maintenance services meant the airline needed to access an alternative new engine.

The airline not only suffered a financial hit, but it also ran a huge risk of reputational damage. It operates from hubs in Guernsey and Jersey in the Channel Islands. Those communities rely on air travel to access services not available locally. That means reliability is a paramount requirement when selecting an airline and Blue Islands does not have a monopoly. The good news is that, in August, of 863 flights, 74% arrived on time and 99% of the schedule was completed.

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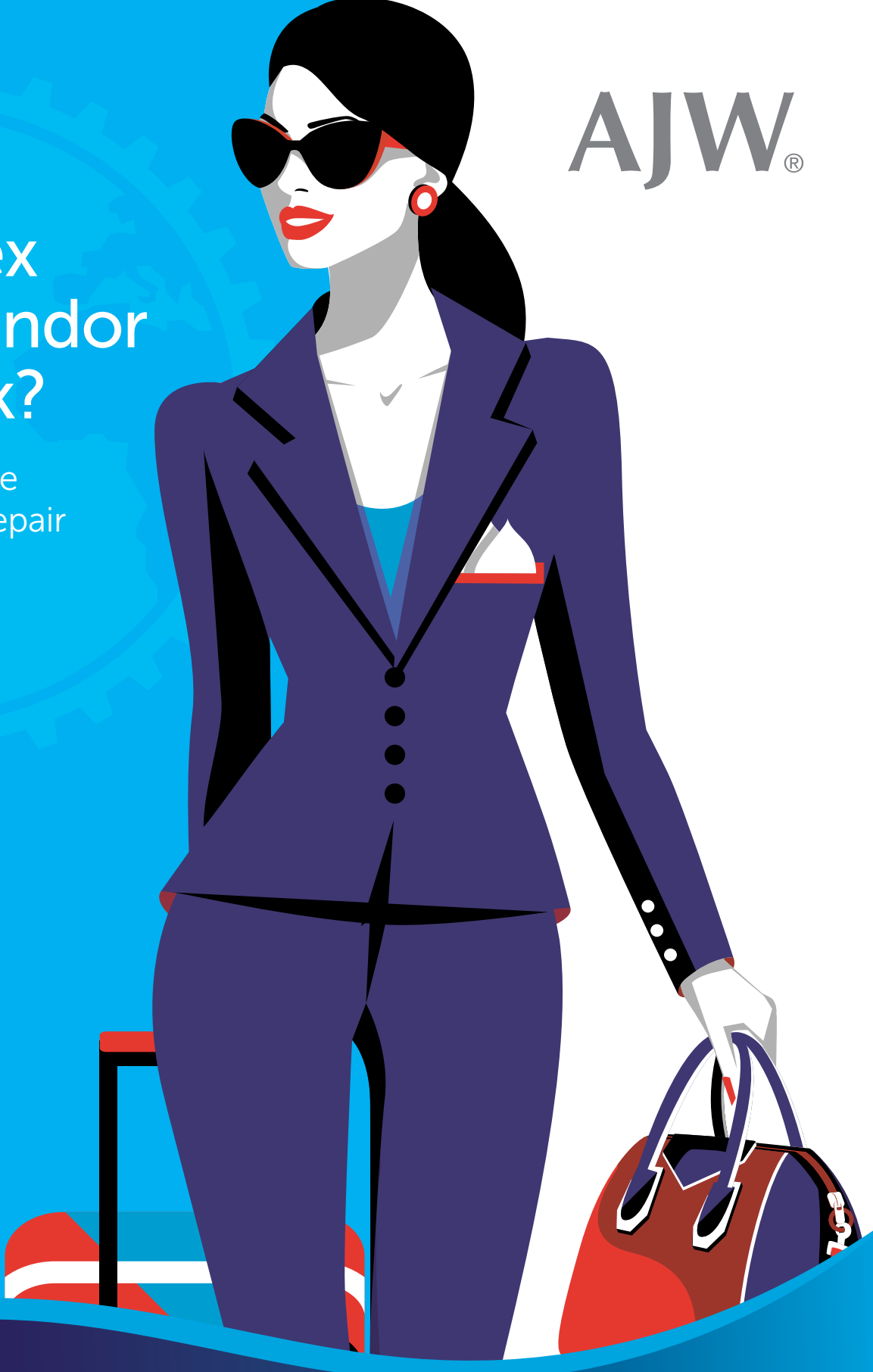

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By James Careless

What's in the Ultimate Tool Kit?

In an industry where cutting-edge airframes and advanced engines grab the public's attention, the actual tools that MROs use to keep these items in service rarely get much attention, if any at all.

But make no mistake — without high quality hand tools, equipment testers and durable lightweight ladders, no MRO shop would be able to maintain, repair, and overhaul any of these high-tech items. To shed light on these vital assets, Aviation Maintenance magazine is examining three leading suppliers — Sonic USA, Druck, and LockNClimb — to learn more about their products, including the new tools they are bringing to the MRO market.

Three Trusted Tool Suppliers

When it comes to doing aircraft and engine repairs, Sonic USA (sonictoolsusa.com) naturally comes to mind. Sonic USA provides high-quality hand tools, toolboxes, and premium storage solutions to the aviation, space and automotive sectors. Founded in 2015, Sonic USA is the North American subsidiary of the Netherlands-based Sonic Group, a global specialist in the development, marketing, and distribution of professional hand tools and storage solution systems since 2004.

Colby McConnell, Sonic USA

"Our aviation toolsets generally come in three versions with customizable foam inserts and serialized tool ID laser etching: basic (145 pieces), intermediate (263 pieces), and advanced (454 pieces)," said Sonic USA CEO Colby McConnell. "We most recently announced a TSA-approved mobile case that can hold either the beginner set, or our latest MRO offering, the intermediate mobile case set, respectively. We also provide a Sonic Next S12 XD storage system with eight drawers."

Durability is a top priority for Sonic USA. "We want to ensure our tools are built to last a lifetime," McConnell said. "This is why Sonic USA stands behind every Sonic tool we make via the hassle-free lifetime warranty program that is the best in the tool industry. Our online warranty process takes just a few minutes to submit and replacement tools are processed within 24 hours. They are

Sonic 1 – Sonic's Basic Aviation Toolset has 145 pieces.

Sonic 2 – The Sonic Intermediate Toolset has 263 pieces.

Sonic 3 – The Sonic Advanced Toolset has 454 pieces. Sonic USA images.

then shipped out from our warehouse in Auburn, Alabama."

Of course, one major reason that mechanics lose access to their most-prized tools is not because they break, but rather because they go missing. This is why Sonic USA offers its aviation customers the "No Lost Tools" Guarantee, which the company announced earlier this year. "Sonic will replace up to $250 in hand tools on any of Sonic's preconfigured aviation complete toolkits in the Sonic Foam System (SFS)," said McConnell. "The No Lost Tools Guarantee applies for one calendar year after purchase, or from the toolkit ship date. Customers can file a claim through sonictoolsusa.com and then each claim will be processed within 24 hours whereby Sonic will then ship the replacement tool."

The second trusted tool supplier that spoke to Aviation Maintenance for this article is Druck (www.bakerhughes.com/druck). Starting as a small business in Leicester, U.K., in 1972, Druck (a Baker Hughes business) has grown into a global pressure measurement company specializing in high-quality, high-accuracy silicon-based pressure sensors and calibration instrumentation for various markets, including aviation.

"For the MRO sector, Druck provides essential tools such as air data test sets, pitot static leak testers, handpumps, and after-market pressure sensors," said Chris Roberts, the company's product leader for test and calibration. "Producing more than 400,000 sensors annually, and with some 4,000 customers, Druck's pressure measurement technology provides advanced levels of accuracy, reliability and stability, enabling customers to enhance safety performance and drive efficiencies and productivity."

According to Roberts, "Druck's expertise extends across the aerospace sector; their Aerospace Flight qualified pressure sensors division has served the aviation industry for more than 45 years, supplying over 700,000 sensors. This means 80% of commercial and several military aircraft fly with Druck sensors on board," he said. "Beyond flight-qualified sensors, Druck also offers pitot static testers (ADTS) for precise testing and calibration of aircraft airspeed and pitot static systems, alongside a range of ground test pressure sensors and multi-function calibrators."

Our third trusted toolmaker is LockNClimb, LLC (https://locknclimb.com), whose products make aircraft and engine servicing safer, faster and easier. "LockNClimb, LLC designs and manufactures ergonomic safety ladders for the aviation industry used in MRO facilities around the world," said Banning Lary, the company's communications director. "These ladders have been engineered to meet all applicable OSHA and ANSI standards and are proven to prevent costly accidents and injuries to line and hangar maintenance technicians. They provide a stable means to access many hard-to-reach maintenance areas on most big commercial and corporate jets. LockNClimb ladders' durability is unmatched: after five years of continuous daily service in the demanding MRO environment, their repair costs remain at only 1/10 of 1%."

Chris Roberts, Druck

LockNClimb's product lineup includes safety ladders customized to serve all Airbus and Boeing aircraft along with all corporate and private jets. This company also can custom design and build safety ladders for any specific purpose or industry need. All of LockNClimb's ladders are manufactured in the USA, which is useful information in this time of tariffs.

New Tools for MROs

Savvy MRO technicians and engineers are always on the lookout for new tools to help them do their work better and easier. Aviation Maintenance asked the three trusted suppliers in this article what new items they have to offer to the MRO market. This is what they told us.

In April 2025, Sonic USA released its new 263-piece Intermediate Aviation Toolset with Mobile Case, a mobile toolset comprising sockets, wrenches, pliers, punchers, and other tools all backed by Sonic's hassle-free lifetime warranty. The tools are conveniently organized into one TSA-approved, hard-shell case with multiple handles and wheels.

"The complete Intermediate Aviation Toolkit

Druck says the DPI610E-Aero is a low-cost yet flexible portable calibrator for precision leak testing of aircraft pitot static systems. Druck image.

Banning Lary, LockNClimb

(IAT) weighs less than 100 pounds, ideal for the aviation technician on the go," McConnell said. "This new intermediate set is designed for aviation technicians who are, or are working towards becoming, airframe and powerplant (A&P) technicians. The intermediate toolset is also the perfect solution for hassle-free travel, yet robust enough to tackle most aviation repair and service jobs."

Inside the IAT case, the company's custom Sonic Foam System (SFS) keeps everything in its proper place even during the roughest of transports. (There's no hassle that is more irritating to an MRO technician than opening their toolbox, only to discover everything inside is in a heap.) "When the toolset is in motion, technicians don't need to worry about tools becoming jumbled and falling out of place," said McConnell. "The two-toned chemical-resistant foam interior also maximizes storage space while keeping tools organized during the job."

On the outside, a metal reinforced padlock hole enables technicians to completely secure all of the IAT's compartments with one single lock, as desired. To further aid organization and prevent cross-contamination with other toolsets, serialized tool ID laser etching comes standard on each tool. Custom etching is available at an additional cost.

So, what does the aviation maintenance industry think of Sonic's new product? "We first announced the 263-piece Intermediate Aviation Toolset with Mobile Case at the MRO Americas Show in April, and the initial response has been tremendous," McConnell replied. "We feel we've found the right balance of providing the tools a technician might need for most service and repair jobs, but in a ruggedized yet lightweight TSA-approved casing that enables technicians to easily maneuver the tools wherever they need to go. Furthermore, the case is designed in such a way that it enables full access to the entire toolset at once without tipping over. And there's still room for additional tools. We're excited to offer such a comprehensive yet portable option for technicians who must frequently travel. It's a must for 'fly-away techs'."

Meanwhile, Druck has recently introduced its DPI610E-Aero, which is a low-cost yet flexible portable calibrator for precision leak testing of aircraft pitot static systems. "During aircraft maintenance, when any work is undertaken on the pitot static system of an aircraft, a leak check must be completed to verify integrity," said Roberts. "Any leaks in the avionics system will cause pressure changes resulting in false airspeed or altitude readings. Maintaining accurate airspeed and altitude is a vital safety parameter for aircraft operations. If an aircraft's airspeed or altitude reads incorrectly due to pressure leaks, in-flight calculations become inaccurate. Leak testing is therefore a vital part of MRO procedures, meaning the integrity of the equipment cannot be overlooked. Using accurate and reliable equipment is a necessity."

Worth noting: While pitot static testers can perform leak tests during full maintenance processes, aviation technicians often require a quick leak test for low level, go/no-go testing. Unfortunately, the often-cumbersome pitot static testers, whilst

LockNClimb's 51-inch high platform ladder features an OSHA 1AA Special Purpose ladder, ANSI tested to hold 375lbs. It allows technicians to quickly roll around an aircraft to service avionics, hydraulic, oxygen, E&E ports and many others. LockNClimb image.

more than capable of performing this test, are usually not portable enough to do such quick tests quickly due to their size and weight. As well, pitot static testers are also very often tied up performing more complex scheduled maintenance tasks when a quick leak test is required. "This creates a gap in the arsenal of avionics technicians for a low-cost, portable precision leak tester," Roberts said. "Hence the reason for the recent launch of our DPI610E-Aero portable leak tester."

Now Druck has a history of producing quality pitot static leak testers. In fact, "the legacy DPI610A has been a staple of MRO service providers' equipment for decades," said Roberts. "But given this tester's aging technology and limited user interface functionality, we at Druck decided the time was right for an upgraded leak tester, the DPI610E-Aero. It augments the most-loved features of its predecessor, combined with the latest pressure sensor technology."

As for the MRO market's response to the Druck DPI610E Aero? "Customers value the portability, reliability and long battery life resulting in less downtime," he said. "It also means customers do not have to tie up a pitot static test system for a simple process.

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LockNClimb's 10 and 12 foot cowl pylon ladders allow technicians to quickly access maintenance panels on the top of the wing pylon area of Airbus and Boeing aircraft. LockNClimb image.

This time saving directly influences operational efficiencies, in terms of calibrations completed and aircraft leak tests. The DPI610E-Aero's cost-effective price point is also a benefit to the customer. This is why, since launching the DPI610E in 2024, we've experienced high demand for this tester. Indeed, it is already benefiting many of our customers in Europe, Asia, Americas and the Middle East."

LockNClimb's newest products include a 3-foot platform ladder with fold down tool tray (3LNCB737WWPLT) designed and built for aircraft mechanics who needed a simple sturdy ladder to access the wheel wells and landing gear of Boeing 737 and Embraer aircraft.

According to Lary, a similar request was made by mechanics who wanted a single ladder they could use to access a dozen maintenance points around the exterior of the Airbus 320 series aircraft — and thus the 51LNCWWPLAT was born. This 51-inch high platform ladder features an OSHA 1AA Special Purpose ladder ANSI tested to hold 375 lbs. It allows technicians to quickly roll around an aircraft to service avionics, hydraulic, oxygen, E&E ports and many others. When the company is designing new ladders, "maintenance technicians, supervisors and safety managers are consulted during the research and design phase of each ladder," said Lary. "It is not unusual for prototypes of new ladders to be brought back to the hangar and flight line half a dozen times for testing and development until they perfectly match aircraft profiles with technician working comfort. When we do bring the prototypes to market after being refined into finished products, mechanics and management alike praise our ladders for making work faster, safer and easier. This increases morale and productivity, thereby decreasing aircraft downtime."

What's Coming Next

As we have seen, Sonic USA, Druck, and LockNClimb are doing their best to bring advanced tools to the aviation maintenance sector. This leaves one last question to be answered: What's coming next?

"Sonic USA remains focused on providing complete tool solutions that improve efficiency and asset management, along with FOD (foreign object debris) mitigation," replied McConnell. "Sonic provides solutions to assist in FOD mitigation by implementing our organization system that optimizes tool control and inventory control system, allowing technicians to ensure every tool is back in place. We also want to ensure we provide complete hand tool solutions, including tools, toolboxes, and cabinets tailored for the aviation industry, eliminating the need to wait for a tool truck. For these reasons and more, international airlines ranging from United Airlines to Alaska Airlines, to regional players such as Piedmont Airlines rely on Sonic tools every day."

Druck's future plans rely on "harnessing our culture of innovation," Roberts said. "At Druck we're always looking to push the boundaries of innovation and reinforce our market leading position with new technologies. While our product launch plan is a closely guarded secret for commercial reasons, I can tell you that across aviation MRO we are looking to build a more systems-based offering with integration across the range, from asset management and calibration software to third-party instruments to drive operational efficiencies and deliver productivity gains. So, watch this space!"

"LockNClimb is continually engaged in developing new and better ladders to match the working needs of technicians with new and improved aircraft," concluded Lary. "These include the 10- and 12-foot cowl pylon ladders that allow technicians to quickly access maintenance panels on the top of the wing pylon area of Airbus and Boeing aircraft. Our complete line of advanced A-frame ladders is preferred by many mechanics today and will be just as preferred tomorrow." AVM

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Accelerating Special Missions Aircraft Development: Leveraging Business Aviation for Defense Innovation

By Christopher Brumitt

Introduction: The Urgency of Now

Special Missions Aircraft utilization is not a new concept in the history of the military or U.S. Government. The Civil Reserve Air Fleet (CRAF) dates to the early 1950s and as early as WWII, the DC-3 was used as the CH-47 for cargo and troop transport. It was even earlier — during WWI — when the Curtiss Jenny was first utilized.

The demand for special aircraftr — whether for intelligence, surveillance and reconnaissance (ISR), electronic warfare (EW), medevac, tactical transport, or maritime patrol — continues to provide value and utilization. But the traditional path to developing "clean-sheet" aircraft is long, costly, and increasingly misaligned with today's defense realities. With budgets under pressure and operational needs evolving faster than ever, the Department of Defense (DoD) and other agencies are seeking smarter, more agile solutions. Though conversions of civilian aircraft typically require adapting military avionics, sensors, and defensive systems, the path to integration is still usually more advantageous due to leveraging inherent civilian design capabilities, such as range, payload capacity, speed, fuel efficiency, modular interiors, or low operating costs.

Furthermore, the current administration has made it clear: efficiency and expediency must be prioritized. Programs must move from concept to deployment faster, without compromising capability. This shift calls for a fundamental rethink of how we develop and deploy aircraft, including broader thinking on how we can optimize the use of special missions aircraft.

The Case for Change

Historically, developing "clean-sheet" aircraft specifically for special missions has involved years of design, testing, and production — often resulting in delays, cost overruns, and missed operational windows. In today's volatile geopolitical climate and rapidly changing mission requirements, that model is no longer sustainable.

Defense leaders are increasingly asking: How can we meet urgent mission needs without waiting years for new aircraft to be designed and built? How can we reduce acquisition costs while still delivering high-performance platforms according to DoD policies on Military Commercial Derivative Aircraft (MCDA)? How can we reduce long-term sustainment costs while maintaining and upgrading aircraft that will be in service for decades?

Accelerated Aircraft Completions & Conversions

Aircraft completions and conversions allow "green" aircraft (those delivered without mission-specific systems) to be transformed into fully operational platforms to suit military and non-military government needs. This approach has been used successfully in the past, and with today's advanced technologies and integration capabilities, it's more viable than ever.

The process of converting a green aircraft into a mission-ready platform involves many potential adaptations, including:

- Installing specialized avionics and sensor suites per mission parameters
- Configuring interiors for medevac or tactical transport
- Adding aerostructure, landing gear, and underwing modifications for maritime, cargo and airlift roles

These modifications can be executed on a far shorter timeline than the years it typically takes to develop them from scratch, leveraging existing supply chains and proven engineering practices. The result? Faster deployment, lower cost, and greater flexibility.

Design for Excellence (DFX) and Supply Chain Optimization

To further accelerate development, adaptation and reduce cost, military aircraft programs can apply Design for Excellence (DFX) principles. DFX focuses on designing systems with manufacturability, maintainability, and scalability in mind from the outset, while aligning functional organizations like supply chain, production and engineering around a clear and concise mission.

Supply chain optimization processes and capabilities such as strategic sourcing, vendor collaboration and supply chain visibility, coupled with DFX, enables faster customization and deployment. It also reduces program risk by minimizing complexity and reducing supply disruption.

Innovation Meets Practicality

This approach isn't just innovative — it's practical. It aligns with DoD priorities for speed, cost efficiency, and mission readiness. It also opens the door for public-private partnerships, where civil aviation aircraft can be harnessed to meet defense needs.

By rethinking how we approach special missions aircraft development and opening up more DoD budget to potential adoption, we can deliver fixed-wing, vertical lift, unmanned/autonomous and other platforms that are not only capable but also responsive to the realities of the ever-changing geopolitical climate and evolving needs of the U.S. military.

Conclusion: A Call to Action

The need for agile, cost-effective special missions aircraft has never been greater. By leveraging existing platforms, accelerating completions, and applying smart design and supply chain strategies, defense agencies can meet urgent needs, with improved affordability and without waiting years for new development.

The time is right for a resurgence of an aircraft acquisition model that has been in use for decades but perhaps never fully optimized — one built on innovation, speed, and practicality. The mission demands it. The technology enables it. And the opportunity is now. AVM

Christopher Brumitt is Managing Director, Aerospace & Defense, at global supply chain and operations consultancy Maine Pointe. You can reach him at cbrumitt@mainepointe.com.

Missing Piece in Crash Investigations

By Marijan Jozic

During 2025, there were a couple of accidents in aviation that made me think. I know I can't change the world, but I can try.

Just to remind you about a few accidents:

The most recent major aviation accident in South Korea involved Jeju Air flight 7C2216, which crashed at Muan International Airport on December 29, 2024. The plane, a Boeing 737-800, belly-landed, overran the runway, and collided with an embankment, resulting in a fireball. Out of the 179 people on board, only two cabin crew members survived.

Air India Flight 171 was a scheduled passenger flight from Ahmedabad Airport in India to London Gatwick Airport in the United Kingdom that crashed 32 seconds after takeoff at 13:39 IST (08:09 UTC) on June 12, 2025. All but one of the 230 passengers and all 12 crew members died. An additional 19 people were killed, and 67 were seriously injured on the ground.

Germanwings Flight 9525 was a scheduled international passenger flight from Barcelona–El Prat Airport in Spain to Düsseldorf Airport in Germany. The crash was deliberately caused by the first officer, Andreas Lubitz, who had previously been treated for suicidal tendencies and had been declared unfit to work by his doctor.

In all these flights, there was something strange in how pilots handled procedures under extreme stress. In two cases, they switched off perfectly good, working engines. If those two cases were isolated, I wouldn't even mention it — but let me remind you of another crash in Hawaii several years ago when Transair Flight 810 (a 737-200) lost one engine due to failure, and then the pilots switched off a good working engine and crashed into the sea. There was also an accident at Schiphol Airport when the pilots of a Cityhopper SAAB 2000 set a good working engine to ground idle, then tried to perform a go-around and crashed KLM cityhopper flight 433 on April 4,1994).

In all these cases, there was one common denominator: the investigators could not play back the last few critical minutes of the flight and make 100% sure what caused the crash. Black boxes, although designed to be very sophisticated, didn't provide enough data to be certain why the accident happened. We may know how it happened, but the why is still a big unknown. Why did the pilot switch off the wrong engine in the Hawaii accident? Why did the Cityhopper pilot pull the throttle to ground idle? Why did the Air India pilot cut the fuel off just seconds after takeoff? And what was the Germanwings pilot doing in the cockpit before the crash?

The whole investigation in all these cases could have been more thorough if there had been video footage from the cockpit. But there was nothing. Nowadays, the technology is available to

accomplish that task. There is absolutely no problem installing a few cameras in the cockpit and recording all the actions pilots are taking. All control panels, displays, and pilot actions could be recorded from multiple angles, and nothing would be hidden. Such an installation wouldn't even be extremely expensive.

Just to remind you — many people use dashcams in their cars. They can record while driving, and in case of an accident, you can see exactly what happened. Such a dashcam can be purchased for less than $50 USD. It is proven that it works fine, and the footage can be used in court.

I was personally involved in several projects related to video recordings. Many years ago, KLM had problems with passengers flying to Suriname and Caribbean destinations. There were regular fights on board, and KLM decided to carry a policeman on board. But within a few months, someone decided it was too expensive to pay for police services. Therefore, they decided to install a camera by the aircraft door to record passengers entering the aircraft and show it in real time on a screen in the cabin. The goal was to create awareness among passengers that they were being recorded — and therefore would not fight. That was, of course, not a good strategy, but management bought it and decided to invest in installing the camera and interfacing it with the onboard video system.

Just a few weeks into the project, the lawyers stopped the activity because of privacy violations. KLM continued flying for another half a year with sky marshals, and then that activity was also discontinued. I never heard of onboard fights after that.

A few years later, the Russian company Transaero hired me to run a project for them. They were having problems with — guess what? Yes, passengers fighting on board. My first reaction was: don't give them vodka during the flight. But Russians are different. They were afraid that passengers would fly with someone else, so they wanted to keep them by offering vodka. The problem was quite serious — they had fights almost every day, and they had to appear in court every week. The big question was: who delivered the first punch? Therefore, they wanted to have video recording capability on board. And that is exactly what I provided for them.

I installed a server on board capable of recording 24 hours of video from eight cameras. After 24 hours, the system would overwrite the previous recording. So, if there was a fight, after landing, the engineer could simply connect a laptop to the server and download the video. In the beginning, they had three active cameras in the cabin, and later they added two cargo cameras because, at some airports, thieves were opening suitcases and stealing the contents. The video recordings helped identify the crooks.

Eventually, I managed to install such a system in 75 aircraft (all Boeing: 747s, 777s, 767s, and 737s). Transaero went out of business after Putin invaded Crimea and Russia got sanctioned.

Coincidentally, almost 10 years later, I was leading an ARINC committee named Cabin Systems Subcommittee, which standardized such systems for the benefit of aviation. In Denver I even presented that standard — A628 Part 1 (Cabin Surveillance System) — for adoption. In my presentation, I mentioned my project with Transaero, and engineers immediately started asking about privacy. It is obviously a big concern. However, with the Russians (Transaero), privacy was never a point of discussion. Others — especially in Europe — are totally different.

That brings me back to the cockpit and the installation of video recording for monitoring pilot actions. After the crashes described earlier, discussions started about installing cameras and recording cockpit actions. It is no longer a technical discussion. Technically, everything is possible. Besides FDR (Flight Data Recorder) and CVR (Cockpit Voice Recorder), a new box could be introduced: VDR (Video Data Recorder). It wouldn't be a system for real-time video streaming to the ground, but a much smaller and limited system that can record and store video on board. That's exactly what we're already doing with FDRs and CVRs. The data — and the video — should only be retrieved in the case of an accident or incident.

Such systems are already installed in some aircraft like helicopters for search and rescue, and in test and training aircraft. Agencies like the National Transportation Safety Board (NTSB) have often demanded the installation of video recorders. From the investigators' point of view, it's obvious — they would have more information, clear visual evidence of the pilots' actions, and could reach conclusions faster. This discussion has been going on for more than two decades.

But that step is a problem because pilots don't want it. That's because of privacy. They are afraid the videos could be leaked to the media or used in court — and what if the video is not used for safety investigations but to assign blame to the pilots? If the videos are made available to the public, they could be misinterpreted and misused. Besides, knowing that video recording is ongoing can influence a pilot's behavior in a performative way.

It's obviously a matter of trust. Pilot unions like ALPA, BALPA, and IFALPA are opposing cockpit video recording. They argue that video recording poses a massive privacy risk. They are also afraid that the video could be used for disciplinary purposes.

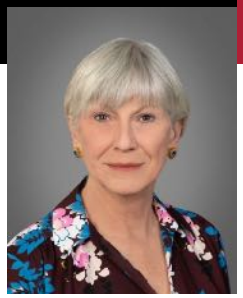
Let's deviate a bit here: About 20 years ago, the company Spirent came up with a modification for 747 Classics. They proposed removing the P2 panel (the panel in the middle of the cockpit used for engine instruments) and installing a pallet with displays that fit into the P2 position and used the same connectors as the steam gauges. It was a more reliable system and easy to install. Atlas Air decided to install it in their aging 747 Classic fleet. Technically, it was successful — but the system reported that some pilots were exceeding EGT limits during takeoff. The result was a decrease in engine-on-wing time, which cost the company a lot of money. Now, management and pilots were in conflict. Pilots blamed engineers and computers for providing wrong information, and engineers checked and rechecked the system but found nothing wrong. The bottom line: After some months of operation, the problem disappeared — not because engineers changed the sensor limits, but because pilots started operating more carefully and avoided exceeding limitations.

I'm convinced similar situations could occur with video recordings. I can imagine that pilots would change their behavior simply because they know they're being monitored. But that change could also have an adverse effect on their performance.

One idea is to set up a system that starts recording in case of a TCAS alert, EGPWS alert or any other warning — and record video for 2–3 minutes. But you wouldn't know what happened before the alert — and that could be crucial.

Eventually, I am certain it will take a few more years of discussion before video recording becomes a standard cockpit feature. The bottom line is to improve safety, to conduct proper investigations of each accident and incident and to ensure such situations are not repeated. That is in the best interest of pilots, investigators, authorities and the public. AVM

By Sarah MacLeod, Executive Director, Aeronautical Repair Station Association



What's an OEM?

Words and phrases are so important. When used in commercial relationships or for regulatory compliance, understanding a term's meaning is vital.

From the myriad manufacturers that contribute to the design and production of an aircraft, which one is the original equipment manufacturer or the euphemistic "OEM"?

For over forty years, the acronym "OEM" has been tossed around in aviation with various meanings, none of which carry any legal or regulatory meaning (without context) or provide for a singular definition.

I have never found the term defined in any regulatory context within my area of knowledge and it shouldn't mean anything to a civil aviation regulator. Under the aviation safety rules, one must be a design and/or production holder with an approval (of some sort) to manufacture products or articles for sale for installation on civil aircraft. In the case of aircraft, there are many manufacturers that contribute to the design and construction of the product. Each may have commercial "rights" to aspects of the design or production, but none are "OEMs" under civil aviation regulations.

If a word or phrase is neither defined nor understood, communication is problematic. For example, the supposed controversy over using PMA parts. Many, in fact the majority, of PMAs issued by the FAA are held by "OEMs"— in this context meaning the production approval holder's chosen supplier that may also own the "proprietary" rights to the design.

So, when an airline or leasing company states it does not "use PMA parts," I don't believe it. The disbelief comes from the fact that if the same company was asked if it only bought from "OEMs," the answer would certainly be yes. How could that be? Those contradictory responses are evidence that there is a misunderstanding of the use of that acronym in the context of civil aviation.

In civil aviation there are no "OEMs", only design and production approval holders. Commercially, the acronym has little impact without a contractual definition that both parties understand. Signing a contract to be a supplier to a production approval holder doesn't make a designer or manufacturer an "OEM" under the civil aviation regulations either.

The answer to the core question of "What is an OEM" really is "You better find out if you see the term in a contract." In general, using "OEM" in civil aviation is dangerous and misleading. AVM

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