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CONTENTS

Q2 2025

The World's Leading Aviation MRO Publication

DEPARTMENTS

04 Editor's Notebook

06 Intel

48 Legal Spin
Jason Dickstein shares his take on tariffs.

50 Straight Talk
ARSA's Sarah MacLeod says SMS should be integrated into existing requirements, not piled on top of other manuals and programs.

24 STOP AND GO
SPONSORED BY TPAerospace
THE CYCLICAL JOURNEY OF WHEELS AND BRAKES
Maintaining aircraft wheels and brakes is a complicated yet crucial facet of MRO. Ian Harbison takes a deep dive.
Cover image courtesy of TP Aerospace.

18 New-Age Avionics Maintenance
Avionics testing and repair are undergoing a rapid transformation as new technologies redefine how maintenance crews diagnose, service, and upgrade aircraft systems. Jim Romeo investigates.
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32 SMS
Safety Management Systems (SMS) have evolved, helping support informed decision-making across aviation operations, maintenance and even boardrooms.

36 Tariffs
Tariffs continue to present significant challenges for the aviation maintenance sector, especially due to the ongoing state of flux. We spoke to the experts to gain insight into surviving the uncertainties they have imposed.

40 Human Factors
Understanding human factors, the study of the relationship between humans and machines, is crucial to aircraft MRO and can impact the safety, efficiency, precision and overall integrity of aircraft operations. Mark Robins revisits this perennially important topic.

CATEGORIES
GENERAL AVIATION | COMMERCIAL | BUSINESS JET | MILITARY
ENGINES | TECHNOLOGY | PRODUCTS/TOOLS | SPECIAL REPORT | AFTERMARKET

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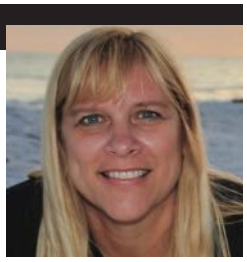

The Impossible

BY JOY FINNEGAN
EDITOR-IN-CHIEF

The news cycles this month were full of CCTV surveillance video footage of Air India flight AI-171, operating from Ahmedabad (AMD) to London Gatwick (LGW), that crashed on Thursday, June 12, killing all on board save one lone survivor, and 39 people on the ground. The death toll remains at 270. That horrific event was captured on video and the lone survivor was seen walking to an ambulance in other images and footage.

The aircraft achieved takeoff speed, rotated and climbed to about 625 feet while still over the runway. Then the Boeing 787 can be seen losing altitude while maintaining a slightly nose-up attitude. The flight crew issued a mayday call and reported a loss of power. The aircraft was airborne for about 30 seconds. It then hit a building, which was a hostel for medical students in training in the area, and exploded. The shocking footage showed a fireball erupting from the impact, as the aircraft was loaded with fuel for the flight to Gatwick.

The survivor, Vishwash Kumar Ramesh, a 40-year-old businessman from Leicester, U.K., was in seat 11A next to an emergency exit. Reports quote him as saying that the section of the aircraft he was seated in detached and came to rest on the ground floor of the hostel building. After unfastening his seat belt, he said he escaped through an opening where the emergency exit had broken apart. His brother was seated in a different row and did not survive.

"Thirty seconds after takeoff, there was a loud noise and then the plane crashed. It all happened so quickly," he said in local media reports. "When I got up, there were bodies all around me. I was scared. I stood up and ran. There were pieces of the plane all around me. Someone grabbed hold of me and put me in an ambulance and brought me to the hospital." Ramesh said that following the loud bang the aircraft began to have difficulty climbing.

Aircraft are designed to have redundancies upon redundancies to help avoid catastrophic events like this. However rare, it is not impossible that a double engine failure occurred in this case. It is possible that a flock of birds could have flown into both of the engines causing that to happen. Having two engines fail is practically unheard of but did happen in the "Miracle on the Hudson" event in 2009 where birds were ingested and shut down both engines on that Airbus A320. But, if one engine had remained operational, the 787 would have been able to continue to climb and likely could have returned to the airport for landing.

Some experts questioned the flaps and slats settings, suggesting they were not set in the takeoff position. These high-lift devices change the shape of the wing and provide extra lift during the takeoff segment. If not set properly, the aircraft would most certainly have struggled to become airborne and climb, especially since it was a hot day and the aircraft was fully loaded with passengers. The flap theory has been discounted, however, due to the multiple checks that would have occurred in the flight deck by the crew and the warnings they would have received if they tried to takeoff without the proper settings. Alternatively, if the flaps and slats had been retracted too soon, that could also cause a loss of lift at a crucial time in the climb.

Regarding the engines, GE Aerospace's GEnx-1B, "The right engine was a new engine put in March 2025. The left engine was last serviced in 2023 and due for its next maintenance check in December 2025," N. Chandrasekaran, the airlines' chairman said in a news report. "There are speculations about human error, engines, maintenance … but AI-171 had a clean history," he said in **The India Times**. "There were no red flags or maintenance issues," he added. Most of Air India's 787s are serviced by Air India Engineering Services Limited (AIESL) or SIA Engineering, Chandrasekaran said at a press conference.

Experts say the ram air turbine (RAT) was likely deployed shortly after takeoff. Initial findings suggest the RAT was operating when the plane crashed, according to reports from **The Wall Street Journal** and other aviation news sources. The RAT is a backup power system that deploys automatically in cases of engine or electrical failure.

The aircraft's flight data recorder and cockpit voice recorder, though damaged, have been found. The analysis of those treasure troves of information will help illuminate what occurred. These critical flight parameters, as well as the cockpit voice recorder audio, will hopefully provide the answers to the mystery of what caused this aircraft to stop producing enough lift to climb out and will be the lynchpin of the accident investigation. Now all that is left to do is wait for the analysis of those black (orange) boxes to see if the mystery can be solved and we can learn how to prevent such an occurrence from happening again. AVM

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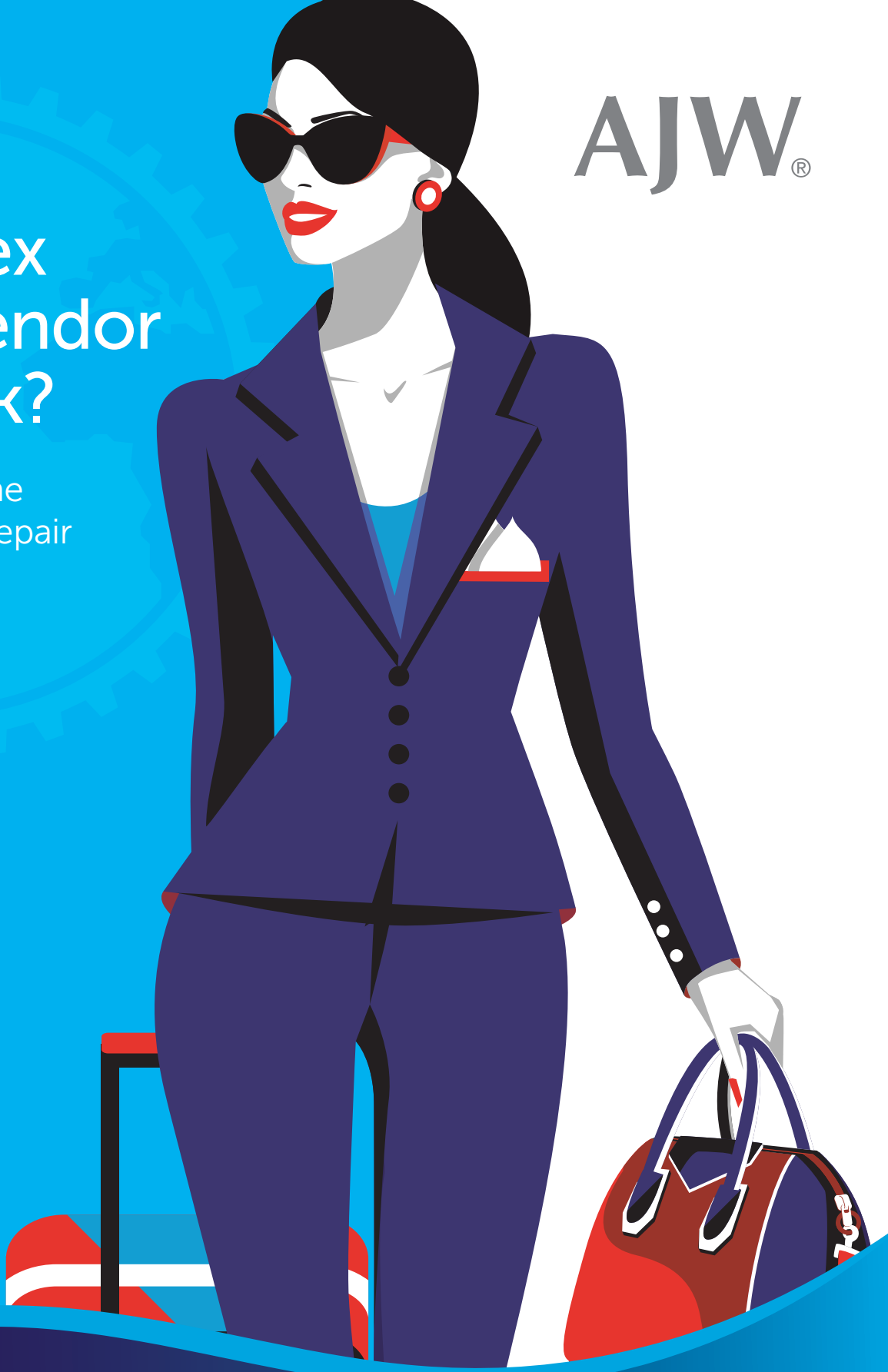

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Lufthansa Technik Opens Training Center for New Employees in Portugal

In preparation for Lufthansa Technik's new facility in Portugal, the company recently opened a training center in Santa Maria da Feira, roughly 35 kilometers south of Porto, and welcomed the first 18 employees of Lufthansa Technik Portugal.

The training center is located in the Perm industrial park about nine kilometers away from the site where Lufthansa Technik Portugal's new facility will become operational by the end of 2027. It consists of two buildings, one of which is now hosting introductory events and theoretical lessons. In the other, practical training units will begin in the coming weeks, supervised among others by qualified and highly experienced Lufthansa Technik employees from Hamburg. The training center, leased for three years, features several seminar rooms and office space with fully equipped workstations.

Lufthansa Technik announced last December its plan to invest a triple-digit million-euro amount in a new facility in Portugal. Located in the Lusopark industrial area of Santa Maria da Feira, the company will begin construction next year on a 54,000-square-meter production facility for the repair of engine parts and aircraft components, creating approximately 700 jobs.

Since announcing the project, Lufthansa Technik Portugal has already recruited 25 people, filling initial positions such as human resources manager, production manager and tool and equipment engineer. An additional 20 employees are expected to be hired before the end of this year. The company is actively seeking technicians, quality engineer auditors and further human resources specialists. Lufthansa Technik says on average, approximately 150 applications have been received for each position advertised so far.

Volker Magunna
Chairperson of the Board,
Lufthansa Technik Portugal

To ensure this continues in the coming years, Lufthansa Technik Portugal says it aims to establish partnerships with nationwide educational institutions and is already collaborating with Cenfim (Centro de Formação Profissional da Indústria Metalúrgica e Metalomecânica). This national vocational training center specializes in the metal, metalworking and electromechanical industries and supports the technical selection process for mechanics.

As chairperson of the board at Lufthansa Technik Portugal, Volker Magunna welcomed all new employees at the training center, together with Ricardo Arroja, CEO of the Portuguese trade and investment agency AICEP (Agência para o Investimento e Comércio Externo de Portugal), and Amadeu Albergaria, mayor of Santa Maria da Feira.

"Today is a special day for Lufthansa Technik Portugal, one that will go down in the company's history — even before construction of the actual production facility has begun," said Volker Magunna at the event. "It is a great feeling to welcome our first 18 colleagues as well as our guests from politics and business at the newly opened training center. This milestone vividly demonstrates the pace and commitment with which we are advancing this major project. I am excited about everyone who wants to shape and build Lufthansa Technik Portugal together with us. This also applies to our partners at AICEP and the city of Santa Maria da Feira, who have welcomed us with open arms and have provided strong support from the very beginning through an intensive process."

Trax Selected to Modernize Delta TechOps' Maintenance and Engineering Systems

Trax has been selected to modernize Delta TechOps' maintenance and engineering systems. Delta TechOps will replace its legacy maintenance and engineering systems with Trax's advanced eMRO and eMobility solutions.

Initially, more than 6,000 technicians across the Delta TechOps line maintenance network will use Trax's innovative technology to digitize their maintenance processes, leading to enhancements in efficiency, data accuracy, and operational performance. The companies plan to use this initial implementation as a foundation for the future deployment of additional Trax eMRO modules and eMobility apps focused on heavy maintenance, maintenance planning, engineering, and quality management — all hosted in the fully-managed Trax Cloud.

"AAR's strategic investments in Trax have enabled the company to scale to support the largest airlines and most diverse fleets," said John M. Holmes, AAR's chairman, president and CEO. "We are grateful to Delta for selecting Trax and look forward to powering their system modernization," he continued.

John Laughter, president of Delta TechOps, added, "We are confident Trax will enhance our operational efficiency by streamlining maintenance processes across Delta TechOps, enabling our people to focus on delivering the Delta Difference."

Alain Bellemare Named Chairman of Delta MRO Advisory Board

Alain Bellemare
EVP and President,
Delta Intl.

Alain Bellemare, executive vice president and president – Delta International, will assume an additional leadership role as chairman of the Delta Maintenance, Repair and Overhaul (MRO) Advisory Board, providing strategic direction, support and guidance to Delta's commercial MRO business. He will work in close partnership with John Laughter, chief of operations and president of Delta TechOps, who will continue leading the business.

"Alain's extensive experience in aerospace systems, engines and aftermarket services — paired with his strategic acumen and global commercial experience — makes him ideally suited to help guide the continued growth of the Delta MRO," said Ed Bastian, CEO of Delta Air Lines.

In this capacity, Bellemare will provide strategic direction, support and guidance to Delta's commercial MRO business, working in close partnership with Laughter and his leadership team. Delta TechOps is a $5 billion industry leader in MRO services, supporting Delta's own fleet and hundreds of airline customers worldwide. Bellemare's role as chairman will complement these operations by bringing his strategic lens and global experience to help strengthen market positioning, deepen customer relationships, accelerate long-term growth and enhance commercial success leveraging Delta's industry-leading aircraft maintenance capabilities.

"We've partnered closely with Alain, leveraging his expertise for years, and it has helped position Delta's MRO for the success we share today," said Laughter. "His leadership in this board position will continue to grow and strengthen this critical part of our business."

Bellemare brings 25 years of global aerospace and industrial leadership experience, having led complex aircraft programs, advanced propulsion and systems technologies, and global aftermarket services. As president and CEO of Bombardier Inc., he led the company through a comprehensive and successful transformation, overseeing the development, certification and successful entry into service of the C-Series, now Airbus A220. Prior to that, as president and CEO of United Technologies Corporation Propulsion & Aerospace Systems, he led Pratt Whitney, as well as the acquisition of Goodrich, with its integration into Hamilton Sundstrand. Delta says he has deep experience leading global teams responsible for the development, certification, maintenance and support of some of the world's most advanced engines and complex aircraft systems. He also serves on the board of directors for Wheels Up.

Bellemare added, "I'm honored to take on this expanded role. Delta TechOps is a world-class operation with talented people, deep technical capabilities and a strong customer foundation. I look forward to partnering with John and the team to help shape the next chapter of growth and commercial success."

AFI KLM E&M and Rolls-Royce Induct the First Trent XWB-84 for MRO

Air France Industries KLM Engineering & Maintenance (AFI KLM E&M) and Rolls-Royce announced the first Trent XWB-84 engine scheduled for maintenance, repair and overhaul (MRO) center at Charles De Gaulle Airport, Paris, France, has been inducted.

This establishes capability to exclusively support the Air France fleet and in turn will provide Rolls-Royce additional capacity to support customers around the globe. The facility complements Rolls-Royce's current MRO footprint and addresses growing long-term demand for new civil large engines.

The announcement followed an agreement, made at Paris Airshow 2023, for the maintenance and repair of Trent XWB engines powering Airbus A350, building on an initial agreement signed between the two groups in 2014, as part of Air France-KLM Group's acquisition of the aircraft type.

"We're investing in a resilient future and plan to significantly increase our global MRO capacity and capability by 2030," said Paul Keenan, director, commercial aviation aftermarket operations Rolls-Royce. "Today marks an important milestone on that journey as we see the first Trent XWB-84 inducting for MRO at AFI KLM E&M. AFI KLM E&M has a long heritage of MRO experience that will enhance overhaul and repair capabilities for the Trent XWB-84 engine – we are delighted to have them part of our global network. This will allow for additional capacity in the entire Rolls-Royce network and is further proof of our commitment to deliver both excellent products and services to our global customer base."

Both Air France and KLM have ordered the Trent XWB powered Airbus A350. As part of the deals, the health and maintenance of the engines will be covered by Rolls-Royce's comprehensive TotalCare service. Earlier this year Air France celebrated one million engine flying hours on the Trent XWB-84. The Trent XWB-84 EP offering a 1% fuel burn saving, worth $5m a year for the average fleet according to Rolls-Royce.

"The induction of the first Trent XWB-84 engine into our Paris facility marks a major milestone in our partnership with Rolls-Royce and in the continued evolution of our MRO capabilities," said Anne Brachet, executive vice president, Air France – KLM Engineering & Maintenance. "This new chapter enables us to provide dedicated support for Air France's A350 fleet while also contributing to the global Trent XWB aftermarket network. It reflects our commitment to combining technical excellence and innovation to meet the evolving needs of next-generation aircraft and engines."

ST Engineering Secures Multi-Year LEAP-1A Maintenance Contract with Air Cairo

ST Engineering's commercial aerospace business has secured a five-year maintenance, repair and overhaul (MRO) contract with Air Cairo, a new customer, to support the LEAP-1A engines that power its Airbus A320neo fleet. Under this contract, ST Engineering will provide quick-turn repair and Performance Restoration Shop Visit (PRSV) services at its engine MRO facility in Singapore. The first engine is expected to be inducted in mid-2025.

Captain Ahmed Shanan, chairman and CEO of Air Cairo, said, "We are pleased to form a partnership with ST Engineering, the globally recognized leader in engine overhaul, to support the maintenance of the LEAP-1A engines powering our Airbus A320neo. This agreement underscores our commitment to operational excellence, reliability and the highest standards of safety for our growing fleet."

"As Air Cairo continues to expand its network and modernize its operations, having a trusted and experienced engine MRO provider like ST Engineering ensures that our engines receive world-class maintenance, minimizing downtime and optimizing performance. This collaboration will play a key role in supporting our mission to deliver seamless and efficient air travel for our passengers across the region. We look forward to a long and successful partnership with ST Engineering as we continue to strengthen our fleet capabilities and enhance our service offerings in the competitive aviation market."

Tay Eng Guan, head of Engine Services at ST Engineering, said, "This latest contract demonstrates increasing confidence in our expertise as a Premier MRO provider for the LEAP engines, while marking another significant step in expanding our LEAP engine support for Middle Eastern operators. As we continue to grow our LEAP engine MRO capacity and parts repair capabilities, we look forward to supporting Air Cairo — and more operators in the region — with high-quality, value-added LEAP engine services."

GE Aerospace Expands Hypersonic Testing Infrastructure with Major Facility Upgrades

GE Aerospace is making significant investments in its test infrastructure to accelerate the development of next-generation hypersonic propulsion systems. These upgrades at sites in Evendale, Ohio, Bohemia, New York and Niskayuna, New York will enable the company to conduct higher-Mach, mission-relevant testing at a scale not previously possible.

- Evendale, Ohio: GE Aerospace is upgrading a test facility to provide dedicated test support for larger hypersonic propulsion systems than previously possible. These enhancements will also allow testing at higher Mach numbers and enable more relevant simulation of actual flight conditions.
- Bohemia, New York: GE Aerospace has been upgrading the test cell facilities on site, following the 2022 acquisition of Innoveering, a company specializing in hypersonic propulsion technologies.
- Niskayuna, New York: GE Aerospace is expanding hypersonic testing capabilities at its Research Center, to support the evaluation of larger propulsion systems as well as evaluate and refine a range of next-generation hypersonic propulsion technologies.

"This investment significantly accelerates GE Aerospace's ability to meet future hypersonic propulsion needs," said Mark Rettig, vice president and general manager of Edison Works Advanced Programs at GE Aerospace. "By enhancing our infrastructure, we're not only enabling more representative and scalable testing but also demonstrating our ability to deliver advanced technologies faster and more efficiently, ensuring our customers have the cutting-edge solutions they need when they need them."

The test cell expansion comes on the heels of GE Aerospace's successful development and testing of a hypersonic dual-mode ramjet that went from concept to test in less than 11 months followed by testing of a liquid fueled ramjet 10 months after initial concept definition.

The Flying Fuel Cell from MTU Aero Engines Takes Shape

MTU Aero Engines reports it is working "steadily and with determination" on its Flying Fuel Cell (FFC). The experts are making good progress, and they have reached some important milestones. The design for the Flying Fuel Cell has been nailed down, stack manufacturing for the demonstrator has started, the eMoSys electric motor was successfully tested for the first time, and the first test cell went into operation in Munich.

"With the successful critical design review for our first electric 600-kilowatt powertrain, we are wrapping up the design phase and starting on manufacturing and assembly," said Barnaby Law, FFC head engineer at MTU Aero Engines. Recently, production of the ultramodern fuel cell stacks also began in Munich.

Meanwhile, work was progressing on the electric motor for


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the FFC powertrain, which MTU is developing with its subsidiary eMoSys in Starnberg. An important milestone was reached here, too: in a challenging series of tests, the 600-kilowatt motor reliably had a maximum continuous output of 600 kW for the first time. "The tests confirmed a high efficiency rate of more than 96 percent, both during takeoff and at cruising altitude," said Law.

At the same time, the FFC testing infrastructure was being built at the facility in Munich. It consists of two test cells that include a hydrogen infrastructure as well as cooling water and pressurized air supply. Current status: the fuel cell stack test cell is finished and is now being put into operation. It is designed for stacks with up to 500 kilowatts of electrical power per unit. The second testing setup, the system test cell, is currently under construction and will be used to test the entire engine system.

The company reports that research activities are also going well at the European level. As part of the HEROPS clean aviation research project (Hydrogen-Electric Zero Emission Propulsion System) — building on MTU's FFC — technologies are being developed for a climate-neutral, hydrogen-driven electric powertrain that will be able to power regional airplanes starting in 2035. Led by MTU, there are seven partners working on this project. First, they will analyze powertrains with an output of up to 1.8 megawatts and then they will build a HEROPS ground demonstrator. It will prove that the groundbreaking new technologies are feasible, and that they can be scaled up to outputs between two and four megawatts using a modular engine architecture.

Barfield and Parrot Sign a Distribution Agreement

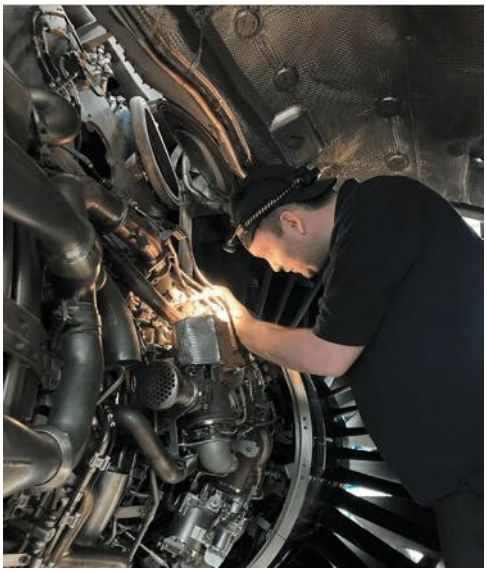
Gilles Mercier CEO, Barfield

Barfield, a subsidiary of Air France Industries KLM Engineering & Maintenance (AFI KLM E&M) in the Americas, continues to expand its participation in the UAV (unmanned aerial vehicle) industry by signing a partnership agreement with Parrot, a design and manufacturing drone company. This agreement is a milestone in the development of Barfield's UAV growth strategy.

"We are excited to be partnering with Parrot. They bring state-of-the-art solutions to the market with a high focus on technology, reliability, resilience and customer satisfaction. This is exactly what Barfield strives to deliver to the MRO and UAV industries," said Gilles Mercier, CEO at Barfield.

"Barfield's expertise in the aerospace supply chain, with its customer focus strategy to deliver exceptional products and services, is a perfect fit to support Parrot's new generation of micro-drones in the USA, where Parrot has the latest and unique technology for defense, federal agencies, law enforcement and enterprise. This is an important step forward in strengthening our U.S. distribution and support development strategy," declared Chris Roberts, senior vice president and chief revenue officer at Parrot Group Global.

HAECO Achieves Milestone with Successful LEAP-1A RBS Installation



Aircraft engineering and maintenance solutions provider, HAECO, announced the successful completion of its first Reverse Bleed System (RBS) installation for the LEAP-1A engine, including fuel nozzle replacement, via its on-wing services team in London, U.K. This achievement marks the third location performing LEAP-1A engine modification following similar milestones at HAECO's Hong Kong and Dallas facilities, the company says.

HAECO Global Engine Support, an operating company under HAECO Group, provides round-the-clock on-wing and in-shop engine support services from its extensive network spanning the Asia Pacific, the Americas, and Europe. The company says the successful LEAP-1A RBS modification is a result of the "trusted partnership between HAECO and major engine OEMs."

"We are delighted to announce this significant milestone of completing the LEAP-1A RBS installation successfully," said Corné van Rooij, general manager of HAECO Global Engine Support. "This accomplishment not only showcases our technical expertise but also reflects the strong collaboration and trust by OEMs, enabling us to enhance our engine service offerings with cutting-edge solutions for our airline customers."

In early 2025, HAECO partnered with the city of Dallas to relocate to an expanded engine facility, enhancing its capabilities for the industrialization and repair of next-generation aircraft engines, such as LEAP. In addition to LEAP-1A RBS installations, HAECO Global Engine Support offers 24/7 on-wing and near-wing engine support, inspections and repairs, and offers a network of EASA- and FAA-approved hospital shops for all major engine types. It also operates engine storage facilities and serves as a center for the lease redelivery of major engine models offering borescope inspection, general visual inspection, inventory check and engine preservation.

At its London facility, HAECO Global Engine Support provides on-wing and near-wing engine services for a wide range of engine types, including the RB211-524, -535, Trent 500, 700, 800, 900, 1000/7000, XWB, and LEAP-1A.

Mankiewicz Coatings is Awarded with Two Airbus Supplier Awards

Mankiewicz has been recognized by Airbus as part of the Supply Chain & Quality Improvement Program (SQIP). For the third consecutive year, Mankiewicz received the Accredited Supplier award in the "Materials & Parts" category — at the highest achievable level. This prestigious status is awarded to suppliers who consistently demonstrate outstanding performance in product quality, delivery reliability and collaborative partnership. With this award, Mankiewicz reaffirms its position among the top-tier suppliers in the Airbus network.

In addition to the Accredited Supplier recognition, Mankiewicz received the Special Award for Digitalization. The award honors a digital system developed to optimize internal material management processes. The program ensures optimal information and material flow across departments, enhancing transparency, efficiency and supply chain integration.

"We are incredibly proud of our entire team," said René Lang, executive managing director aviation at Mankiewicz. "Receiving both the Accredited Supplier status and the digitalization award is a strong validation of our commitment to customer service, quality, and digital progress. We look forward to continuing our close and trusted collaboration with Airbus."

Safran and Bombardier Announce Their Technological Innovation Partnership in Defense

Safran and Bombardier Inc. signed a letter of intent to explore new opportunities for collaboration and foster the joint development of innovative, high-performance and reliable technologies for defense.

This initiative will enable the two companies to leverage their complementary technological expertise and create a conducive framework for innovation and the rapid industrial scaleup of new solutions.

"Strengthening our long-standing partnership with Bombardier is a highly strategic move for both our groups," said Olivier Andriès, CEO of Safran. "By combining our strengths, we'll be well placed to accelerate innovation and deliver

Olivier Andriès CEO, Safran

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"This collaboration between Bombardier and Safran will foster the development of new solutions by leveraging our respective areas of expertise," said Éric Martel, president and chief executive officer of Bombardier. "Bombardier and its more than 18,000 people stand ready to help our nations, and others, meet their evolving defense needs."

The aerospace sector was identified as a priority by French Prime Minister François Bayrou and Quebec Premier François Legault in a joint statement issued in June, highlighting the commitment of their respective governments to strengthening economic ties between Quebec and France.

Rolls-Royce Launches Durability Enhancement Package That Will Double Trent 1000 Time on Wing

Rolls-Royce launched the first of two Durability Enhancement Packages, that will more than double the duration Trent 1000 engines remain in service before needing scheduled maintenance. This marks an important milestone on Rolls-Royce's transformation program into a high performing, competitive, resilient and growing business.

Increasing "Time on Wing" for the Trent 1000 will bring significantly improved asset utilization, reduced maintenance burden and provide far greater fleet planning certainty for customers, the company says. It says the durability enhancement complements the reliability that the Trent 1000 already has.

The enhancement package has been installed in new engines since January 2025, ready for delivery to customers at the earliest opportunity post-certification. They will now be distributed to maintenance facilities globally, to be retrofitted to engines that are already in service. Within two years all of the Trent 1000 fleet will have been upgraded.

The upgraded components have already been enhancing durability since 2022 on the Trent 7000 engine. It is performing better than expected, and in some cases more than tripling Time on Wing. This proven in-service performance gives Rolls-Royce full confidence in the same benefit reading across to Trent 1000 customers.

The new technologies — part of the Trent fleet £1bn durability enhancement program — will contribute to Rolls-Royce meeting its mid-term targets to increase average Time on Wing across all

modern Trent engines, which incorporates the Trent 1000, Trent 7000, Trent XWB-84 and Trent XWB-97. The company announced earlier this year that this target would double from its initial ambition of a 40% average increase to 80% by 2027.

"The Trent 1000 is an important engine for us and today marks a new chapter in its story," said CEO, Tufan Erginbilgic. "When upgraded, we're confident that our customers and their passengers will benefit from increased durability, thanks to the proven enhancements that have already surpassed our expectations on the Trent 7000. As part of our ongoing transformation, the investment we have made in new technologies will see the Trent 1000 deliver for Boeing, our customers and our investors. It's a win-win for everyone involved."

The first phase of durability enhancement includes a 40% increase in cooling to the new high pressure turbine blade. There are also updates to the combustion system, fuel spray nozzles and engine electronic controller software.

"Today is an important day for Rolls-Royce, our customers and our partnership with Boeing," said Rob Watson, president of Rolls-Royce Civil Aerospace. "We know that the same enhancements have already tripled Time on Wing in some cases for the Trent 7000, so we are confident it will deliver for Trent 1000 customers. To do so at pace, we began installing the enhancements into new engines prior to today's certification to reduce the lead time as much as possible. They will now enter the fleet immediately."

Phase two of the Durability Enhancement Package is currently being tested at Rolls-Royce's facility in Derby, U.K., and will bring a further 30% improvement in Time on Wing across the Trent 1000 and Trent 7000 fleets. It features advanced coating on combustor tiles in non-benign environments; cooling and coating changes to high pressure nozzle guide vanes; weight reduction and coating improvements to high pressure turbine blades; and a redesigned combustor-to-turbine interface taken from the latest variant Trent XWB-84 EP. This further enhancement will start entering the Trent 1000 fleet from early 2026.

Rob Watson
President Rolls-Royce
Civil Aerospace

Tufan Erginbilgic
CEO,
Rolls-Royce

Safran and Saft to Co-Develop a High-Voltage Battery System for Aviation Electrification

Safran Electrical & Power, a world leader in electric aircraft systems, and Saft, a subsidiary of TotalEnergies, which develops advanced batteries for a wide range of industrial sectors including aerospace, have signed an exclusive partnership to develop a high voltage battery system for aviation, paving the way for the next generation of aircraft.

The new high-voltage battery system is designed to meet the growing demand for aircraft electrification. It will revolutionize onboard energy by delivering unprecedented power levels, allowing more energy to be stored and supplied over longer durations. Thanks to the combined expertise of Safran and Saft, the system incorporates high-performance lithium-ion cells, cutting-edge technologies in thermal runaway containment, system management, and safety-related algorithms, ensuring the highest safety standards.

The battery's performance is fully scalable: modules and cells are engineered for easy adaptation to various aircraft configurations. Its modular design, with length-adjustable modules, allows seamless integration, meeting diverse installation constraints across aircraft platforms. Leveraging the latest battery technologies — from today's lithium manganese ferro phosphate (LMFP), to solid-state cells in the near future — this new system will guarantee optimized performance tailored to the stringent requirements of aviation.

"Our initial collaboration with Saft has shown the powerful synergy between our two companies, and we are thrilled to move forward," said Bruno Bellanger, Safran Electrical & Power CEO. "We aim to bring to market a groundbreaking high-voltage battery system — a true game-changer for the industry. As the industry charts its path towards net-zero emissions by 2050, electrification will be a cornerstone of the transformation, and we are determined to lead the way."

"We are delighted to combine our expertise with Safran to leverage our complementary skills and pool our resources," said Cedric Duclos, Saft CEO. "Joining forces with Safran will enable us to accelerate the innovation in high voltage battery systems to meet safety, performance and emissions reduction."

This collaboration is part of the strategic alliance between Safran and TotalEnergies signed in 2021 to jointly develop technical and commercial solutions for reducing the carbon footprint of aviation. Saft and Safran have been working together as part of an aviation battery research consortium with the support of the French Civil Aviation Authority (Direction Générale de l'Aviation Civile-DGAC).

FDH Aero Unifies its Legacy Hardware Brands Under Single Division

Matt Lacki President, FDH Hardware

FDH Aero, an independent supply chain solutions partner for the aerospace and defense industry, announced the formation of FDH Hardware, a unified division comprising its five legacy hardware brands within a cohesive, focused structure.

The newest of FDH Aero's core divisions, FDH Hardware follows the formation of FDH Electronics and FDH Defense Aftermarket. This new FDH Hardware collective brings a deeper technical expertise and a more coordinated approach to supporting both OEM and aftermarket customers worldwide.

"The creation of FDH Hardware is an important step toward improving and simplifying the global supply chain," said Matt Lacki, president of FDH Hardware. "I'm excited about the technical depth and operational strength this collective team brings, and we're eager to apply the lessons learned from the formation of FDH Electronics and FDH Defense Aftermarket to deliver even

greater flexibility, reliability and product breadth for our customers and supplier partners."

The company says the move comes as OEMs continue to accelerate production across the globe while supply chains remain strained due to geopolitical challenges, creating significant bottlenecks in regions where aircraft parts are difficult to source. By unifying these companies under one coordinated division, FDH Hardware says it will simplify access to inventory, expertise and support while empowering regional teams to make decisions on the ground. This will offer customers access to a faster, more tailored service without the added complexity of managing multiple vendors.

"By consolidating backend systems and inventory, expanding our talent pool, and maintaining regional autonomy, we've created a model that combines the scale of a global distributor with the responsiveness of a local partner," added Lacki. "We've seen how well this strategy works for FDH's other core divisions and we already see how our hardware customers are benefiting from new efficiencies that we're bringing to their operations."

FDH Hardware now offers customers broader access to a complete line of aerospace fasteners, from specialized items to C-class parts, all rigorously tested and inspected to meet the highest industry standards. FDH Aero's continued investment in its hardware division reinforces its commitment to setting a new standard for supply chain responsiveness, reliability, and customer-focused service across the aerospace and defense industry.

Astronautics Selected to Provide Avionics System Solution for Radia Windrunner

Astronautics Corporation of America has signed an agreement with Radia for the design and development of a complete avionics system solution for their WindRunner cargo aircraft.

"The opportunity to work collaboratively with Radia on the avionics architecture for their one-of-a-kind WindRunner aircraft is an exciting project for all of us at Astronautics," said Eytan Saletsky, Astronautics director of system solutions. "We look forward to applying our avionics products and system integration expertise to a platform that will reshape global aerospace logistics."

The WindRunner is the largest aircraft ever built by volume and is designed for large-scale logistics in locations with limited infrastructure — serving energy, aerospace and defense, and emergency response missions.

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By Jim Romeo

New-Age Avionics Maintenance

Avionics Testing and Repair Advances with New Tools and Technology

Avionics testing and repair are undergoing a rapid transformation as new technologies redefine how maintenance crews diagnose, service, and upgrade aircraft systems. From AI-assisted diagnostics to portable test platforms and augmented reality overlays, today's avionics maintenance is more precise, predictive, and efficient than ever before. As aircraft become increasingly software-defined, staying ahead in the hangar now means embracing tools once reserved for the lab.

A predominant theme in avionics testing and repair seems to be the role that technology and advances in science and engineering plays — be it artificial intelligence, software-centric solutions, more effective equipment, or new digital tools. All are contributing to advancements in avionics testing and repair.

Michael Miles is an avionics manager with Standard Aero in Springfield, Illinois.

"Computer-based troubleshooting continues to advance, modernizing avionics repair methodology. Hardware has given way to software and more and more systems from avionics manufacturers must be downloaded and sent to a repair center for each manufacturer," says Miles. "The days of an avionics mechanic being able to overhaul or replace small parts in instrument and computer systems are long gone. Most analog test equipment has gone by the wayside for bus readers and laptop connections. However, the one constant has been the multimeter. The multimeter has advanced from analog to digital over the years, but the basics remain the same. Troubleshooting wiring and components still comes down to power, ground, and continuity checks. If a component or system fails or gives an error message, the first manufacturer-directed step is to always to check the wiring to the system to ensure proper connection. While we have moved away from simpler diagnostic tools to the digital and software-based world, the multimeter is the one constant backbone of troubleshooting and provides us with the confidence in the source of issues to make the decision to repair or replace the failed system. However, with today's modernization in avionics, many advancements in component complexity have been offset by user-friendly systems and much better training for technicians."

In the past decade, there has been an ongoing emphasis on automated testing methods in avionics. This has enhanced productivity by providing hands-off testing with a wider depth of subsystem interrogation. Muirhead Avionics image/AMETEK MRO.

Dror Yahav, CEO Universal Avionics

Louis Mallette, President AJW Technique

Marlon Bustos, Accountable Manager Air Accessories and Avionics

Artificial Intelligence (AI) Offers New and Advanced Maintenance Methods

Artificial intelligence is also playing a role in new and more effective approaches to avionics testing and repair. Dror Yahav is the CEO at Universal Avionics in Tucson, Arizona.

"Avionics testing and repair have always been based on proven methods with strict standards that ensure reliability, such as bench testing and built-in diagnostics," says Yahav. "These essential practices are critical, but with the rise of AI and access to deeper operational insights, we're evolving our processes. We're now able to move from reactive maintenance to predictive, using AI data-driven strategies. AI helps us identify trends, streamline repair techniques, and optimize inventory, reducing both downtime and cost."

Yahav adds that they are feeding all their insights back into our AI models to train new design processes. Lessons learned in the field are directly shaping the next-generation product development and improvements we introduce to existing products.

Advancements in Test and Repair Are Incrementally Integrated

Louis Philippe Mallette is the president of AJW Technique in Montréal, Canada, a maintenance, repair and overhaul (MRO) facility for business and commercial aircraft and the global repair hub for AJW Group. Mallette says that primary testing of avionics components is performed using automated test equipment where a full functional test of the equipment is performed. This generally highlights any failures in specific areas of the component requiring attention. But there's an evolution to more sophisticated tools, technology, and techniques.

"Avionics components have evolved significantly over the years, progressing from principally analog electronics in the 1980s to the latest digital technologies today with increased use of microprocessors embedded in aeronautics," says Malette. "The testing of avionics components has become significantly more intensive, driven by new testing standards from the aircraft manufacturers and equipment OEMs to drive increased reliability and enhance safety on modern platforms. As an example, the number of test points performed during a typical avionics unit test is now easily 10 to 100 times what it would have been 20 years ago. The performance of the automated test equipment has clearly improved over the years and this, in conjunction with more efficient test software, has been accomplished without increasing the overall test time."

Mallette explains that once component failure is narrowed down to a specific circuit card, manual testing using an oscilloscope, for example, is used to verify the integrity of the circuit card assembly and to test individual devices on the card to identify the cause of failure.

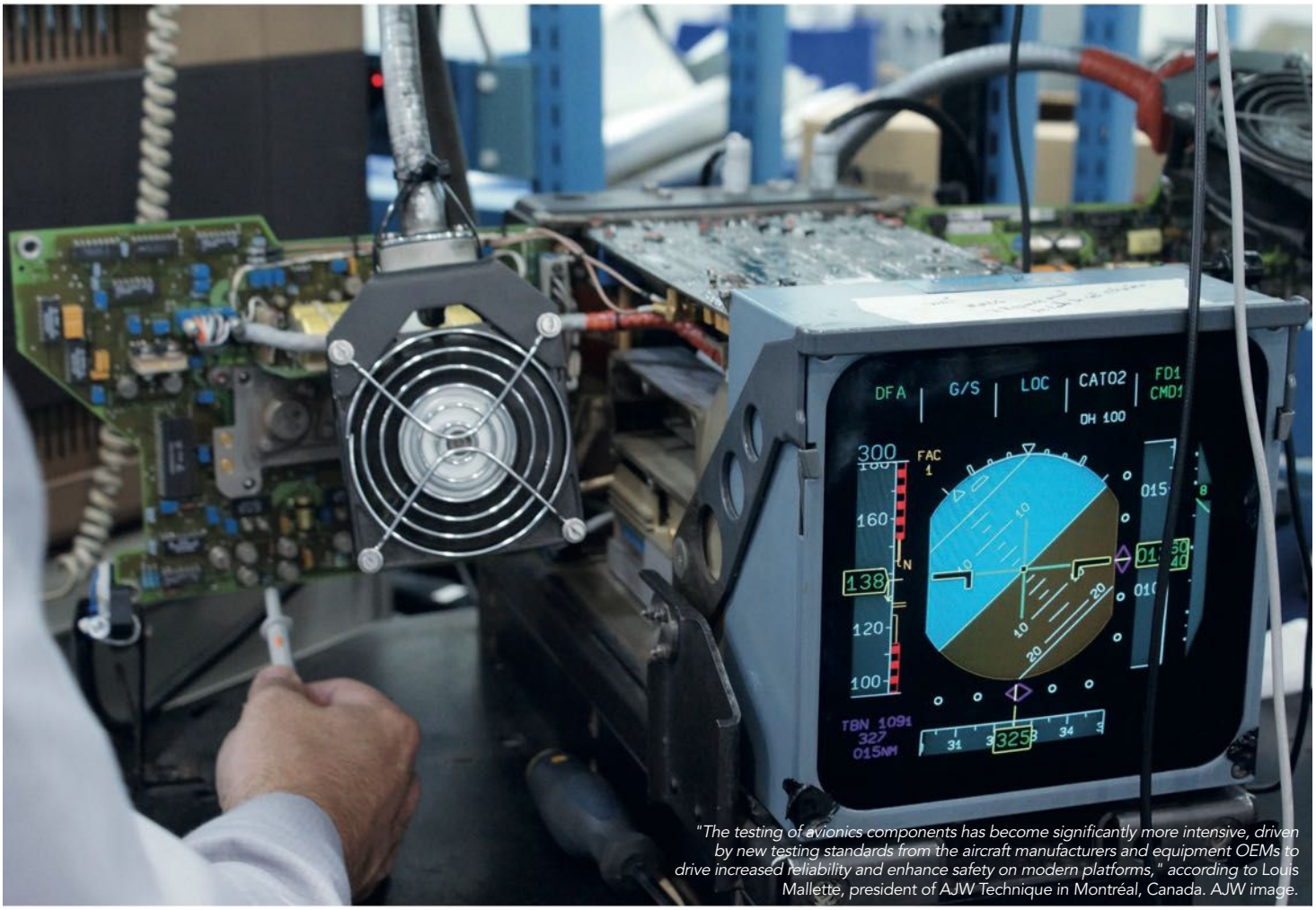
"It goes without saying that the workshop environment in which we are testing is more stable than the actual environment on the aircraft, so, if necessary, we also adopt stress testing techniques," he says. "In these instances, we heat and/or cool the component whilst testing, and subject it to vibration. This helps identify latent failures as simple as cold solder joints, which do not show up in regular testing."

Advancements in avionics are not taking place all at once but are incrementally finding their way into shops and depots. Sometimes this takes place as upgrades to existing equipment and procedures. Marlon Bustos is an accountable manager at Air Accessories and Avionics, a Broward Aviation Services Group Company, located in Florida.

Bustos says that the fundamental methodologies tend to remain quite consistent over time. "Most component maintenance manuals (CMMs) continue to specify the use of established test equipment," says Bustos. "However, at Air Accessories and Avionics we do observe incremental advancements. This often involves the integration of supplementary equipment, or the adoption of upgraded versions of existing testers. This evolution is partly driven by the fact that certain older test equipment models are no longer manufactured or supported for repairs, necessitating updates to our capabilities."

Concerning advancements or changes in how avionics are maintained, his observation is that many avionics components are typically not removed from the aircraft unless a failure has occurred.

"Unlike mechanical systems, avionics components generally lack parts susceptible to wear and tear," says Bustos. "As long as they receive the correct input power and are adequately cooled, their longevity is typically excellent. However, it's important to note that the repair and troubleshooting of individual processor boards within these components is generally not feasible due to insufficient information provided in the CMMs. This detailed knowledge is proprietary to the original board manufacturer. Consequently, in approximately 98% of cases, board-level failures result in component replacement rather than repair."



"The testing of avionics components has become significantly more intensive, driven by new testing standards from the aircraft manufacturers and equipment OEMs to drive increased reliability and enhance safety on modern platforms," according to Louis Mallette, president of AJW Technique in Montréal, Canada. AJW image.

Ramey Jamil is the director of engineering at Muirhead Avionics/AMETEK MRO in London, U.K. He says that in the past decade, there has been an ongoing emphasis on moving towards automated testing methods, systematically enhancing productivity by providing hands-off testing with a wider depth of subsystem interrogation. This inherently allows engineers to gain greater insight into the root cause of problems, thereby enabling more effective and reliable resolutions.

"In some cases, at Muirhead Avionics/AMETEK MRO, we have seen LRU testing times cut down by more than 80%," says Jamil. "A test program that used to take two hours can now be reduced to mere minutes. With each passing year, these systems continue to improve their efficiency, leveraging advancements in the next generation of computing and sensors to provide greater productivity and further insight into our daily operations. Muirhead Avionics observes that these systems allow us to collate new data, detailing downtime and common failures, thereby fueling preventative maintenance routines. This enables us to predict potential issues before they arise and ensures we can secure our stock and supply chain. We are now looking at automating legacy avionics into automatic testing regimes, developing purpose-built rigs that mimic the manual operator-driven test programs through in-house developed sub-routines."

Ramey Jamil Director, Muirhead Avionics/ AMETEK MRO

There are many digital tools as well as new skills available that enable avionics testing and repair to be more expedient and effective. With such tools and technologies, tribal knowledge and reliance on specific personnel experience is less than in the past.

"Historically, many avionics technicians were referred to as 'sparkys' or other informal monikers, in relation to their work with the instrument and autopilot systems," says Michael Miles. "This is more prevalent in today's software-based systems. Bendix/King Sandia and some of the older analog systems have given way to Garmin, Collins, and Honeywell smart digital systems. The use of laptop computers has become a way of life for maintaining and updating the modern systems. Troubleshooting skills are now based on component diagnostics through the systems themselves and computer-based downloads that will point to likely root causes of the affected systems. I have seen technician skill levels with computer and diagnostic skills rise significantly over the years due to many more learning opportunities for the early career technician. Each manufacturer has its own classes and schools nowadays and they are invaluable tools for the line technician. AEA and FAA classes can also help teach the basics of avionics wiring and general repair for someone just beginning. This has been a great help in getting technicians qualified at a quicker rate than years past. The complexity of the systems has increased, but thankfully the training and OJT programs have kept up with the

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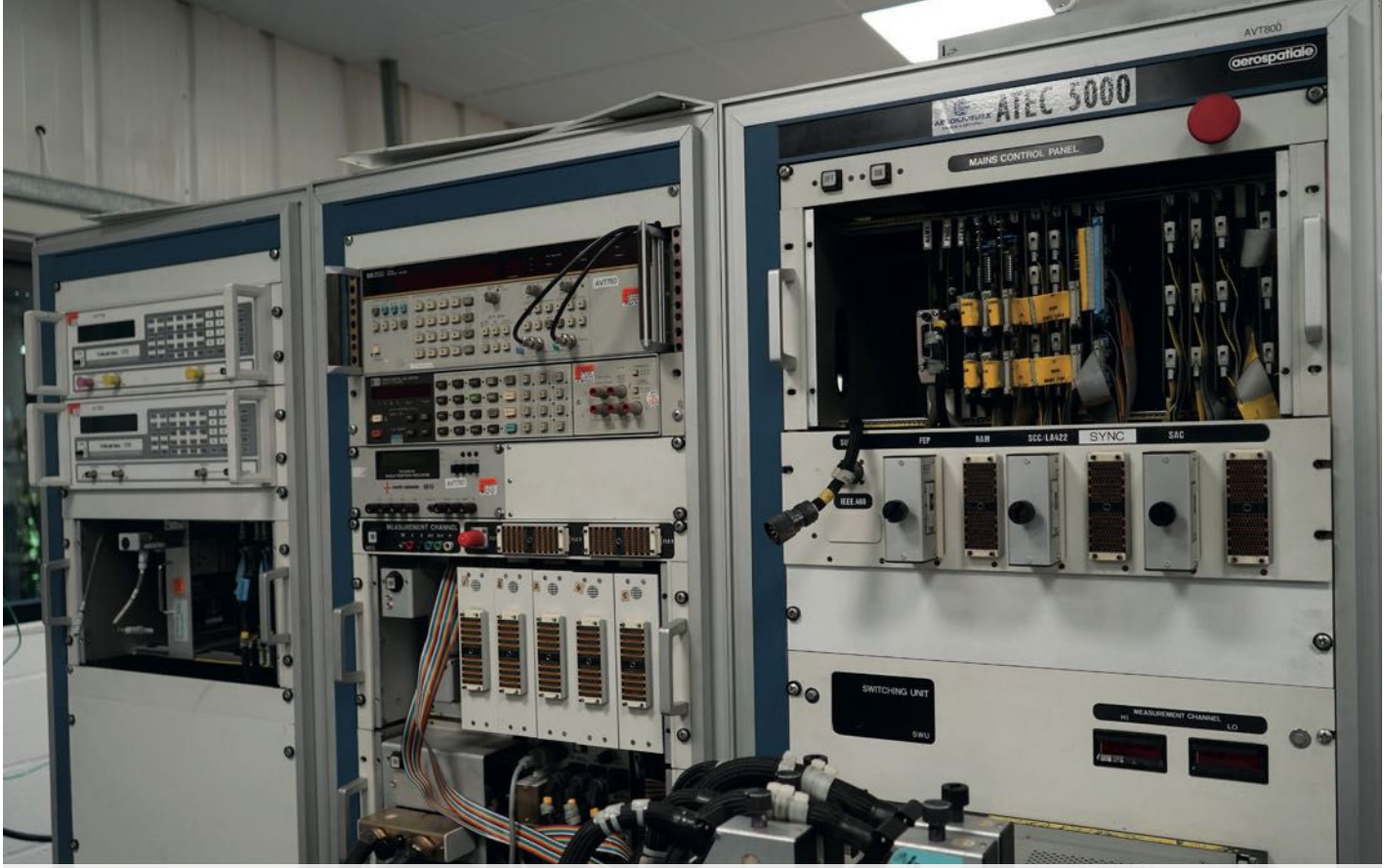

Muirhead Avionics says it has seen some LRU testing times cut down by more than 80%. "A test program that used to take two hours can now be reduced to mere minutes." says Ramey Jamil, director, Muirhead Avionics/AMETEK MRO. "With each passing year, these systems continue to improve their efficiency." Shown here, is the ATEC 5000. Muirhead Avionics/AMETEK MRO image.

advances in technology. No longer is 'tribal knowledge' needed as much today because of the many digital tools at our disposal."

Yahav says that avionics maintenance is moving from traditional scheduled maintenance toward a more intelligent, predictive model. Data is continuously gathered across the entire lifecycle of the system. This creates a real-time digital profile of the equipment's health and usage.

"With Universal Avionics, this proactive maintenance is enabled using UA FlightPartner and FlightReview iPad apps, recording data across connected systems (such as flight management systems and flight data recorders) for extensive aircraft and fleet reporting after every flight," says Yahoo. "This cloud connectivity streamlines maintenance workflows, helping technicians save 45 minutes on aircraft database updates each month. Predictive maintenance algorithms run in the background, analyzing this data to detect early signs of degradation. Instead of waiting for a fault or relying solely on routine intervals, we can now recommend preemptive actions before any equipment fails. This enhances safety, reduces unscheduled downtime, and optimizes lifecycle costs."

Software-Centric Test and Repair

Muirhead's Jamil says that along with other industries, aerospace has continued its trend towards more software-centric development. In the past, specific functions were developed using hardware alone, that is in the form of logic circuits, made up from resistors, diodes, breakers, etc., and spread across several different boards.

"Now avionics development has shifted most of these functions to a single IC, utilizing advanced software logic and control laws instead," he says. "In essence avionics have become smaller and smarter, fundamentally impacting the way we maintain them at Muirhead Avionics. This approach demands currency and competency in software development as well as requiring a whole new set of specialized tools. However, this trend does come with a major set of benefits; it has now become easier to execute modifications which rely on software updates, as opposed to a board replacement or complete overhaul. We can also interrogate them further, giving us the ability to explicitly analyze the root cause of the issue. When coupled with automatic testing methods this process is dramatically improved in both efficiency and reliability."

Ismael Fadili, VP of sales, AMETEK MRO, Europe

Jamil adds that now, more than ever, avionic MRO specialists like Muirhead Avionics are becoming a key focus point of the aerospace industry, housing critical and cross sectoral data. Hence, with the advancements in data analytics and AI, this data can be used to drive the development of the next generation of avionics, making them cheaper, more reliable, and easier to maintain.

"Over the next few decades, we expect to see a shift in the way the aerospace industry operates," he says. "OEMs will seek to establish long-term partnerships with MROs earlier in the development cycle, leveraging their data, knowledge base, and experience to ensure a smoother deployment and go-to-market strategy."

Ismael Fadili is vice president of sales for AMETEK MRO Europe. He concludes by saying that one of the key things impacting the industry is formal FAA rulemaking on the 25-hour CVR mandate which is forthcoming.

"Airlines will likely need to retrofit their existing fleets by 2030 at the latest but can accelerate the safety benefits by adopting the 25-hour CVR earlier through a simple box swap. This will be a challenge for many avionics shops over the next few years and Muirhead Avionics is well positioned to prepare this transition. We anticipate that the digital transformation will be another challenge with AI integration, especially to support predictive maintenance." AVM


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By Ian Harbison

Stop And Go
The Cyclical Journey of Wheels and Brakes

Maintenance for aircraft wheels and brakes is more complicated than it might seem. Ian Harbison spoke to some of the leading players.

Nikolaj Jacobsen, CEO of TP Aerospace, says the MRO market for aircraft wheels and brakes closely mirrors global airline activity. These components are among the most cycle-driven parts of an aircraft — meaning their maintenance schedules are directly tied to how often an aircraft takes off and lands. Typically, aircraft wheels require servicing every 250 to 400 flight cycles, while steel brakes see maintenance between 800 to 1,000 cycles and 1,500 to 2,000 flight cycles for carbon brakes.

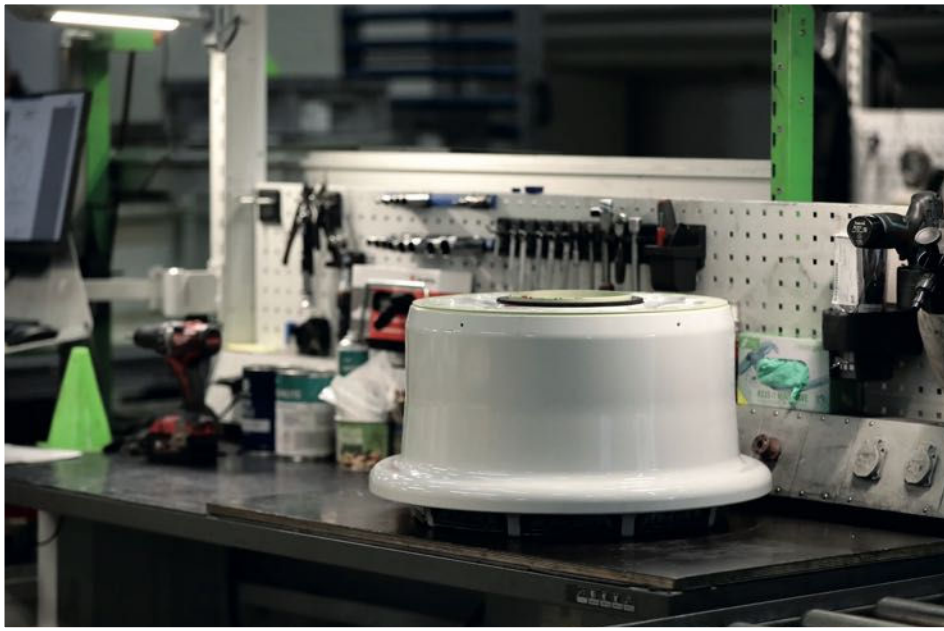
The company operates across 12 strategic locations worldwide, covering the full spectrum of commercial aircraft, from regional jets to widebodies, and it supports both passenger and cargo operators, with long-term service contracts for close to 1,000 aircraft globally.

Those locations are: Bangkok, Brisbane (opened in 2024), Brno, (also opened in 2024), Copenhagen (headquarters), East Midlands, Hamburg, Kuala Lumpur, Las Vegas, Melbourne, Orlando, Shenzhen (sales representative office) and Singapore.


Nikolaj Jacobsen, CEO, TP Aerospace

He says this global footprint enables the company to keep a close eye on the state of the industry. In 2025, the year started with unexpected turbulence — largely due to U.S. tariffs and the economic uncertainty they triggered. While these factors

Wheels and brakes are among the most cycle-driven parts of an aircraft. Their maintenance schedules are directly tied to how often an aircraft takes off and lands. TP Aerospace image.



International markets in Asia Pacific and Latin America are experiencing robust growth and increased demand for wheels and brakes services. TP Aerospace image.

have introduced some headwinds, the overall trajectory remains positive. Key indicators like Revenue Passenger Kilometers (RPK) and Available Seat Kilometers (ASK) are on the rise.

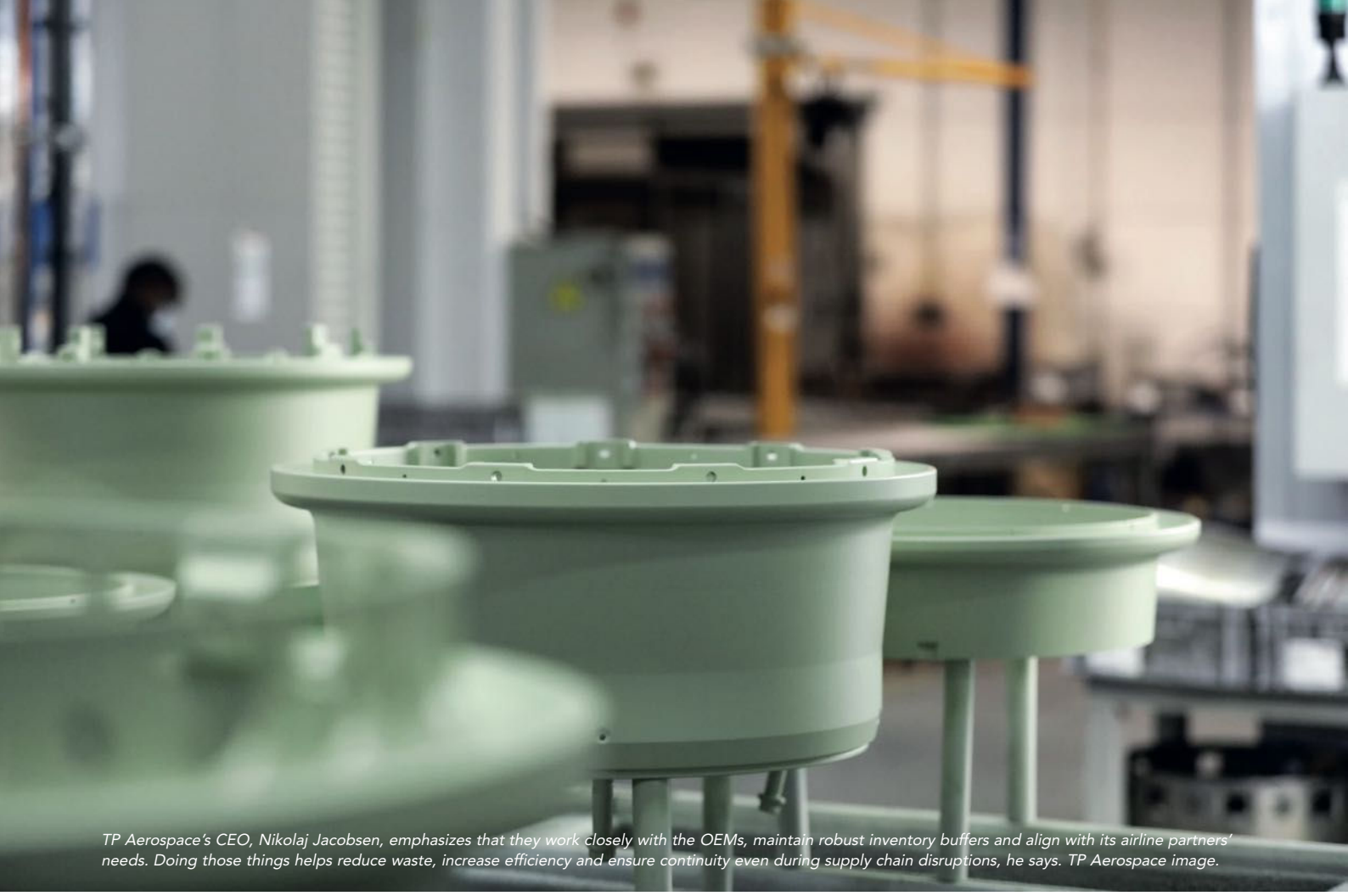
There are some regional imbalances that have been noted. North America and Oceania are showing signs of softness, with some U.S. carriers already adjusting capacity and adopting a more cautious outlook. In contrast, international markets in Asia Pacific and Latin America are experiencing robust growth. This divergence is reflected in the wheels and brakes segment as well — Asia Pacific is buoyant, while the Americas are more reserved. Europe remains relatively stable, with the exception of some transatlantic routes. He comments that these dynamics are shaping how and where the company invests in capacity, inventory, and talent.

A clear trend is emerging that airlines are increasingly seeking long-term partnerships with specialized providers like TP Aerospace. They're not just looking for a repair shop — they want a strategic partner who understands their operational needs and can deliver tailored, efficient solutions that are agile and trustworthy. This shift spans all airline segments, from cargo to passenger and ACMI operators.

He says this is great news for the company, which prides itself on being more than a service provider. It is a value chain optimizer. By working closely with OEMs, maintaining robust inventory buffers and aligning with its airline partners, it helps reduce waste, increase efficiency and ensure continuity even during supply chain disruptions. The extensive network also contributes to efficiency, as customers can find a service center close to them. Recent examples include Ukrainian operator Supernova, which has a fleet of Boeing 737NG freighters and is mainly serviced by Brno, the Czech Republic, while the U.K.-based ACMI specialist Ascend Airways will have its existing and future planned fleet of 737MAX aircraft, support by East Midlands.

He adds that airlines today demand more than just repairs, they want predictability, transparency and peace of mind. They don't want to worry about whether a specific fastener is stuck in a producer's backlog. They want a partner who understands the intricacies of the wheels and brakes ecosystem and can proactively mitigate risks. The great thing is that OEMs also want a partner that can handle this part of the value chain and that is why the company partner with both sides.

TP Aerospace has embraced this shift, with a service model built around end-to-end lifecycle support, ensuring that customers can focus on flying while it handles the rest. From predictive maintenance to inventory planning, it is helping airlines turn uncertainty into reliability.



TP Aerospace's CEO, Nikolaj Jacobsen, emphasizes that they work closely with the OEMs, maintain robust inventory buffers and align with its airline partners' needs. Doing those things helps reduce waste, increase efficiency and ensure continuity even during supply chain disruptions, he says. TP Aerospace image.

Interestingly, he says, the demand for specialized wheel and brake services is not confined to any one type of airline. Low-cost carriers, full-service airlines, cargo operators, and ACMI providers are all converging on the same need of operational reliability at a predictable cost. This convergence is driving a more unified approach to MRO partnerships, where flexibility and customization are key differentiators.

The company offers fully integrated exchange Flat-Rate Programs where the customer pays a fixed rate per landing and Land For Less (LFL) Programs that provide a less-integrated solution where customers pay a fixed fee per exchange event. In addition, it has the largest spares stock in the aftermarket and is an active purchaser of inventory, either serviceable or in need of repair. It also offers a 24/7 service for AOG situations or routine delivery. The third leg of the business is distribution of new OEM wheels and brakes piece parts and assemblies across all types and platforms.

Laurent Bouissou, MD, Antavia

He says innovation is a continuous journey. The company is constantly evaluating how to make the repair and overhaul processes more efficient and sustainable, especially as some steps are quite tough and labor-intensive and involve chemicals that it is actively working to reduce or replace. These improvements not only benefit the environment but also enhance employee safety and reduce costs, savings that can be passed on to customers and invested in upskilling the workforce.

Investments are also being made in automation and digital tracking, as well as a focus on AI and machine learning in the planning process. The latter helps to predict and mitigate supply chain disruption, again reducing the pain for airlines and OEMs.

TP Aerospace says their clients want a partner who understands the intricacies of the wheels and brakes ecosystem and can proactively mitigate risks. TP Aerospace image.

Antavia

Laurent Bouissou is managing director of Antavia, which has been part of AMETEK MRO since 2007 but has a history of more than 30 years. The activities cover commercial, business, helicopters and military market sectors.

Corporate headquarters and a workshop are located in Campsas, just under 20 miles north of Toulouse-Blagnac Airport, with a larger facility, covering commercial, business and military aircraft in Le Mesnil-Amelot, on the edge of Charles de Gaulle Airport (CDG) and just eight miles northwest of Le Bourget. There

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Antavia has been part of AMETEK MRO since 2007 but has been around more than 30 years. Their activities cover commercial, business, helicopters and military market sectors. Antavia image.

is also a workshop in Singapore, which is growing.

Campsas is dedicated to supporting the ATR and Dassault production lines as well as the Airbus Transport International fleet of three Beluga ST and six Beluga XL.

For Le Mesnil-Amelot, proximity to CDG makes airline work important, particularly from Air France while a lot of business aviation work comes from Le Bourget, including Cessna, Dassault, Bombardier and Embraer types. As well as contracts with operators like NetJets, it works closely with Dassault Aviation Falcon Spares (DAFS) and Dassault Aviation Business Services (DABS), a worldwide service organization. Antavia works as well for the Dassault Production line in Merignac. In fact, it has just delivered the first set of wheels and brakes for the prototype Dassault Falcon 10X.

He notes that the business aviation market has high expectation of reduced turnaround times (TRTs) and quality. The company can often be expected to return a wheel in 48-72 hours, even if this includes 12-24 hours needed for pressure testing, as well as paint stripping, balancing, NDT (dye penetrant, eddy current and magnetic particle). In addition, Dassault, for example, requires that wheels are resprayed at every tire change. For DAFS, this can mean wheels being returned to a specific aircraft, while for DABS, with its worldwide network, they often go back into a pool.

Military work includes support for Boeing on the USAF C-17 fleet in Europe; for Sabena Technics for the French Air Force Airbus A330 tanker and VIP aircraft and the Lockheed Martin C-130 Hercules; and for Air France for French Air Force Boeing E-3F AWACS. He says it is an important and growing part of the business.

As a rough guide to the market split, he explains that Paris handles around 5,000 wheels a year, of which business aviation is 50%, military is 30% and commercial 20%.

He comments that airlines tend to have their own particular models. Some have their own wheels and brakes shop; some perform tire changes in-house but subcontract overhaul work; some subcontract specialized repairs; and some use outside shops for overflow work.

He adds that tire work is very cyclical. Tire wear is highly dependent on outside temperature, with a rule of thumb that every 1°C increase will cost 10 landings. His own airline experience showed a tire that would do 400 cycles in winter would only achieve 200 in summer. This is complicated with long haul services crossing continents and climate zones. A freeze or a heatwave over several weeks can also throw up unexpected wear levels. The other major factors affecting tire wear include use levels of thrust reverse and brakes, and runway and taxiway abrasion levels.

There are averages, he says, but there are always surprises. One customer forecasted 300 wheels in 1Q25 but only sent 180. Having recalculated their annual requirement, it dropped from 1,000 to 800 wheels. Recently, they delivered 20 wheels in one week. All these uncertainties, combined with demand for fast TRTs, means load planning is "our daily nightmare!"

On brakes, he says carbon is dominant, with aircraft like the Boeing 737, where there is an option of steel brakes, seeing a shift from steel to carbon. They are lighter and much more durable, but also very, very expensive. Also dominant are the OEMs. They control prices to third-party MROs and no PMAs are available. In fact, the carbon heatstack is their exclusive preserve and is often supplied as embodiment loan to the MROs, who can work on the rest of the system.

Another part of the Air France contract for French Air Force Boeing E-3F AWACS is steel brakes.

Finally, he adds, electric brakes are an upcoming requirement, with the Airbus A220 and Boeing 787, which will require investment in different test benches.

Safran

From an MRO perspective, Safran Landing Systems sees a trend towards carbon technology, as it offers lighter equipment and greater energy absorption capacity as well as faster cool down than steel. In 2023, 13% of commercial aircraft with 100 seats or more were equipped with steel brakes, compared with 87% with carbon brakes.

Now, the carbon brake production level is higher than before Covid due to the unprecedented production ramp-ups by the airframers and the growing maintenance needs of airlines, both driven by the strong recovery in air traffic since the pandemic.

The company adapts to the specific needs of each airline with a comprehensive range of services, from heat sink exchanges to "all inclusive" support including the supply of components and even tire change. As part of this tailor-made services offer, it provides cost-per-landing contracts, particularly interesting for airlines with large fleets,

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Uncertainties in customer planning combined with demand for fast TRTs, mean load planning is a daily challenge for companies that provide wheels and brakes services. Antavia image.

for which maintenance and repair costs are based on the number of landings made by the aircraft. This cost is variable depending on traffic levels, which is linked to revenues. This enables operators to manage their maintenance costs more predictably.

In order to offer increasingly responsive support and improve fleet availability for customers, Safran Landing Systems has its own MRO workshops in the USA and soon in Asia, as well as MRO partnerships around the world to cover major airports with very short turnaround times. In the USA, in particular, subsidiary Wheel & Brake Repair & Services relies on five repair stations strategically located in Miami (Florida), Milwaukee (Wisconsin), Las Vegas (Nevada) and Grand Prairie (Texas), to be as close as possible to customers, while wheels, brakes and heat sink are manufactured by a plant in Walton (Kentucky).

In addition, it is developing projects leveraging the potential of Artificial Intelligence, allowing it to better anticipate customers' demand for carbon disk exchanges.

Each airline has its own support model, either by completely outsourcing the maintenance of its wheels and brakes, or by carrying out all or part of these operations in-house, through its own MRO workshop which, in some cases, may even provide maintenance services to other airlines. There are more and more requests from airlines to outsource their maintenance to maximize variable cost.

Safran says the trend for their airline clients is towards increasingly robust brakes, with a short turnaround time between overhauls and lightweight brakes, to help reduce fuel consumption. Safran image.

Safran says it adapts to the specific needs of each airline with a comprehensive range of services, from heat sink exchanges to "all inclusive" support including the supply of components and even tire change. Safran image.

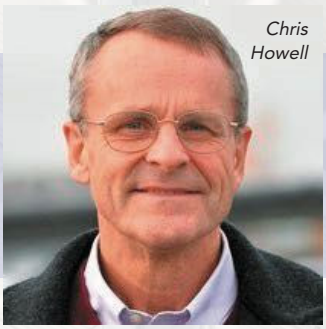
Today, supply rather than demand defines growth, whether on medium-haul or long-haul routes. More broadly, at the request of airlines, the trend is towards increasingly robust brakes, with a short turnaround time between overhauls and lightweight brakes, to reduce fuel consumption.

The company is able to remanufacture carbon brake disks as new by reusing/recycling up to 50% of the disk, depending on the configuration. While guaranteeing the same level of performance and safety, this process contributes to significantly reducing needs for materials and the energy associated with manufacturing.

By James Careless

Advances in SMS: An Aviation Maintenance Virtual Roundtable


Chris Hill


Chris Howell


Debi Carpenter

Once seen as bureaucratic obligations, Safety Management Systems (SMS) have evolved into dynamic, data-driven ecosystems that support informed decision-making across aviation operations and maintenance, and even boardrooms. In this Aviation Maintenance 'virtual roundtable' discussion, three SMS industry leaders take a look at what SMS is, where it is headed, and why operators should care about SMS more than ever.

Aviation Maintenance: Let's begin by asking each of you to introduce yourself, and to tell us about your role in aviation SMS.

Chris Howell: I am CEO at NorthWest Data Solutions, a leading provider of aviation safety solutions. My work focuses on overseeing the development and implementation of SMS tools that enhance risk management and safety culture for airlines and operators. With 17 years of experience in aviation safety, I collaborate with stakeholders to ensure our solutions align with regulatory standards and industry needs.

Chris Hill: I am the senior director of safety at Vertical Aviation International (VAI). I lead VAI's strategic initiative to elevate safety throughout the vertical aviation industry by delivering high-quality safety programs and educational resources. My focus includes advancing SMS awareness, adoption, and effectiveness across diverse operational profiles worldwide.

Debi Carpenter: As executive director of the Air Charter Safety Foundation, my role is to drive the ACSF's mission to influence industry safety by empowering our members with educational tools and resources to proactively drive their organization's safety culture and safety performance. More specifically, I oversee the development of our SMS tools for operators of varying sizes. At ACSF we also have an ASAP (Air Safety Action Plan) program, plus our Member Assistance Program (MAP) where we help operators prepare for audits, get their SMS set up and get ready to submit compliance.

Aviation Maintenance: Thanks! So, to begin with, what trends are driving the SMS market today?

Chris Howell: The SMS market is evolving rapidly, driven by several key trends.

First, there's a strong shift toward data-driven safety management, with organizations leveraging advanced analytics and artificial intelligence to predict and mitigate risks proactively. For instance, real-time data from flight operations and maintenance records is being used to identify patterns that could indicate potential hazards.

Second, there's a growing emphasis on integrating SMS across all aviation domains, including manufacturers and air traffic control, as regulators like the FAA expand requirements and oversight capabilities. Finally, fostering a robust safety culture remains critical, with more organizations adopting anonymous reporting systems to encourage open hazard identification, which has led to a notable increase in reported safety issues.

Debi Carpenter: The integration of AI and predictive analytics is a major trend driving SMS these days. AI is a great way to enhance hazard identification and risk assessment. Predictive analytics tools can forecast potential safety issues, which helps to be more proactive and more informed for decision-making.

Additionally, there is a rising emphasis on FDM (Flight Data Management), which adds objective data to support a Safety Management System. Within the framework of the SMS, FDM provides insight into what's really happening during flights, so operators can spot patterns, fix issues early, and continually improve. It's a powerful way to make sure safety isn't just a plan — it's something that's always improving.

Chris Hill: The recent expansion of the U.S. Part 5 SMS rule has brought renewed attention to SMS implementation across the industry. In response, VAI is focused on equipping our members with the resources they need to build effective safety management systems that support daily operational risk management.

Despite broad industry support, many smaller operators remain hesitant. We understand their concerns and are working alongside regulators, industry partners, and volunteers to help demystify SMS and emphasize its practical benefits when implemented properly.

With compliance deadlines approaching, we expect to see a spike in attention, some of it sincere, some of it perhaps less so. Regardless, we encourage all operators to pause, assess where they stand, identify gaps, and begin closing them. Don't wait for a due date or, worse, a preventable tragedy. Take the time now to ask, "What could go wrong today?" and address it before it becomes a regret.

Aviation Maintenance: Has the recent spate of aircraft accidents had an impact on SMS and the use of these systems in aviation?

Chris Hill: I'd like to believe so. Every operator and maintenance provider should use each accident report as an opportunity for reflection and improvement. The findings, causal factors, and recommendations should prompt meaningful conversations and guide practical changes that enhance safety at every level.

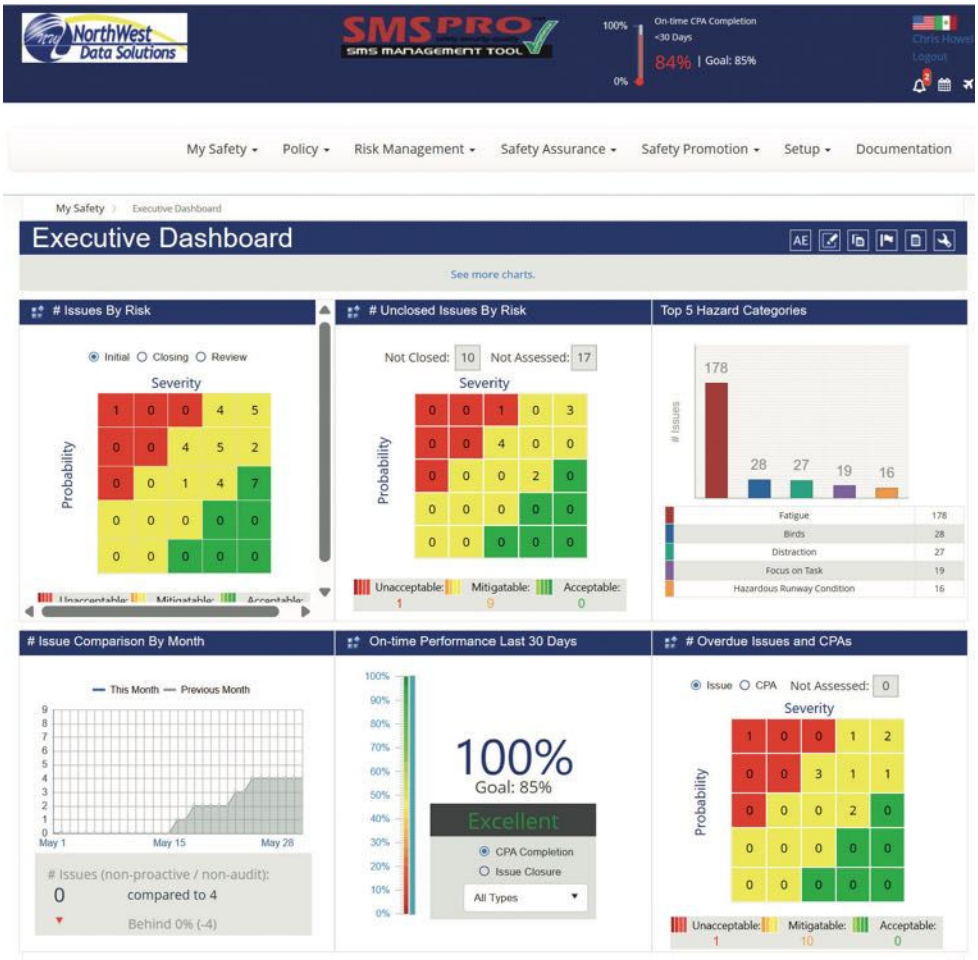
Debi Carpenter: We have seen an increase in interest from operators seeking guidance on how to strengthen or implement their SMS. We have also seen more engagement with our tools and programs, including our new MAP and Industry Audit Standard Lite audit.

A number of high-profile aviation accidents have drawn public attention, prompting increased concern even among those who fly privately. Passengers and executives are asking more questions about the safety practices of their operators. In response, we're helping operators use objective safety data not only as an internal tool, but as a transparent layer that can inform and reassure decision-makers.

Chris Howell: Recent aircraft incidents, such as near-collision events at major U.S. airports, have heightened the focus on SMS adoption. These incidents have underscored the need for proactive risk management, prompting operators — particularly in the Part 135 and general aviation sectors — to accelerate SMS implementation.

While Part 121 operators have long had SMS mandates, smaller operators are now recognizing the value of structured safety systems to prevent incidents and enhance compliance. This increased scrutiny has also driven demand for training programs that strengthen crew resource management and situational awareness, further embedding SMS principles into daily operations.

Aviation Maintenance: Okay, let's get practical. What new SMS products and services have come onto the market recently, including any of your own?



SMS Pro is a cloud-based SMS platform that streamlines hazard reporting and risk analysis through an intuitive interface, according to Chris Howell, CEO of NorthWest Data Solutions. Northwest Data Solutions image.

Debi Carpenter: Over the past year, I've seen a range of new SMS products and enhancements across the industry, including improvements in data visualization, accessibility, and integration with other platforms. Some operators are even developing their own in-house SMS tools tailored to their specific needs.

At ACSF, we've been focused on making our SMS tools more user-friendly and adaptable across departments to support cross-functional collaboration as well as integrating with other platforms. We also introduced two key initiatives, which I have touched on before.

The first is our Member Assistance Program (MAP). This program offers hands-on coaching, including a GAP Analysis (a structured process that evaluates the current state of a safety program against its desired state, such as compliance with civil aviation authorities like FAA, ICAO, or IS-BAO) and step-by-step guidance to help operators build or improve their SMS and reach compliance with FAA Part 5 requirements.

The second is Industry Audit Standard (IAS) Lite. Designed for operators who need a more accessible pathway to compliance, IAS Lite helps ensure alignment with FAA Part 5 and ICAO Annex 19. Once certified under IAS Lite, an operator is well-positioned to submit their SMS for FAA compliance acceptance.

These additions aim to provide practical, scalable solutions for operators at different stages of SMS maturity.

Chris Hill: VAI has partnered with several trusted providers to offer SMS solutions tailored to a wide range of operator sizes and missions. These are not off-the-shelf templates or shelf-sitters. Our

partners work directly with operators to identify real capability gaps and deliver tools, assessments, and coaching that align with their specific operational needs and maturity levels.

Chris Howell: The market has seen several innovative SMS products emerge recently. At NWDS, we've continued to expand on SMS Pro, a cloud-based SMS platform, which streamlines hazard reporting and risk analysis through an intuitive interface. This tool integrates with existing operational systems, allowing operators to aggregate data from multiple sources and generate actionable insights. Other notable enhancements include built in a learning management system (LMS), and computer-based training modules for safety procedures, which enhance employee preparedness and reduce human error. These advancements reflect a broader industry push toward technology-enabled safety solutions.

Aviation Maintenance: To close out our discussion, what do you foresee the future holding for SMS?

Chris Howell: Looking ahead, I see SMS becoming even more predictive and interconnected. As artificial intelligence and Internet of Things (IoT) technologies mature, SMS platforms will increasingly anticipate risks by analyzing vast datasets in real time — everything from engine performance to weather patterns. Regulatory harmonization will also play a key role, with global standards like those from ICAO ensuring seamless SMS implementation across borders. Additionally, the rise of autonomous aircraft and urban air mobility will necessitate new SMS frameworks to address unique safety challenges.

Ultimately, SMS will evolve into a cornerstone of aviation operations, prioritizing prevention and fostering a culture of continuous improvement.

Debi Carpenter: I believe SMS will continue evolving from a compliance-focused framework to a more integrated, data-informed safety culture. We'll likely see broader use of predictive analytics, AI, and real-time data, both at the macro and individual level, to identify and mitigate risks proactively.

I also expect SMS to become more cross-functional and extend beyond flight operations to include maintenance, ground handling and other departments as standard practice. Greater collaboration between regulators and industry will be important in refining what effective SMS implementation looks like across diverse operations. In the near future, insurance underwriters and insurance brokers may require charter operators to have an SMS program before they offer them a policy.

Chris Hill: I am optimistic about the future of SMS. There's a growing pool of talented professionals committed to simplifying SMS implementation while retaining its core value. The future lies in practical tools and intuitive strategies that make safety management easier to understand and apply.

SMS shouldn't feel like an unsolvable puzzle. It should be clear, effective, and integrated into everyday operations. We're moving toward that goal, and the momentum is encouraging.

How MROs Can Survive Tariffs: Advice from the Experts

With tariffs being an integral aspect of Donald Trump's legislative platform, the time has come for MROs and their supply chain partners to cope with this unpleasant new reality of business life. This is no easy task: "Tariffs continue to present significant challenges for the aviation maintenance sector, particularly in terms of cost predictability and supply chain efficiency, with the ability to forward-plan hampered by the ongoing state of flux," said Hamish Martin, partner at LAVA Advisory Partners.

So how can MROs find ways to survive tariffs, let alone thrive? Aviation Maintenance polled the experts to find out. Here's what they told us.

A Vulnerable Sector

People in the space equipment and launch industries like to explain the many problems they face by saying, "Space is hard". Well, when it comes to dealing with tariffs, "MRO is hard too".

"MRO is one of the sectors that is feeling more of the pain than other sub-sectors of aerospace and defense, both on the price side of the tariff and on general parts availability, which is already pretty scarce in the market today," said Meghan Welch, managing director of Brown Gibbons Lang & Company. Her firm is a middle market mergers and acquisitions consulting agency that also covers debt capital markets and equity capital markets. "There's a big supply demand imbalance already for MRO parts and repair capabilities, and this has just been exacerbated by the tariffs themselves."

"From a broader macro perspective, the tariffs, especially all the news that was announced about China and Boeing, really called into question further delays on the production side for the OEMs like Boeing," she added. "The cancellation of Boeing orders that China has announced has repercussions throughout the supply chain and the aftermarket. Of course, the longer that new aircraft production continues to get delayed, the longer that airlines and operators will continue to fly older aircraft, which directly translates to increased need for MRO services — as long as they can get parts. So the news isn't all bad for MROs."

The Tried and True Methods Still Work

Chris Brumitt is managing director, aerospace & defense, for Maine Pointe. "We are a supply chain and operations implementation firm, specializing in transformational change for major private and public companies," Brumitt told Aviation Maintenance magazine. "Our focus is on delivering measurable economic returns in cost and cash flow across planning, procurement, operations and logistics, enabled through hands-on execution, data analytics and leadership, and organizational effectiveness."

When it comes to surviving tariffs, Brumitt prescribed the "tried and true methods" that give companies the best chances of surviving today's tariff wars. "Ultimately, most businesses, whether in strong or weak economic times, must strive to be more efficient, reduce costs and deliver quality products to their

customers on time," he said. "Our consulting business is not being directly affected by tariffs. But our clients are experiencing dramatic swings in how they must adjust their approach to not only the tariff cost, but also the administrative burdens and ongoing uncertainty from frequent adjustments to tariff policies. Many clients are forced to reassess their strategies on short notice, which can impact operational capabilities and increase operating costs, as well as drive up material cost."

In some instances, consulting with an expert like Maine Pointe can be a smart move for MROs and their suppliers — because fresh minds can sometimes come up with useful ideas. A case in point: "Our current engagement with a composite aircraft parts company is focused on two critical areas," said Brumitt. "The first area is Strategic Sourcing, to improve procurement maturity and reduce material cost in the most critical categories of the supply chain. The second is operations excellence, to drive improved productivity, quality, and throughput within the enterprise itself."

When choosing an expert, make sure that they practice what they preach. Otherwise, their advice may not be based on firsthand experience and thus lack value.

At Maine Pointe, "we are always focused on managing our financial status in alignment with changes to our long- and short-term revenue projections," Brumitt said. "This is why we believe that most companies must pay attention to their end-to-end supply chains, and in difficult economic times, the key is for them to stay focused on their costs and cash flow, which is our greatest area of expertise. Because Maine Pointe's approach is implementation-based and directly impacts cost and cash, our model fits well with our clients' near-term need to deliver bottom-line results."

Diversification and Other Options

Diversification is a great way to add new revenue streams, and move into new markets that can help a struggling company do better. Perhaps the most striking example of this truth is Amazon, which started as an online bookstore and now sells everything. Disney achieved similar success by diversifying from purely creating movies, to tie-ins such as theme parks and cruise ships. Apple began by building computers, then branched into MP3 players (iPods) and now smartphones (iPhones).

When it comes to aviation maintenance, "the airlines have been cutting routes, leading to concerns that there's going to be reduced passenger travel because people are tightening their wallets globally, and thus resulting in less work for commercial passenger aviation MROs," said Welch. "One way to deal with a potential drop in business is by diversifying into commercial freight, and even the military side of MRO."

In either case, the key is to look for opportunities in untapped markets that tap into an MRO's existing capabilities and services. By diversifying in this manner — especially in domestic markets that may be less affected by tariffs — MROs can bring in new work, at rates that factor tariffs into the cost.

Focusing on domestic markets is yet another way to potentially boost revenue streams.

"While cross-border deals now require more careful navigation and a robust approach to due diligence, the focus on regional self-sufficiency is opening up fresh avenues for investment. With the right strategy, businesses can turn tariff pressures into a catalyst for long-term competitiveness and value creation," Martin said. "This could prompt a wave of exits from innovative founders considering their succession plan and willing to find the right advice to capitalize on the market opportunity."

In a similar vein, there may be opportunities for smaller MROs to band together and share projects based on their respective strengths, such as an engine shop and an airframe shop. Another solution is for smaller shops to either merge with large MROs, or to be acquired by them. "A lot of my clients are the smaller companies in the middle market, where we're seeing interest in possibly selling or finding a successor for their business, because they're getting squeezed on overall costs," said Welch. "This is creating M&A opportunities for some of these larger consolidators."

"From an M&A perspective, we're seeing increased interest in local partnerships and regional consolidation, which can strengthen supply chain resilience and create new growth opportunities for both small companies with a stronghold in a specific region or capability, and for the acquisitive companies looking to broaden their reach," Martin agreed. "Across the wider aerospace community, these changes are driving innovation in sourcing and logistics, and encouraging more agile and adaptable business models."

Finally, it may be possible to expand the degree of services that an MRO offers, such as paid online/over-the-phone support to airlines and other aircraft operators, because such services are not being tariffed. Again, a case in point: "While the majority of Maine Pointe's business is in the U.S., our international business is not generally affected by tariffs because we are exclusively a service business, and the tariffs are directed at physical products," Brumitt said. "Meanwhile, the adjustments we have made for market changes are based on a customized, strategic approach to each market. Aerospace & Defense, Automotive, and Electronics all require a different approach, depending on what tariffs are being levied and to which countries."

Chris Brumitt, Managing Director, Aerospace & Defense, Maine Pointe

Hamish Martin, Partner at LAVA Advisory Partners

Meghan Welch, Managing Director, Brown Gibbons Lang & Company

Toughing It Through Supply Chain Woes

Even before Covid, the aviation supply chain was experiencing serious delays due to lack of parts and distribution issues. Covid made matters worse. Afterwards the supply chain situation was finally starting to improve, until tariffs were added to the mix and messed things up again.

In the hardest, starkest terms, tariffs are now a fact of business life, and a force that has upended the survivability of many MRO businesses. To cope with the additional costs being generated by tariffs, some MROs are changing their ways of doing business. "We used to see a lot more MRO shops operating on a purchase order basis," said Welch. "Now we're seeing them move towards a short contractual agreement basis with potential customers, to better manage their costs and revenue streams."

"Tariffs can create direct financial pressure and significant supply chain disruption," Brumitt noted. To mitigate these facts, "Maine Pointe is uniquely positioned to help clients offset the impacts of the tariffs and reduce other cost areas to rebalance operations and restore performance. The number one thing that Maine Pointe does to retain our clients and keep them happy is to deliver on what we commit to and focus on total client satisfaction. We utilize extensive analytical tools to determine the potential benefits for our clients and go through a rigorous due diligence process that gives us and our clients the highest level of confidence that we will deliver on our promises."

The Bottom Line

There is nothing that we at Aviation Maintenance magazine would like to do more than offer our readers an easy, surefire way to survive (and even thrive) during tariffs.

Unfortunately, there are no surefire solutions available at hand. But what does exist is useful advice as offered by our experts above. With any luck, it will help your company get through these tough times, and keep going until things eventually improve. That's not a "magic bullet" solution, to be sure, but at least we are telling you the truth. AVM

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This maintenance technician is trying out a head-worn display of maintenance instructions. Federal Aviation Administration image.

Human Factors in Aircraft MRO

Significantly impacting the safety, efficiency, precision and overall integrity of aircraft operations

Human factors (HF) play a critical role in aviation maintenance ensuring aircraft safety and reliability. It is human factors that too often affect MRO functions that can cause or contribute to many aircraft accidents. Some examples of HF maintenance errors are parts installed incorrectly, missing parts and also required checks not being performed. As the aviation industry continues to grow, the importance of reliable and competent maintenance, repair and overhaul (MRO) services also grows.

Human factors is the study of the relationship between humans and machines. There's been such an emphasis on recognizing and responding to human factors in aircraft MRO, that the Federal Aviation Administration's (FAA) Flight Standards Service Aircraft Maintenance Division, together with the Office of Aviation Medicine (AAM), developed and formalized the agency's Human Factors in Aviation Maintenance and Inspection research program. This program was implemented in response to a congressionally mandated requirement (Aviation Safety Research Act, Pl. 100-591, 1988) and is aimed at reducing the number of accidents and incidents resulting from human error in maintenance.

This strategic program plan describes industry-government-labor partnerships that characterized the human factors in aviation maintenance and inspection research program at the time. The plan provides historical scientific explanation and rationalization of the need for applied human factors research and development.

Significant Impact

Dr. Maggie J. Ma, FRAeS, certified human factors professional (CHFP), technical fellow customer support, Boeing Commercial Airplanes, Seal Beach, California, explains that human factors can significantly impact safety, efficiency and overall reliability through:

- Investigating events and near misses to understand contributing factors (a.k.a. performance shaping factors), so we can manage/influence human behaviors — preventing and mitigating human errors and violations.
- Designing for maintainability; applying Human-Centered Design (HCD) approach and design for maintainers to ensure they can perform their tasks (maintaining/servicing/inspecting the aircraft) safely and efficiently in the actual operational environments.
- Ensuring effective and ease-of-use of work instructions and user interfaces of maintenance applications/systems.
- Understanding changing demographics of aircraft maintainers, their changing needs/preferences in seeking information, using

Dr. Bill Johnson, President Drbillj.com

Dr. Maggie J. Ma, Technical Fellow Boeing Commercial Airplanes

technologies, learning, as well as impact of new technologies on the workforce and performance (e.g., artificial intelligence, drone assisted visual inspection, human-robot teaming).

Dr. Bill Johnson is president and chief scientist of Drbillj.com LLC, Atlanta. Over the past 15 years he has spoken to many FAA airworthiness inspectors (perhaps 2,500 ASIs), FAA certification inspectors, NTSB and other international investigative and defense personnel, and U.S. and International airline and MRO employees. At the start of each of his classes he asks the class to use a blank sheet to list the top five HF challenges related to airworthiness.

"I started doing this in 2010," Dr. Johnson says. "Surprisingly, the lists have not changed radically in that 15-year period and there is a high overlap between U.S. and international audiences. That says that the age-old challenges have not gone away and need continuing reinforcement. These lists include: company safety culture; enough qualified MRO personnel; management and self-induced time and quality pressure; fitness for duty (mostly fatigue); communication; complacency; procedural compliance; learning new technology; and more."

When it comes to recognized HF challenges, there was an initial industry "Dirty Dozen," a list of the twelve most frequent pre-cursors or contributing factors to human errors that can lead to incidents and accidents. This list has evolved and expanded to be called the "Filthy Fifteen," which includes modern stressors and influences in aviation maintenance. The three additions to the original twelve help address risks from new technology regulations and workforce changes:

- Lack of Communication
- Complacency
- Lack of Knowledge
- Distractions
- Lack of Teamwork
- Fatigue
- Lack of Resources
- Pressure
- Lack of Assertiveness
- Stress
- Lack of Awareness
- Norms
- Technology Overload
- Information Overload
- Procedural Drift

Advances, Technologies and Training

What's available to aid HF in aircraft MROs and keep the Filthy Fifteen at bay? Dr. Johnson explains that while procedural compliance is still a primary challenge, "New delivery methods like hand-held computers make it easier to always have the right documentation available. Younger workers are likely to consult documentation when they have a device readily available. FAR Part 5, related to Safety Management System (SMS) is working for airlines and most MROs. With proper scaling, it will also have a positive impact on general aviation MRO operations. Tied closely to SMS is voluntary reporting. FAA inspectors are adopting the attitude/philosophy that it is better to find ways to address hazards and possibly increase risks rather than find ways to punish

Aviation MRO professionals work on an airplane at the Xiamen Airlines - Fuzhou Maintenance Base in Fuzhou, China. Photo courtesy of Dr. Maggie Ma.

Dr. Maggie Ma helped launch the Ethiopian Airlines (ET) Maintenance Line Operations Safety Assessment program in Addis Ababa, which is a Boeing and ET collaborative effort. Photo courtesy of Ethiopian Airlines and Boeing.

personnel and organizations that make mistakes. FAA, company management, organized labor and individual workers are thinking more like risk assessors."

DOT TSI Mx HF classes use the PEAR model, which was created by Dr. Johnson and another developer in 1995. The model (actually a mnemonic) was initially designed to be understood and used by the aviation maintenance and engineering audience. PEAR remains a main HF training paradigm for FAA inspector training and is also widely used by the Civil Aviation Safety Authority (CASA), Australia training program. PEAR is the basis for maintenance HF training at many airlines and maintenance, repairs and operations. For over two decades, the term "PEAR" has been used as a memory jogger to characterize HF in aviation maintenance. PEAR prompts recall the four important considerations for HF programs:

- People who do the job
- Environment in which they work
- Actions they perform
- Resources necessary to complete a job

Dr. Ma notes that the release of ICAO Doc 10151: Manual on Human Performance (HP) for Regulators in 2023 been a very useful tool. The document has defined the five principles of human performance and provided guidance to the regulators and the regulated on how to best support human performance in aviation.

There is a trend for organizations to rely on computer/web-based training to satisfy the aircraft MRO requirements whenever they can for cost-saving reasons. Dr. Ma warns there is a lot of empirical evidence that CBT/WBT for human factors is not as effective as in-person facilitator led training. "Organizations

should implement in-person HF training to take advantage of the human interaction in learning and team building."

Increasingly, XR (Extended Reality) technologies — a broad term encompassing immersive technologies that merge the physical and digital worlds — are gaining in usage. Virtual Reality (VR) is being used for training and design/development activities. Mixed Reality (MR)/Augmented Reality is being used for training, remote assist, remote inspection, intuitive work instruction with built-in work-progress tracking and error-proof features. Dr. Ma says the fourth wave of computing — enabled by mixed reality immersive wearable technology — target users are first-line workers (2 billion) such as maintainers. Previously the key target computing users were information workers (480 million).

A Shift to Cognitive Interface Management

It is impossible to ignore the rise of AI. "AI is taking the world by storm and will transform aviation/aircraft MRO by transforming what people do and how people work," Dr. Ma says. "Correct AI use is likely to improve accuracy and efficiency like what automation has done. However, there will also be challenges like misinformation, mistrust, over trust and ethical concerns that are more complex than those concerns associated with automation. The Intl. Society of Human Factors and Ergonomics has released AI 'guardrails' for human use."

"Automation, like AI, can follow a lot of worker activity and provide real-time advice," Dr. Johnson says. "A smart computer will advise you a lot quicker than a co-worker who does not want to offend you. Automation can make it easier for workers to report and learn from personal errors and the collective errors of other workers. Manufacturers are increasingly offering a built-in test. No matter how much automation there is in the equipment we will always need a competent mechanic to help diagnose, service and R&R hardware."

Dr. Ma believes that both mechanical interaction and cognitive interface management have been important focuses for maintenance HF and will continue to be in the foreseeable future. "The trend in aircraft maintenance is becoming more proactive and predictive. HF needs to shift to assisting maintainers in proactive and predictive maintenance related training, planning and tasks. As airplanes and systems become more sophisticated, maintenance HF must engage early in the design and development and help to keep maintainers in the loop. [This] allows them to see the logistics behind how systems function and the 'whys' when something failed to work properly."

Technologies are evolving and AI is rapidly re-shaping the world and changing workplaces. Dr. Ma believes that investing in aviation HF research and innovations will help to understand how human performance is affected by these changes and how to keep maintainers and other aviation professionals safe, productive, efficient, healthy and happy. "We need to support new generations of maintainers based on their information search and consumption preferences and learning needs. We need more HF practitioners."

A technician's human factors will influence aircraft MRO performance. Investing in aviation HF research and innovations will help to understand how human performance is affected by these changes and how to keep maintainers safe, productive, efficient, healthy and happy. Photo courtesy of Ethiopian Airlines and Boeing.

Safety Culture

While implemented in the MRO trenches, the focus on HF must start at the top. An organization's safety culture is a pervasive attitude that places safety at the heart of every operational decision. Dr. Johnson says, "The concept of safety culture is increasingly familiar to management and the workforce. It is a safety culture evolution with new technologies ensuring continuing safety. That's true for all types of organizations. Enlightened management is continuing to move in the right direction. If management does not do the right thing then organized labor and individual workers will encourage them. The maintenance workforce is determined to do the right thing."

Dr. Ma quotes a common HF expression, "To err is human and to drift is human," when discussing organization culture and company policies/protocol (e.g., SMS) that manage human behaviors based on the understanding of human behaviors. "To prevent and mitigate human errors and violations, the key is to manage/remove contributing factors that precede errors and violations. Telling people to not make errors or not violate procedures or just punishing people won't prevent reoccurrence. Organization culture/safety culture should make people feel comfortable, and encouraged and incentivized to report events, near misses and any safety concerns. For example, by having established psychological safety among teams, established just culture and reporting culture, and an easily accessible/easy-to-use reporting system. Employees know what to report and have the options to report confidentially or anonymously." AVM

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Quick Reference
Aviation Safety Regulations Affecting Aircraft MRO Human Factors

International Civil Aviation Organization (ICAO)
Doc 10151: Manual on Human Performance (HP) for Regulators
Human Factors Training Manual (Doc 9683)
Human Factors Guidelines for Aircraft Maintenance Manual (Doc 9824)
Human Factors Digest No. 12 — Human Factors in Aircraft Maintenance and Inspection (Circular 253)

Federal Aviation Administration (FAA)
Human Factors Design Standard (HFDS), HF-STD-001B (2016)
Operator's Manual: Human Factors in Aviation Maintenance (2014)
FAA AC 120-92B Safety Management Systems for Aviation Service Providers (2015)
FAA AC 120-115 Maintainer Fatigue Risk Management (2016)
FAA AC 120-72A Maintenance Human Factors Training (2017)

EASA
Airworthiness Maintenance
EASA 145/JAR145, EASA147/JAR147, EASA66/JAR66
EASA Safety Training (December 2022)

Transport Canada
CAR 573.06 & 573.09 AME Licensing Training Program (1996)

UK Civil Aviation Authority (CAA)
CAP 719: Fundamental Human Factors Concepts (2002) (JAA JAR 145)
CAP 716: Aviation Maintenance Human Factors (2003)

Information provided by Dr. Maggie J. Ma, FRAeS, certified human factors professional (CHFP), technical fellow customer support, Boeing Commercial Airplanes, Seal Beach, California.

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By Jason Dickstein

Navigating Tariffs

Tariffs continue to dominate the headlines. Many companies that tried to avoid tariffs by drawing-down existing inventories are realizing that tariffs may change, but they do not appear to be going away. In this column, I want to talk about (1) a basic background on tariffs, (2) legal challenges to tariffs and the likelihood of tariffs in the future, and (3) some strategies that repair stations and other aircraft parts-users can use to minimize their tariff obligations.

Background

Tariffs are specifically reserved to Congress under the Constitution. Congress has granted to the President certain delegated authority to enact tariffs in limited circumstances. The President has used this authority to enact broad tariffs on goods from foreign countries in response to trade deficits, as well as broad tariffs on certain countries in response to fentanyl trafficking. In all such cases, the importer is typically responsible for paying the tariff.

Unfortunately, some of our trading partners have implemented their own reciprocal tariffs on U.S. goods in response to these U.S. tariffs. This creates a regulatory regime in which importers are paying various new tariffs on goods that cross borders. For a global industry like aviation, this can reflect a significant set of new costs on the industry.

Are Tariffs Legal Today?

First of all, let me be clear that I think the current tariffs as they are applied to aircraft parts are illegal. I am not professing an opinion about whether tariffs are a good idea or a bad idea. I am professing an opinion about the interaction between certain recent chapter 99 tariffs and the Agreement on Trade in Civil Aircraft ("ATCA").

This column is not the only place that I have expressed this opinion. I have also stated it in a petition filed with the U.S. government, seeking redress for a client.

When you apply the current tariffs to aircraft parts, you run into the ATCA. Under that agreement, the United States agrees that it will eliminate tariffs on most imported aircraft and aircraft parts. ATCA became a part of U.S. law as a "congressional-executive agreement," and has subsequently been implemented through various acts of Congress.

The duty-free treatment of aircraft is established under both the ATCA and also by implementing legislative language. Because of the way that ATCA has been implemented under federal law, it would take legislation to counter it. Many of the new tariffs have been enacted pursuant to executive orders. In many cases, the legislative grant of power that authorized the President to establish new tariff programs was not broad enough to circumvent ATCA. In summary this means that even if the tariffs (as described above) are legal when applied to other products, I think that they are illegal when applied to aircraft and aircraft parts that are within the protection of ATCA.

Bear in mind that this is part of an open petition, so the United States has not yet agreed to my position. This means that import duties are currently being charged for aircraft parts imports. If I am successful in establishing a precedent that negates application of tariffs to aircraft parts, then the importers who are affected would need to file for a refund.

Will Tariffs Be Legal Tomorrow?

The Commerce Department has initiated a number of special investigations into various goods. One of those investigations – known as a "section 232 investigation" – targets aircraft, engines, and parts. The investigation is examining the balance of trade related to aircraft and their parts, to identify whether U.S. national security interests are threatened by the current balance of trade.

There are a number of ways that one could find a relationship between commercial aviation and potential national security needs. The finding may be driven by politics (and the Administration's desire for negotiating tools) rather than by true national security interests. As a consequence, you may look at the results and recognize them as undermining national security interests, to the extent it leads to U.S. job loss, shortages of parts used in commercial aircraft that are also used for defense purposes, or a diminution in our ability to safely dispatch aircraft. Don't let these facts distract you from the other potential effects of the section 232 investigation.

It is possible that the section 232 investigation could give the Administration the legal basis that it needs in order to impose sanctions that would limit imports of aircraft parts. I filed comments in response to the 232 investigation into aircraft and parts, and my comments highlighted the existence of the ATCA, and suggested that unless Congress eliminates the ATCA implementing legislation, ATCA prevents application of tariffs to aircraft parts imports. But ATCA does not inhibit non-tariff limits, like numerical limits on volume of imports or other restrictions. So the section 232 investigation could result in new limits imposed on aircraft parts, and if the Administration disagrees with my assessment about tariffs the Administration could apply duties directly to aircraft parts (contrary to the dictates of ATCA).

The section 232 provisions seem to provide the Administration with more options than the existing balance-of-trade-based and fentanyl-based tariffs. The section 232 investigations take longer, and require certain findings, but even if the current tariffs are struck down, the section 232 investigations could provide the Administration with new options that may interfere with aircraft parts imports. This investigation will be carefully watched by the aviation industry because it has the potential to inhibit global aviation.

Strategies for Minimizing Obligations

Repair stations import aircraft parts under a variety of circumstances. Some of those transaction models can provide relief from tariffs if they are declared the right way. And if they were incorrectly declared, then you should consider working with an attorney to seek a correction that would lead to a refund.

Chapter 98 of the Harmonized Tariff System provides a number of special tariff codes that can be used to reduce or alter the duties applied to certain types of imports.

One common form of business is where a U.S. repair stations obtains components intended to be repaired from a non-U.S. customer. These goods are considered to be imported, even if the import is intended to be temporary. The origin of the goods becomes important – even though they are coming from a non-U.S. customer, they may be U.S. origin parts if they were produced in the United States. If the goods are U.S. origin (and have not been advanced in value), then they can typically be imported

under HTSUS heading 9801. For example, if the aircraft parts are U.S. goods that are classified under heading 8807 (a common classification often used as a default for aircraft parts that do not have a more specific classification), then the tariff code for their return would be 9801.00.1079, and they would return as duty-free imports.

If a repair station temporarily imports goods that are the product of a foreign nation, with the intention to repair and then export them back to the customer, then these parts may be imported under HTSUS heading 9813. This is the temporary-in-bond provision, and you will likely have to complete some paperwork associated with the transaction and the bond provisions. Typically, you will need to return (export) the component within one year to avoid paying a tariff. This period can be extended.

Another common business model is where a U.S. repair stations removes a component and sends to another shop for work. If that "other shop" is outside the United States then the initial send is an export, and the subsequent receipt is an import. The U.S. repair station must assess whether the initial export is required to be licensed, and whether there is a license exception that applies. The receipt may be characterized as an import. But you don't necessarily have to pay duty on the full value of the unit. Instead, the duty will typically be based on the invoice price of the work that was done abroad. These provisions specifically fall within the new tariffs. So if you are sending the component for repair in a country where there is an across-the-board 10% duty rate, then the 10% duty rate would apply to the value of the repair.

As an example, let's say you have a component worth $170,000 that is a product of the United States so it is normally not subject to duty. You send it to France for repair. Remember that the duty rate on products of France is currently 10% (this number is scheduled to be increased in July, unless negotiations change the plans). The repair is invoiced at $10,000. When you import it back into the United States, you will declare it to be subject to tariff code 9802.00.5060 and you will pay a chapter 99 tariff on the work done in France equal to 10% of the invoiced value of the repair (which was $10,000). 10% of $10,000 yields a duty of $1,000.

There are other ways to approach tariffs. The Administration intends tariffs to influence sourcing to create a preference for U.S.-sourced goods. If you are looking for U.S. sourced alternative aircraft parts, then you should be focused on FAA-PMA parts, which are parts manufactured under FAA design-and-production approvals. As products of the United States, they are often available domestically, and even if they need to be imported from a foreign warehouse, the import is typically duty-free because they are products of the United States.

Another strategy that we've been implementing for clients is to create a foreign trade zone (FTZ). When goods enter the FTZ, they are not yet entered into the customs zone of the Unite States. This means that if they are subsequently exported then they have never entered the U.S. customs zone and no duty was required to be paid. This is especially useful for a business that is frequently importing and exporting goods, as it allows the business to decide on the ultimate disposition of the goods before making a decision on whether to incur an import duty (for U.S. disposition), or to export the goods to a non-U.S. customer. AVM

Trust the Process

By Sarah MacLeod, Executive Director, Aeronautical Repair Station Association

The requirement for U.S. repair stations to establish, implement, and maintain a Safety Management System (SMS) under the U.S./European Union Bilateral Aviation Safety Agreement (BASA) became official in February. The Bilateral Oversight Board's decision No. 13 amended Annex II of the BASA and brought to regulatory reality the warning of FAA's June 2024 InFo 24007.

The American aviation safety rules (in part 5) for domestic repair stations do not require an SMS, but those holding or applying for EASA approval under the bilateral must establish one. The requirement is effective right now for applicants; existing approval holders must show compliance by Jan. 1, 2026.

The exact language added to Appendix 1 of Annex 2 provides the following requirement:

"The repair station shall establish, implement, and maintain a Safety Management System (SMS) acceptable to the FAA and compliant with ICAO Annex 19 as applicable to maintenance organizations. The FAA SMS Voluntary Program outlines the process and requirements." (See, Annex II, Appendix I, Paragraph 1.1.1.(b).)

The FAA SMS voluntary program has had a less than stellar beginning; it is hard to navigate, few inspectors understand the "scalable" requirements, and even fewer can apply ICAO standards — particularly since ICAO "requirements" are directed at the countries (states), not the applicants or certificate holders. It has taken years for the countries to adopt, implement, and manage their own SMS, and that confusion will be brought to American repair station applicants and certificate holders. To sell maintenance services worldwide, a repair station must take on the cost of compliance, but whether an SMS reduces risk in the aerospace environment has yet to be supported by objective data.

Despite the dubious value of the requirement, ARSA urges both government and industry to make good on the promise of "safety management." That means both sides must recognize the safety continuum is contained in the regulations: American standards for safety management of aerospace maintenance start with part 43, add the repair station's quality system mandates in § 145.211, and the personnel requirements in subpart D. These provide the foundation for managing technical and human risk. A certificate holder's business must be focused on maintaining compliance.

How can the regulator demand and oversee SMS if it punishes certificate holders for revealing non-compliance? Government tendency towards hunting "violations" deters the very communication on which "safety management" depends. Forcing corrective action based on guidance or preference rather than rule-based safety analysis produces nothing but defensiveness and mistrust. Mistrust is not removed by silence; it can only be addressed through open, honest, boundary-pushing communications that do not punish indiscriminately.

Regardless of its regulator, a repair station/approved maintenance organization would do well to layer SMS within existing quality management systems. At its core, safety management is a human factors discipline, training in which is already required for American facilities holding EASA approval under the bilateral. Those approval holders integrate "lessons learned" from within the quality system into "lessons received" by personnel to prevent future escapes — a considerable step towards SMS implementation. Closing the gap between how things work in a repair station's systems and applying it to what the company does to control organizational risk is the key to a successful program.

Last year, ARSA's member newsletter explored the PEAR Human Factors Model (People, Environment, Actions, Resources) in safety risk management for aerospace maintenance. In a maintenance facility, each element in the model helps focus the organization on airworthiness. Tending to these characteristics ultimately ensures the company can "do … work in such a manner and use materials of such a quality, that the condition of the aircraft, airframe, aircraft engine, propeller, or appliance worked on will be at least equal to its original or properly altered condition." The performance standard of § 43.13(b) establishes the foundation for human factors in aviation maintenance Safety Management Systems.

A true SMS will be integrated into existing requirements, not piled on top of other manuals and programs designed to elicit self-disclosure and corrective or remedial action, e.g., Aviation Safety Action Programs, hotline and whistleblower systems, and other avenues to communicate potentially non-compliant behaviors or actions. Certificate holders meet regulatory standards to demonstrate system safety. Their business strategies must protect private interests while eliciting information detrimental to safety or profit. To avoid creating more opportunities for miscommunication, mistakes, and mistrust, SMS cannot be added to existing systems; it must be integrated. AVM

Sarah MacLeod is managing member of Obadal, Filler, MacLeod & Klein, P.L.C. and a founder and executive director of the Aeronautical Repair Station Association. She has advocated for individuals and companies on international aviation safety law, policy, and compliance issues since the 1980s.

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