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FEATURES

DEPARTMENTS

66 *A modification of Lockheed Martin Skunk Works' X-56A is on track to become the first digitally certified aircraft.*

ON THE COVER

Leonardo is flight-testing its new AW249 attack helicopter, the AW129 Mangusta successor designed to fight near-peer adversaries in a multidomain anti-access/area-denial environment. Our report by Senior Defense Editor Tony Osborne begins on page 19. Leonardo Helicopters photo by Fabio Facco.

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FEEDBACK

BEHIND THE SCENES

Aviation Week Executive Editor for Commercial Aviation **Jens Flottau** (far left) participated in the Global Aerospace Summit in Abu Dhabi Sept. 25-26 as a moderator. The event covered a broad range of topics including space, defense, technology innovation and commercial aviation. Sustainability pathways such as sustainable aviation fuel (SAF) were discussed, with a focus on the United Arab Emirates' programs. Panel participants criticized unilateral initiatives such as European Union SAF mandates and highlighted the need for coordinated action.

DEENA KAMEL

RISK ASSESSMENT

Jens Flottau's "What Risks?" (*June 17-30*, p. 44) quotes Simon Evenett, professor of trade and economic development at the University of St. Gallen in Switzerland, suggesting that another Donald Trump presidency would be a "global risk for aviation" and that "Europe will abandon North America." Those are strong statements.

One could surmise that Trump as president could help end current world conflicts (Ukraine and Israel), based on his current proposals. Global stabilization would actually benefit the aviation industry, as would lower energy costs.

Last time Trump was president, the aerospace and defense industry benefited quite well from both his rebuilding of the U.S. military and his pressure on NATO countries to contribute closer to 2% of GDP to defense spending. The industry also benefited from a strong U.S. economy. Even with increased trade and political tensions with China, there was still robust travel demand prior to the COVID-19 shutdowns and disruptions from which we're still recovering.

Harrison Francett, Queensbury, New York

'CONTROLLED INFORMATION'

Brian Everstine's "Osprey Oversight" (*Sept. 16-29*, p. 20) was interesting and somewhat concerning. I am a retired 30-year U.S. Air Force officer and pilot who attended squadron- and senior-level safety training. I have been an *AW&ST* subscriber for over 30 years, and I don't recall ever reading another article that quoted an Air Force Safety Investigation Board (SIB) report.

Accident Investigation Board reports are released to the public, but the SIB report is not for many reasons. In the course of reporting on the "Gundam 22" mishap, Mr. Everstine obtained the "nonpublic" SIB report, which is "deemed controlled unclassified information." I guess stating that the information is "unclassified" makes it OK, even though the information is "deemed controlled." He was doing his job as an aviation reporter, I suppose.

My main concern is that someone within the Air Force Safety enterprise released or leaked the "controlled" SIB report and/or findings, which is never supposed to happen. The SIB's sole focus is on preventing another mishap, and the witnesses and experts can speak freely to provide testimony without fear of repercussion. The AIB president advises witnesses and experts of specific rights, and sometimes the information received is not necessarily the same as what the SIB gets.

My hope is that this leaking of "nonpublic" and "controlled information" does not become a habit because accident witnesses and experts may not be so willing to discuss information that could prevent another mishap and save lives.

U.S. Air Force Col. (ret.) Paul Harmon, Navarre, Florida

BEHIND THE SCENES

As a member of the U.S. Congress, **Bill Nelson** (right) flew on the space shuttle Columbia in 1986, returning just 10 days before the ill-fated launch of the space shuttle Challenger. Now administrator of NASA, the longtime space veteran sat down in his office at the agency's headquarters for a wide-ranging conversation with Aviation Week Space Editor **Irene Klotz** (second from right), Business Editor **Michael Bruno** (second from left) and Editor-in-Chief **Joe Anselmo**. Highlights from their interview begin on page 35.

MEIRA BERNSTEIN/NASA

CORRECTION

The corrections in the *Sept. 16-29* Feedback should have identified the energy density of the batteries discussed in watt-hours per kilogram (Wh/kg).

Address letters to the Editor-in-Chief, *Aviation Week & Space Technology*, 2121 K Street, NW, Suite 210, Washington, DC, 20037 or send via email to: **awstletters@aviationweek.com** Letters may be edited for length and clarity; a verifiable address and daytime telephone number are required.

WHO'S WHERE

Megha Bhatia has been appointed chief commercial officer at *Eve Air Mobility*. She was chief strategy officer at Jet Support Services Inc. and before that worked for 13 years at Rolls-Royce, ending as vice president of sales and marketing for business aviation.

Aviation asset manager *Altavair* has named **Nick Hazeldine** chief operating officer. He held the same position for six years at CDB Aviation, before which he oversaw credit risk, transaction management and other sectors at SMBC Aviation Capital.

Tameika Hollis has joined The *Aerospace Corp.* as vice president and chief information officer, succeeding Tammy Choy. Hollis was chief operating officer and then CEO of information services provider Illuminate and before that worked at Northrop Grumman.

Electric vertical-takeoff-and-landing vehicle developer *Horizon Aircraft* has hired **Tom Brassington** as chief technology officer. He was head of system design engineering at Lilium and prior to that led engineering programs at Marshall Aerospace and Saab.

Gabriel Semelas has rejoined *Airbus* as president for Africa and the Middle East. He spent four years as chief commercial and financial officer at Eurofighter, having overseen sales and contracts for commercial and military aircraft in his prior position with Airbus.

Loren Neuenschwander has been named vice president of membership at *Oneworld*. He was with Boston Consulting Group most recently and spent almost 30 years at Delta Air Lines, where he worked as managing director for alliance partnerships in Europe, the Middle East and Africa and then for finance.

Alaska Airlines has named **Jason Berry** executive vice president of Alaska Air Group, adding to his position as president of subsidiary Horizon Air. He oversaw cargo operations at Air Canada, Alaska Airlines and Alaska subsidiary McGee Air Services. **Ian Morgan** also joins the airline as vice president of cargo. He was vice president of cargo for the Americas at Qatar Airways and before that worked with Centurion Airlines and Cargolux Airlines.

Milena Lerario has been named CEO at *e-GEOS*, a geospatial joint venture comprised of the Italian Space Agency and Leonardo-Thales joint venture Telespazio. She joins after many years with Airbus, most recently as managing director of Airbus Italia.

Lockheed Martin has promoted **Dennis Goege** to vice president and chief executive for Europe and hired **David Young** as vice president and deputy manager of national security space. Goege was vice president and general manager for Central and Eastern Europe; he joined Lockheed in 2020 from German aerospace center DLR. Young was chief operating officer at CAES and before that was vice president of advanced program development at Lockheed; he also worked for more than 11 years at Northrop Grumman.

Noud Tillemans has joined leading sustainable aviation fuel company *SkyNRG* as chief financial officer. He takes the reins from cofounder Theye Veen, who retains his role as chief commercial officer. With a background in finance and renewable resources, Tillemans was chief financial officer and managing director at Fairphone and before that was finance director at sustainable chemistry technology developer Avantium.

Anduril has promoted **Brielle Terry** to vice president and general manager of rocket motor systems from general manager of the sector. She was cofounder and chief technical officer of solid rocket motor and fuel manufacturer Adranos before its 2023 acquisition by Anduril.

Philip Passarello has joined *CPI Aerostructures* as chief financial officer. He was vice president of finance at TTM Technologies and before that held senior positions at Telephonics prior to its acquisition by TTM.

European air cargo transport company *Magma Aviation* has appointed **Peter Kerins** as CEO. He was head of global accounts and products at Etihad and before that worked at HAE and DHL Aviation.

Sean Menke has joined the board of directors at *JetBlue Airways*. He was executive chairman and before that CEO at travel technology company Sabre. Prior to joining Sabre, Menke held executive roles at Hawaiian Airlines, Pinnacle Airlines, Frontier Airlines and Air Canada.

Jamie Landers has been named president at space logistics company *Outpost*. She was vice president of business development at Maxar Space, and before that she worked for five years at Lockheed Martin, where she finished as director of business development for advanced programs.

Aerospace private equity firm *AE Industrial Partners* has hired **Lewis Sutherland** as managing director for aerospace leasing, **Ryan McCarthy** as an operating partner and promoted **Jonathan Lusczakoski** to principal from vice president. Sutherland was chief commercial officer at Deucalion Aviation, before which he worked at Investec Aviation Equity Funds. McCarthy was secretary of the U.S. Army from 2019 to 2021 and under secretary from 2017 to 2019. Before that, McCarthy was a vice president at Lockheed Martin, working on the F-35 Joint Strike Fighter program. Lusczakoski was a lead engineer at Williams International.

To submit information for the Who's Where *column, send Word or attached text files (no PDFs) and photos to:* **whoswhere@aviationweek.com** *For additional information on companies and individuals listed in this column, please refer to the* Aviation Week Intelligence Network *at* **AviationWeek.com/awin** *For information on ordering, telephone U.S.: +1 (866) 857-0148 or +1 (515) 237-3682 outside the U.S.*

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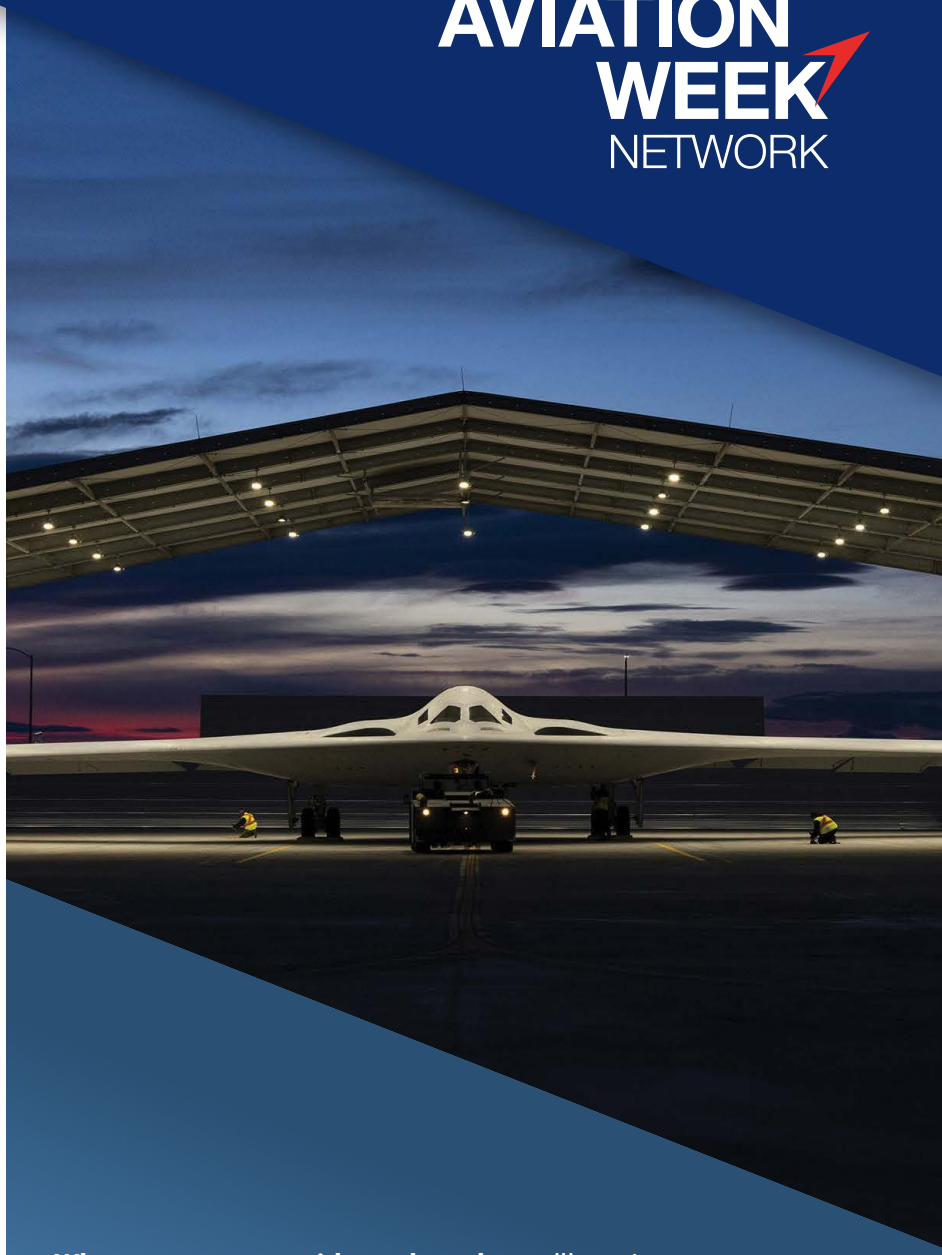

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TECHNOLOGY

Skydweller Aero has completed the initial autonomous flight campaign for its heavy-payload, solar-powered uncrewed aircraft with a 22.5-hr. mission over the Gulf of Mexico.

SKYDWELLER AERO

Rolls-Royce has elected to shut down its electric propulsion unit, Rolls-Royce Electrical, having failed to find a buyer for the business (page 12).

Drone delivery company Matternet is expanding beyond the health care market, launching its first home delivery service in Silicon Valley, California.

DEFENSE

The French government has greenlit the enhanced F5 standard of the Dassault Rafale fighter for 2030, as well as its pairing with an uncrewed combat air vehicle (UCAV) by 2033.

Taiwan has shelved its Advanced Defense Fighter program, saying the country's industry is not ready to proceed with development and will instead procure fighters from overseas.

France plans to provide Ukraine with Dassault Mirage 2000 fighters in the first three months of 2025, while the Netherlands has delivered the first of a planned 24 Lockheed Martin F-16s to Ukraine.

Ukraine released imagery on Oct. 5 that appears to show Russia's Sukhoi S-70 UCAV being shot down by its own fighter escort over Ukraine after a control failure.

California-based Scaled Composites has reactivated its Model 355 Old School medium-altitude, long-endurance aircraft amid growing demand for extended-duration testbeds.

Leidos' Black Arrow small cruise missile will start guided flight demonstrations this fall on a U.S. Air Force Special Operations Command AC-130 gunship.

Iranian forces fired more than 180 ballistic missiles at Israel on the night of Oct. 1, causing minimal damage and two civilian injuries in the Tel Aviv area.

The European Common Radar System Mk. 2 active, electronically scanned array sensor for the Eurofighter Typhoon made its long-awaited first flight on Sept. 27 in the UK.

OBITUARY

Ramsey E. Hashem, president of Informa's Agriculture, Aviation and Healthcare businesses, which includes the Aviation Week Network, died Sept. 27 at the age of 61. Hashem had assumed his post just eight months earlier after serving as president of *The Economist*'s Intelligence unit. In that short time, he made an indelible impact, establishing himself as a highly engaged and likable leader who motivated his team to aim high. Hashem's inquisitive nature made him an avid consumer of Aviation Week content, one who closely followed trends in the aviation and aerospace markets. His leadership was defined not only by his strategic insight but also by his genuine enthusiasm for the industry and his team. Born in Lebanon, Hashem had previously served as president and CEO of Informa's Pharma Intelligence/Citeline, where he demonstrated his ability to lead with vision and passion. Hashem is survived by his wife, Cheri, and daughter Emilie as well as a large network of family and friends across the globe. All who had the privilege of working with him feel a deep sense of loss.

VIEW FROM SEATTLE

Impasse Again for Boeing and Strikers

Boeing and the International Association of Machinists and Aerospace Workers (IAM), on strike since Sept. 13, accused each other of being unwilling to move after another round of mediated negotiations collapsed Oct. 8.

"Further negotiations do not make sense at this point," Stephanie Pope, Boeing's chief operating officer and commercial airplane division CEO, wrote in a memo to staff. To preserve cash, Boeing is looking "to take actions and consider next steps" after withdrawing its latest offer, she said.

The talks lasted two days, and both parties sent conflicting messages afterward about the lack of a breakthrough. "The company was hell-bent on standing on the non-negotiated offer that was sent directly to the media on Sept. 23," the IAM stated. "By refusing to bargain . . . the company made it harder to reach an agreement."

Pope's memo said Boeing made "new and improved proposals to try to reach a compromise, including increases in take-home pay and retirement," but the union made "non-negotiable demands far in excess of what can be accepted if we are to remain competitive as a business."

Check 6 *Aviation Week editors discuss the Boeing strike:* **AviationWeek.com/Check6**

The Czech government is set to sign for two Embraer C-390 Millennium airlifters in November, becoming the fifth European nation to acquire the aircraft.

The UK Defense Ministry has acquired the only secure facility in the country capable of manufacturing gallium-arsenide semiconductors, which was threatened with closure by its U.S. owners.

COMMERCIAL AVIATION

The FAA has warned Boeing 737 operators of the potential for jammed or restricted rudder movement in aircraft equipped with an optional component supplied by Collins Aerospace (page 16).

Boeing delivered 28 single-aisle and five widebody aircraft in September but expects delivery numbers to fall for October due to the ongoing machinists union strike in the Seattle area.

The European Union Aviation Safety Agency will start public consultation this month on methodology for its planned eco-label system to inform passengers about their flights' carbon efficiency.

Europe's air traffic control situation continues to worsen, with a significant jump in flow management delays over the peak summer season, according to the body overseeing the sector.

Airbus, Embraer, Rolls-Royce and the International Air Transport Association have agreed on how to use aircraft operational data, giving carriers some control of the data their aircraft share with manufacturers.

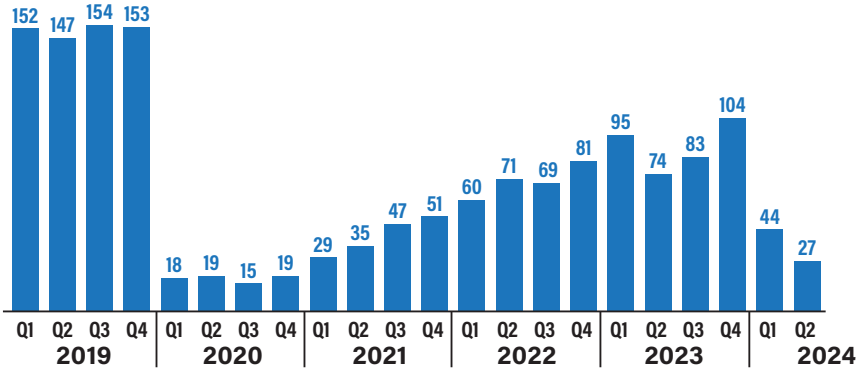
Having two pilots onboard is a vital safety asset that reduced-crew concepts are threatening, U.S. National Transportation Safety Board Chair Jennifer Homendy said Oct. 3.

Qatar Airways has confirmed plans to purchase 25% of Virgin Australia, which may also allow Virgin to return to long-haul flying with wet-leased aircraft.

SPACE

A SpaceX Falcon 9 on Oct. 7 launched the European Space Agency's (ESA) Hera spacecraft and a pair of cubesats toward an asteroid system targeted by a 2022 NASA planetary defense mission (page 39).

Spirit AeroSystems 737 Fuselage Deliveries to Boeing



Source: Company data and Melius Research

Prior to the International Association of Machinists and Aerospace Workers strike at Boeing, 737 production was slowed by the dearth of clean fuselages supplied by Spirit AeroSystems. In the second quarter, Spirit managed to deliver only 27 (nine per month) 737 fuselages to Boeing, and if the strike continues for another three weeks, Spirit might furlough employees to preserve cash, Melius Research says.

United Launch Alliance conducted the Certification-2 mission from Cape Canaveral SFS on Oct. 4, the second launch of its Vulcan Centaur rocket (page 34).

ESA says the road is clear to return the Vega-C launcher to flight after Avio successfully tested the Zefiro-40 second-stage engine on Oct. 3.

NASA's SpaceX Crew-9 docked at the International Space Station on Sept. 29, delivering a U.S. astronaut and Russian cosmonaut for a five-month tour.

50 YEARS AGO IN AVIATION WEEK

A Grumman Aerospace advertisement in our Oct. 14, 1974, edition offered aircraft maintenance specialists "the chance of a lifetime for both you and your family": a job in Iran. While Iran today evokes thoughts of hard-line leaders and state-sponsored terrorism, a half-century ago the country was seen as a rapidly modernizing monarchy that was spending its oil riches on a lot of Western military equipment—including Grumman's F-14 fighter jets. "Whether you're looking for a change or a challenge, chances are you could be one of 500 to 1,000 people selected by Grumman to live and work in this old land that is rapidly taking on a new look," the ad proclaimed. "Many skills will be required to help this up-and-coming nation put into operation the world's most advanced fighter aircraft, the F-14, for improved air defense." The jobs required a minimum tour of two years. Interested applicants were to send their resume to Mr. Charles I. Pfaeffle, employment manager, presumably via the postal service. Brandon Patrick, Aviation Week's senior military analyst for the Middle East and North Africa, estimates that Iran still has 30-40 airworthy F-14As, although only 25 individual tails have been seen in service since 2014.

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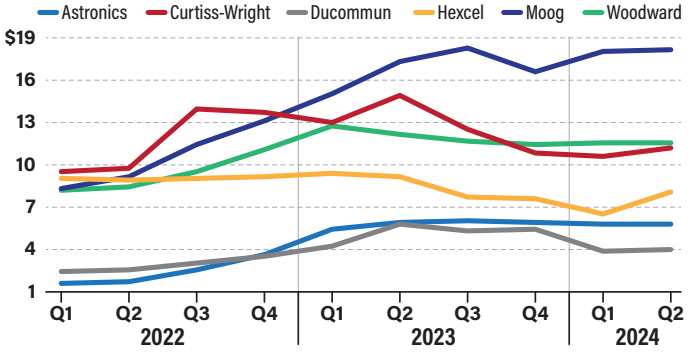
UP FRONT
ALEX KRUTZ

MISALIGNED SUPPLY AND DEMAND, now exacerbated by the International Association of Machinists & Aerospace Workers strike at Boeing, continues to affect the supply chain in a profound way. Production master schedule changes by the airframe OEMs are obfuscating production rates and spurring suppliers to stockpile inventory, as I discussed in my last Up Front column (*AW&ST* July 29-Aug. 11, p. 10).

Suppliers have struggled since the COVID-19 pandemic's decline to position themselves for an eventual—albeit distant—increase in commercial aircraft production rates. The challenge has been bridging to that while not going out of business in the meantime because so much money is tied up in maintaining readiness. But a key method for remaining ready, stockpiling goods, is coming back to haunt suppliers.

Tier 2 Supplier Interest Expenses
(U.S. $ Millions)



Source: Bloomberg Intelligence

Company balance sheets measure inventory levels in the areas of raw material, work in progress (WIP) and finished goods. Overall, these three categories are rising in relation to production rate increases by the airframe OEMs.

Raw material has been piling up because companies need to buy material when it is available to avoid the risk of shortages.

There is more WIP as well because a variety of components, such as bearings or fasteners, continue to have long lead times. Shortages of these components cause WIP to grow as machined parts and assemblies are held in production waiting for components. WIP is also increasing because of industry constraints in special processing and continued growth in processing lead times.

Finished goods are accumulating at suppliers due to the continued volatility of demand caused by the misalignment of production rates and inventory. Customers throughout the supply chain are ordering more parts from their suppliers than they are able to consume, produce and ship to their end customers, which results in excess levels of inventory for all suppliers.

There are three primary reasons for aerospace companies to procure and hold excess inventory. The first is purchasing power in the supply chain. Ordering larger quantities of raw material or components tends to drive price breaks. The second is uncertainties around future lead times and cost. The third is inefficiencies in manufacturing planning and scheduling.

Inventory Dilemma

The heavy move
from 'just in time' to 'just don't know'

In the short term, the labor strikes currently at Boeing and recently at Spirit AeroSystems will have a negative impact on production rates and lead to higher finished goods levels. However, customers throughout the production value stream are not pulling at scheduled rates, and parts are staying in stock longer for their suppliers.

Financing costs are still stubbornly high, twice what they were before 2021, and the cost of financing increased inventory levels is problematic for the supply chain.

Both inventory and financing costs have been trending upward for the last 10 quarters. Increases in inventory and rising interest rates, effectively twice what they were before the pandemic (see chart), are creating a challenging situation for suppliers.

The industry has benefited from long lead-time windows of firm demand and projected demand from previous OEM forecasts and purchase orders. A key lesson here is to address increasing inventory levels by:

❶ Creating a system and process around "target inventory level" utilization.
❷ Defining projected lead times, lower-limit inventory and appropriate reorder points.
❸ Analyzing the history of usage and forecast demand.

These activities can help companies prepare for the coming quarters of increased inventory levels.

Higher borrowing rates to fund inventory growth have affected the entire supply chain. The rising inventory levels and higher borrowing rates are combining into a pernicious effect on suppliers.

Inventory in the supply chain will continue to grow, and as long as interest rates stay high, the carrying costs of inventory will remain problematic, since higher capital costs make the inventory more expensive. The industry has gone from systems like just-in-time to just-in-case to now just-don't-know. Just-don't-know inventory reality and the higher capital and carrying costs will weigh heavily on balance sheets in the quarters to come.

Alex Krutz is managing director at Patriot Industrial Partners, an aerospace and defense advisory firm that focuses on manufacturing strategy and supply chain optimization.

AIRLINE INTEL
JENS FLOTTAU

Rebuilding—But When?

The Aviation Week Network's latest **fleet forecast** reflects the industry's troubles

COMMERCIAL AVIATION IS OFTEN described as a never-ending growth story. General economic growth leads to a faster increase in demand for air travel and more aircraft deliveries. Recapturing that historic growth pattern in the aftermath of the COVID-19 pandemic is a task the industry has been working on, and the Aviation Week Network's 2025 Commercial Fleet & MRO Forecast is again showing how hard it is to climb back up to previous heights and to continue onward. It also provides clues on market shares of the different manufacturers.

The industry as a whole is still not where it used to be in terms of production levels. Combined 2024 deliveries will still be below 2019—when Boeing 737 MAX deliveries were suspended following the type's two fatal accidents—and even further below 2018, which should be the real reference year to eliminate anomalies. Next year will be the first in which the industry will likely exceed 2019 production, but it will be another year until it can claim to have resumed growth where it left off eight years earlier.

The near-term predictions are, of course, subject to some caveats, the main one being a relatively swift end to the mechanics' strike at Boeing and a fairly quick rebuilding of parts supply and final assembly by a financially and operationally battered supply chain. Doubts that both can be achieved are entirely legitimate at this point.

The reasons for the eight-year industry crisis are well known: the pandemic and the supply chain constraints affecting both Airbus and Boeing, and, of course, the seemingly endless series of mishaps and failures at Boeing that has led to 737 MAX output much below original estimates.

The forecast shows that while both Airbus and Boeing have ambitions to climb further, there are also defined limits: By 2028, or 2029 at the latest, production is expected to plateau at around 2,200 aircraft annually. The figure includes all manufacturers and regional aircraft, but Airbus and Boeing will still capture 91% of the total market.

The production number is defined by the capacity of the current industrial setup, among other things. Should anyone else want to go further, heavy investment in new plants and tools would be required. That is unlikely to happen for several reasons. For starters, could the supply chain really deal with it? The risks in a future downturn would also escalate.

More important, Airbus and Boeing customers have been very clear that they want to receive the next generation of single-aisle aircraft sooner rather than later. Airbus CEO Guillame Faury said at the recent U.S. Chamber of Commerce Global Aerospace Summit in Washington that production has to be stable for some years before the airframer can make a firm launch decision. That milestone is already moving to the turn of the decade from around 2028 because of the current production mess.

AIRBUS

While Airbus faces more political pressure to make flying more sustainable, Boeing also has market considerations to take into account. Its overall share of deliveries is 40%—Airbus' is 51%—but for the all-important narrowbody market, Boeing's slice of the pie is likely lower, given the relative weakness of the MAX versus the A320neo family.

The Aviation Week Network's forecast clearly shows the root causes: More than three-quarters of the A320neo deliveries over the next 10 years will be A321neos, or 6,500 of roughly 8,500 units. The A321neo alone will therefore account for almost one-third of all commercial aircraft globally, including regional jets and turboprops. By contrast, the competing 737-10 will, if and when certified, be less than one-third of the 6,600 737 MAX deliveries for the period.

The need for Boeing to act is blatantly obvious, and all eyes are on new CEO Kelly Ortberg and his strategy, beyond fixing the current quality issues, which he has yet to articulate.

In the widebody market, some 800 777Xs are forecast to be delivered in the next 10 years, well below the 787 and A350 but well above the A330neo.

The forecast is not very good news for Embraer, which Aviation Week Network analysts project will deliver 712 aircraft over the next decade, well below its previous peak production of up to 130 aircraft annually. Embraer is weighing entering the market for larger narrowbodies, but even if it does, a new model would not have a large impact on market share in the next 10 years, given how long development times have become.

Comac is forecast to deliver 291 C919s and 307 ARJ-21s through 2034. Its production of 20-30 aircraft per year is about one-third of the output Airbus targets per month.

LEADING EDGE
GUY NORRIS

Short Circuit

Rolls closes its **electric propulsion business**

IN 2019, A YEAR DOMINATED BY sustainability and advanced air mobility news, it seemed Rolls-Royce had pulled off a spectacular strategic coup when it announced at the Paris Air Show its surprise acquisition of Siemens' electric and hybrid-electric aerospace propulsion unit.

Based in Germany and Hungary, Siemens' eAircraft business already had been developing all-electric and hybrid-electric propulsion systems for aircraft such as Eviation's Alice, the CityAirbus electric vertical-takeoff-and-landing (eVTOL) vehicle and the projected Airbus-Rolls E-Fan X hybrid-electric demonstrator. It seemed a natural fit with Rolls' own fledgling electrical unit, set up to support commercial and military engine hybridization as well as to target a burgeoning eVTOL market predicted at the time to be worth $285 billion by 2030.

What could possibly go wrong?

Plenty, as it turned out, starting with the devastating impact of the COVID-19 pandemic the very next year. Triggering a global air transport meltdown, the pandemic hit Rolls-Royce's reliance on engine support income from the long-haul international widebody market. Added to this, the engine-maker racked up cumulative costs of more than $4 billion between 2017 and 2023 to fix durability issues on the Trent 1000 family.

COVID-19 also was blamed for the Airbus and Rolls decision to cancel the E-Fan X in April 2020. And just months before the Siemens acquisition, Eviation had selected competing electric motor developer MagniX to be the propulsion system provider for the Alice.

Despite these early setbacks, confidence remained high in Rolls-Royce's plans to focus on the development of transverse flux, air-cooled electric propulsion units covering the 150-200-kW range for urban air mobility vehicles, as well as a larger radial flux 300-400-kW motor and a turbogenerator for regional platforms. Buoyed by a series of agreements, including a deal with UK-based launch customer and VX4 eVTOL developer Vertical Aerospace, Rolls-Royce Electrical was spun off in 2022 as an individual business to support both wider electrification in aerospace and the advanced air mobility market.

But the arrival of Tufan Erginbilgic as the new CEO and his decision in early 2023 to launch a strategic review of what he described as a "burning platform" immediately cast doubts over the continued future of Electrical. Amid these doubts, a promising program with Italy-based Tecnam Aircraft to develop the P-Volt—an all-electric version of the company's P2012 twin-engine light regional aircraft—was meanwhile abandoned in mid-2023.

It was not much of a surprise, therefore, that the unit was put on the auction block as part of the ensuing companywide restructuring plan announced in November 2023. The new strategy signaled the sale of non-core assets as part of a wider plan to refocus on traditional turbofan business sectors and was expected to raise up to £1.5 billion ($1.9 billion) by around 2028.

The real surprise came late last month when Aviation Week broke the news that no buyers had been found. Despite talk in late 2023 of a potential sale to a prospective party—rumored to be U.S.-based—there were no takers. With its patience at an end, Rolls announced internally that the Electrical business was to be wound up pending the completion of contractually obligated work, such as its contract to deliver several lift motors to Eve for the Embraer subsidiary's eVTOL prototype. Meanwhile, the program with Vertical for the VX4 was terminated in May under mutual agreement.

Not all is lost, however. Much of the electrical expertise gained over the past five years has been funneled into hybridization projects underway across Rolls' commercial and military portfolio, including electrical generation technology for the engine in development for the UK Global Combat Air Program. The company also continues to be involved in hybrid electric research efforts such as the European Clean Aviation Hybrid Electric propulsion system for regional Aircraft (HE-ART) program together with Airbus, ATR, Leonardo and Safran.

While Rolls' asking price may have been too steep, its failure to sell its Electrical unit may have more to do with the fragility and apparent overoptimism of the near-term electric propulsion market than with the value of the products the engine-maker was developing.

THE DEW LINE
STEVE TRIMBLE

Can 'Attritable' Be 'Affordable'?

Balancing CCA **survivability and cost**

THE FIRST DEFENSIVE PAYLOAD expressly designed to suit the needs of the new class of autonomous aircraft raises a question: Will collaborative combat aircraft need it?

Syracuse, New York-based SRC Inc., which has unveiled an electronic support measures payload for collaborative combat aircraft (CCA), certainly thinks so. The nonprofit research and development corporation that also developed the high-performance computing Agile Condor pod expects CCA will need a modern electronic support measures suite—but with an important caveat: It must be affordable.

SRC's newly unveiled Ghost Mantis combines the functions of a radar warning receiver, decoy emulator and self-protection jammer into the same multifunction array.

That means that during the same mission, a CCA equipped with the Ghost Mantis can identify the radio frequency (RF) signature of a hostile threat, masquerade as a crewed fighter by emulating its RF signature and then jam radar-guided threats headed its way.

Such a package has become a standard electronic warfare kit on crewed aircraft, along with warning systems and countermeasures for heat-seeking threats. But CCA are a new category defined in part by their relative affordability. The concept evolved from the low-cost attritable aircraft technology.

The awkward term "attritable" comes with a fluid definition. It fits in a gap between "disposable" and "reusable." At one time, the Air Force Research Laboratory put a price tag on it: Disposable munitions generally fell below about $2 million, reusable aircraft cost more than $20 million and anything in between was defined as attritable. In other words, they were cheap enough to lose on the first mission but ideally could be recovered.

When the Air Force replaced low-cost attritable aircraft technology with the CCA concept, however, officials redefined the term "attritable" as simply uncrewed—and thus, by definition, expendable. The average unit-cost estimate of the CCA rose to between one-third to one-fourth of a Lockheed Martin F-35, creating a range of roughly $23-31 million at Lot 16 flyaway unit rates.

The estimated price range for the CCA leaves little room in the budget for nice-to-have features. The CCA bill of materials already includes the airframe, engine, targeting sensors, and—not least—software and processing capable of performing advanced autonomous behaviors.

But survivability remains a concern. Recent war games performed by the Mitchell Institute for Aerospace Studies found the key factor desired by CCA operators, and it was not to achieve reusability. In combat, armed CCA needed to survive long enough to reach the launch points for their munitions, the think tank wrote in a February report.

Some industry officials have echoed the think tank's findings. In July, Northrop Grumman Aeronautics President Tom Jones said he was concerned that survivability requirements are being overlooked in the Air Force's selected CCA so far.

GENERAL ATOMICS AERONAUTICAL SYSTEMS INC.

"There's probably a fine line between getting the survivability of a platform right so it can deliver effects and where it would be much less effective at doing that," Jones said at the Global Air and Space Chiefs' conference in London in July.

Survivability is a function of passive and active features. Passive features include the shape and materials of the airframe, engine inlets and control surfaces, with the goal of reducing their visibility in all bands of the electromagnetic spectrum. Active features require systems that provide situational awareness and countermeasures to potential threats.

That is where the Ghost Mantis—or any of its future competitors—might come in.

The focus of SRC's designers was to keep the system's cost as low as possible while meeting certain performance requirements, says Dave Toomey, SRC assistant vice president of business development. "It's: 'OK, how much money is going to be available for that payload on that sensor?'" Toomey tells Aviation Week. "We've heard [Air Force] Secretary Frank Kendall talk $20 million, we've heard $30 million and somewhere in between the two of those for the entire platform.

"We said: 'All right, let's go down to the low-single-digit millions and see what we can build,'" Toomey continues. "Because we know when you put mission systems on there, you put sensors on there, when you put payloads on there, and you put [command and control systems] on there, you're going to get up to that $25-30 million level really quick. That's how we settled on that low-single-digit million-dollar range."

PROS AND CONS

Guy Norris Toulouse

In the high-stakes industry of commercial aviation, Airbus' upcoming choice of engine architecture to power its next-generation single-aisle airliner is about as pivotal as it gets.

Whether Airbus decides to go with CFM's open fan or with advanced ducted engines from Pratt & Whitney or Rolls-Royce, the choice will have industry-changing ramifications for decades to come. Its decision also may be a factor in Boeing's next-gen engine deliberations, as the U.S. manufacturer has expressed reservations about the open fan for its 737 successor.

The Airbus engine contest is unlike anything civil aviation has yet witnessed. Since the birth of the jet age, every major new airliner design has been compatible with multiple powerplant options that could fit beneath the same wing or around the same tail. This time, it is not so simple.

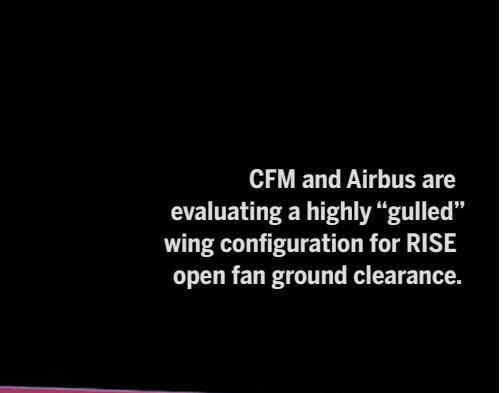
The open fan of CFM's Revolutionary Innovation for Sustainable Engine (RISE) technology program is expected to have a diameter of about 13 ft., similar to the GE Aerospace GE9X that powers the Boeing 777-9. Mounting such a large fan on, above or below the wing of a single-aisle aircraft necessarily drives key airframe configuration design choices, particularly the shape of the wing and how and where it connects to the fuselage.

To compete with the advertised propulsive efficiency benefits of the open fan, which is targeted at bypass ratios of 45-60 and up to 20% better fuel burn than current generation engines, the ducted designs also will need to incorporate higher-bypass, larger-diameter fans. It is unlikely, however, that even the largest ducted option would require the same ground clearance as the open fan—or other related installation features such as fuselage shielding to protect against blade shedding.

The bottom line is that one aircraft design does not fit all engine options. Unless the competition evolves into a face-off among multiple ducted engines or open fans, the odds are that the race for the next Airbus single-aisle engine could be a case of winner takes all.

Facing these questions, Airbus took the unusual step of joining forces with GE Aerospace-Safran joint venture CFM on a RISE flight-test demonstrator program in 2022. Now two years in, Airbus is providing new details about what the effort involves, how the concept is being evaluated and what key factors will be considered as the aircraft-maker nears a downselect decision over the next three years.

"A decision in one or the other direction will drive what the industry does overall—or it will be a big success or big failure for the product driving that change," said Frank Haselbach, senior vice president and head of propulsion engineering at Airbus. "But I'm absolutely convinced that each airframer will follow the data, and if you have a big enough gap be-



CFM and Airbus are evaluating a highly "gulled" wing configuration for RISE open fan ground clearance.

- AIRBUS DETAILS NEXT-GEN ENGINE STUDY OPTIONS
- THE FUTURE IS GEARED, REGARDLESS OF ENGINE CHOICE
- OPEN FAN SHIELDING WEIGHT IS WITHIN MARGINS SO FAR

CFM

tween architectural choices, the better choice will win."

Speaking in Toulouse at a conference for the International Society for Air-Breathing Engines (ISABE), Haselbach, who is also the society's current president, underlined how the unusually integrated nature of the airframe-engine studies for the A320 replacement goes beyond any previous program. Although Airbus is working with CFM on the flight demonstrator, it also is studying ducted fan options with Pratt and Rolls.

"Clearly, the integration question, the product strategy question and the product architecture question reside with the airframer together with the engine company," he said. "So to a certain extent, that's a partnership. There is an interesting sort of technology beauty contest that we're going through, and that is far from being resolved.

"The good thing is that we are doing programs together, which will tell us the answer," he continued. "Engineers act on data, and they have a gut feeling. It's good to have both, and they like challenges. So in that respect, I'm pretty sure in the next three years we will come to the answer. That would be a significant step in the industry, if we go one way or the other."

Airbus was attracted to RISE because of its simpler single-stage puller configuration, compared with the multifan-stage counter-rotating GE36 and Pratt & Whitney/Allison 578-DX pusher concepts flown in the 1980s and '90s. Under the European Sustainable and Green Engines counter-rotating open rotor research program, Safran also tested a dual-rotor pusher engine in 2017. Because it uses a single rotating fan and static stator stages, CFM defines its RISE concept as an open fan rather than an open rotor.

"It's effectively a turbofan without the casing and the nacelle, but you need variable-pitch blades and stators to provide things like thrust reverse and so on," Haselbach tells Aviation Week. While this reduces many of the mechanical and system complexities, as well as potential maintenance issues, the design faces major challenges—not least of which are concerns with the mounting and airframe integration of the larger-diameter fan.

"Integration is the key challenge we have," Haselbach notes. "So of course, you have questions like, 'Well, you lost your casing. You lost your nacelle. You lost your means of managing noise from the fan. How do you do that now?' So clearly, it'll be clever fan blade design. On the one hand, you have a much lower pressure ratio, so that helps as well. So you now need to tackle the noise at source, and that's what CFM is doing."

Low internal noise levels are also important, Haselbach says. "If we do this, people should not hear the engine when they're sitting in the cabin, they might see something different outside, but they shouldn't hear it, so that's the target," he notes.

Other integration-related studies are focused on potential blade release and reaching the best compromise between the weight of the blades and the shielding needed to protect the airframe. "Of course, you no longer have a casing that could hold a fan blade out. Up to now, the preliminary work we're doing, all of that looks like it's within the margins and limits we set ourselves, so that's OK, you can account for that," he says. The relatively slow tip speeds of the gear-driven open fan also are expected to be similar to the blade energy certification requirements for existing turboprops such as the ATR 72.

Aerodynamic effects are another focus area—particularly the impact of prop wash over the wing. "You have to look at the parasitic losses on the lift/drag of the wing because you have a much bigger wetted area that sees the turbulent wake from the fan blades," Haselbach says. "All of those things are accounted for. We have a road map together with CFM to look at this. We have a technology program of engine tests and integrated engine tests, detailed tests, bird strike and so on to see if that will work."

Beyond the technology are considerations of total installed weight and, critically, maintenance costs—particularly on components such as fan blades, which today are expected to enjoy long service lives before inspection, repair and removal.

With these time-on-wing and maintenance concerns in mind, CFM also has revealed plans to conduct dust-ingestion tests of the RISE high-pressure (HP) turbine blade. "We are actually running a durability engine [test] right now," says Mohamed Ali, vice president and general manager of engineering for GE Aerospace. "So that new design of high-pressure turbine is actually on test for endurance testing, and next year we'll be testing that same technology with dust."

Ali says the additional focus on dust ingestion is "the earliest we've ever done that," reflecting the turbine durability lessons learned from the Leap 1 and other recent GE engines that operate at higher temperatures in challenging environments. The RISE's compact core design will add to these challenges. "We had another test to measure performance last year, and it really worked as intended. In fact, in some cases, better than we thought it would be," he says.

Known as CMAS (calcium-magnesium-alumino-silicate) tests, the dust ingestion work evaluates the interaction of molten particles with the thermal barrier coatings (TBC) that protect the turbine blades. TBCs are key to enabling the engine to operate at temperatures up to 1,200C (2,200F), and CMAS issues can degrade coating performance, leading to blade erosion and—in worst cases—component failure.

Due to the smaller size of the RISE core components, the HP turbine blades and nozzles are being evaluated in a GE F110 military donor engine. GE says the endurance and follow-on dust tests "will use the dust ingestion test rig we developed, placed in front of the F110 engine."

Safran continues to evaluate many of the program's propulsive efficiency advances. "There are lots of challenges," Pierre Cottenceau, Safran Aircraft Engines vice president of engineering, research and technology, said at ISABE. "Certainly, the open fan has huge potential in terms of fuel reduction, but this will only be achieved if it is properly integrated with the aircraft, and in a lot of different aspects—such as aerodynamics, for sure, because there will be some key interaction with the wing."

So far Safran appears happy with the aerodynamic and acoustic results, many of which are from recent static and dynamic tests of a small-scale open fan blade set conducted at French national aerospace research center Onera's S1MA transonic wind tunnel in Modane-Avrieux, France. "Acoustics are another important aspect, and it's related to the fuel block performance, because if it's not properly done, then it will have to be compensated somehow with other solutions, which will affect the cost, reliability, all sorts of things," Cottenceau said.

Although they know they cannot compete in terms of bypass ratio, the ducted turbofan developers expect improved geared designs can match the overall performance of the open fan at an aircraft level when considering installed weight, installation and aerodynamic effects. Pratt has laid out plans for a next-generation geared turbofan (GTF) that incorporates an array of propulsive and thermodynamic advances, while Rolls-Royce is targeting an all-new geared design leveraging technology from its recently tested UltraFan engine.

Geoff Hunt, senior vice president of engineering and technology for Pratt & Whitney, says the gear at the heart of the GTF is a "technology we love." The hub-mounted epicyclic fan drive

SAFETY > New skills signal BEA's bid for more autonomy **p. 50**

FAA Issues Safety Alert for Boeing 737 Rudder Issues

- **>** 737 RUDDER JAM LINKED TO SUPPLIER ISSUE
- **>** NTSB SEES RISK IN FAA INACTION

Sean Broderick Washington and **Guy Norris** Colorado Springs

The FAA has issued a safety alert to Boeing 737 operators warning of the potential for jammed or restricted rudder movement in aircraft equipped with an optional component supplied by RTX subsidiary Collins Aerospace.

The warning, issued as a Safety Alert for Operators (SAFO) on Oct. 7, follows an NTSB investigation that revealed the potential for rudder jams in hundreds of system components installed in both 737 Next Generation and 737 MAX series aircraft. The problem is focused on improperly assembled bearings and was uncovered during a probe of a February incident involving a United Airlines 737-8.

In the United incident, pilots reported jammed rudder pedals during a landing rollout at Newark Liberty International Airport in New Jersey following an otherwise routine flight from Nassau, Bahamas. Unable to move the rudder pedals and steer the 737, the pilots used the aircraft's nose wheel steering tiller to turn off of the runway. The incident aircraft, N47280, was delivered in February 2023.

Investigations pointed to an issue with the SVO-730 rudder rollout guidance actuators (RRGA) assembly that provides rudder inputs during landing rollout, where directional guidance is provided by the fail-operational autoflight system after touchdown on aircraft used to conduct Category III B low-visibility landings. The aircraft was equipped with the RRGA but not electrically connected to the Digital Flight Control System. United's 737s do not fly Category III B operations.

The investigation findings "suggest the jammed or restricted rudder was a result of moisture that had previously entered the actuator and froze during flight," the FAA states.

At least nine United Airlines 737 MAXs had the incorrectly assembled parts.

KEVIN CARTER/GETTY IMAGES

"Boeing 737 airplanes with the SVO-730 RRGA installed may be affected by this condition. This also includes airplanes with electrically deactivated actuators that remain mechanically connected to the upper portion of the rudder input torque tube per normal system installation. Airplanes which have the RRGA actuators removed are not affected."

Boeing told operators in an August bulletin it is developing a plan to remove from service the faulty parts, adding that the problem does not pose an immediate safety issue. The bulletin did not provide scenario-specific pilot guidance, leaving flight crews to rely on general procedures covered in 737 flight manuals that focus on using force to overcome rudder jams.

The issue adds to a growing list of serious Boeing production quality issues, and like January's Alaska Airlines 737-9 door-plug blowout, it is linked to an in-service event. The Alaska incident triggered sweeping management and factory floor changes (*AW&ST* July 1-14, p. 54) and led the FAA to modify its oversight of the beleaguered manufacturer's production process (*AW&ST* Sept. 30-Oct. 13, p. 24).

Boeing's lack of scenario-specific pilot instructions and the generic rudder-jam procedure's potential hazards in certain situations highlight weaknesses in the company's flight deck human factors analysis process. Human factors blind spots helped set the stage for the two fatal 737-8 accidents

gear system drives the front-mounted fan at lower rotational speeds than the low-pressure (LP) turbine, which is freed to operate at higher speed. "If you want propulsive efficiency, you're driving up bypass ratio, and that's going to keep pushing on gears," Hunt explains. "We're currently running a little over 3.5:1 gear ratio, but in a ducted configuration you must push up to four or so."

For its next-gen GTF, Pratt has outlined plans to move to a bigger-diameter composite fan contained within a composite case and shrouded within a compact, shorter duct nacelle. The engine also will incorporate a revised, smaller core with a higher overall pressure ratio, ultra-low-emissions combustor and hybrid-electric motor-generators.

Partially backed by Heaven (Hydrogen Engine Architecture Virtually Engineered Novelly), a project under Europe's Clean Aviation research initiative, Rolls is actively studying the development of a version of the UltraFan for single-aisle applications under a strategic plan launched by CEO Tufan Erginbilgic in late 2023.

Alan Newby, director of aerospace technology and future programs at Rolls-Royce, says the requirements for the new engine are clear. "We all know you're going to need a gear," he notes. "You're going to need to split the speed of the LP turbine and the fan—that's a given. You're going to need a high-efficiency, small hot core—we all agree on that. You're probably going to have some more electric systems in there."

The industry has seen what Newby describes as first-generation production GTFs enter service and development. "I suspect Pratt & Whitney has got some ideas how to make that better—we have," Newby says. "I think with the installation and integration challenges that you'll have with an open fan configuration, you can also start looking at the nacelle. There's lots to do on the nacelles and with their integration—we're not short of ideas on that. There's a lot of room ahead of us for a conventional engine."

Addressing Haselbach in person and Airbus in general, Newby adds, "You've got a hard decision to make!"

in 2018 and 2019, prompting the NTSB to call on the FAA to lead an industrywide review of pilot performance assumptions (*AW&ST* Oct. 14-27, 2019, p. 18). Rebuilding its once-vaunted human factors expertise is one of many steps Boeing is taking as part of a larger safety improvement journey.

The SAFO emerged after an NTSB Sept. 26 update that made four urgent recommendations—two to the FAA and two to Boeing—calling for prompt action to address both the parts and pilot guidance issues. Just four days later, NTSB Chair Jennifer Homendy wrote to FAA Administrator Michael Whitaker expressing frustration at what the board considered inadequate responses.

The NTSB reported that United took delivery of nine aircraft—built for another customer—that had the nonconforming actuators, but they were "disabled . . . based on [United's] delivery requirements" before the airline put them into service, the update said. The actuators were electrically disconnected but remained mechanically linked to the rudder system, the board explained.

Deliveries of the incorrectly made parts began in February 2017, just after Collins moved its manufacturing facility from Melbourne, Florida, to Mexicali, Mexico, the NTSB said. All of the problem actuators were made in Mexicali, the board added. Details on why they were assembled incorrectly have not been released.

Boeing in its August message said Collins delivered 353 of the incorrect actuators for installation on 737s. The FAA and NTSB confirmed that United was the only U.S. carrier with any of the parts.

According to the NTSB, 271 of the actuators may be on in-service aircraft operated by as many as 40 non-U.S. carriers. In addition to the inventory sent to Boeing, Collins shipped another 75 directly to operators as spares. "Accordingly, it is essential that aftermarket installations of affected actuators also be clearly addressed," Homendy wrote.

The NTSB's Sept. 26 update said United "in general . . . was unaware that the rudder rollout guidance actuator was installed" on its aircraft. The parts were removed using instructions in a May service bulletin, the board added.

"We are concerned of the possibility that other airlines are unaware of the presence of these actuators on their 737 airplanes," Homendy wrote in her Sept. 30 letter. "Consequently, their flight crews may not know what to expect if the rollout guidance actuator fails at low altitude or during landing and rollout, as occurred in this incident."

Prior to issuing the SAFO, the FAA said its corrective action review board met, and the agency is working with other civil aviation authorities "to ensure they have the information they need from the FAA including any recommended actions." The agency added that it plans to conduct "additional simulator testing" in October.

Equally troubling to the NTSB is an apparent human-factors disconnect between Boeing's pilot guidance on handling a jammed rudder and the additional risks it could introduce until all affected parts are removed.

"Boeing's mitigation for a jammed or restricted flight control in the yaw axis in flight or during landing is to 'overpower the jammed or restricted [rudder control] system,'" the NTSB stated, citing United's 737 flight manual derived from Boeing's guidance. But the amount of force needed to free a frozen rudder actuator could introduce new hazards, the board found.

Flight data recorder data from the United incident showed the pilots tried several times to free the jammed controls, applying as much as 75 lb. of force to the rudder pedals, the NTSB said. Boeing and Collins calculated that a frozen actuator required about 87 lb. of rudder-pedal force to move.

"This amount of force applied during landing or rollout could [lead to] a sudden, large and undesired rudder deflection that could unintentionally cause loss of control or departure from a runway," the board said. "Accordingly, the NTSB is concerned that Boeing's mitigation for a jammed or restricted rudder control system—to apply maximum force to overcome the jam or restriction as indicated in the Boeing 737 Quick Reference Handbook—might not be appropriate during a landing or rollout for the same reason."

The NTSB urged Boeing to review its pilot instructions and consider potentially safer alternatives.

Boeing is "working with our supplier to develop additional guidance to address the potential condition," the company said in a statement. "We will also ensure flight crews have the appropriate operating procedures."

Small Airlifters Are Becoming a Big Priority for the U.S. Air Force

- EARLY REQUIREMENTS ARE FOCUSED ON AUTONOMY AND SHORT-FIELD OPERATIONS
- THE CONCEPT ECHOES VIETNAM-ERA C-7 AND WORLD WAR II-ERA C-47 APPROACHES

Steve Trimble Washington

A new type of military airlifter is rising to the top of the U.S. Air Force's list of modernization priorities: small, autonomous, electric-powered aircraft capable of short takeoffs and landings—and numbering in the hundreds.

Air Force Material Command (AFMC) is in the market research phase for the Next-Generation Intratheater Airlift (NGIA) concept. A five-year prototyping program could begin as early as fiscal 2026, leading to the start in the early 2030s of an engineering and manufacturing development phase for the first newly designed U.S. military air transport since the early 1990s debut of the Boeing C-17.

A shift to distributed operations across the Pacific Ocean is spurring the Air Force to look for airlifters smaller than the Lockheed Martin C-130.

"The Department of the Air Force's goal is to enhance existing airlift capability and capacity with an intratheater platform that can fight through damaged infrastructure on responsive timelines," the AFMC said in a request for information released on Sept. 24. Responses from the industry are due Nov. 1.

Although unclassified, the NGIA proposal is early enough in the acquisition process that Air Force officials are reluctant to elaborate on the concept. An AFMC spokesperson referred questions to the Air Force Futures organization on the headquarters staff. A spokesperson for Air Force Futures declined to answer questions, saying the NGIA concept is still in its infancy.

But the service's interest in a fleet of small airlifters has been building for a few years. The NGIA concept builds on its "Last Tactical Leg" airlifter proposal, which first appeared in an AFMC presentation in July at the Life Cycle Industry Days event in Dayton, Ohio. The Air Force has not set a budget yet, but the presentation included a notional spending plan of $60 million annually for a prototyping program between fiscal 2026 and 2030.

The Last Tactical Leg proposal envisions an autonomous, hybrid-electric short- or vertical-takeoff-and-landing aircraft. This proposed airlifter would deliver small, urgently needed supplies from logistics hubs to forward bases, even with battle-damaged runways on both ends.

The market survey for the NGIA calls for industry "to achieve extremely short- or vertical-takeoff-and-landing capability with smaller payload weight."

The concept echoes an idea floated in 2022 by then-commander of Pacific Air Forces, Gen. Kenneth Wilsbach, who now leads Air Combat Command. On a webinar hosted by the Mitchell Institute for Aerospace Studies, Wilsbach cited the example in World War II of fielding thousands of Douglas C-47 Dakotas to ferry relatively small amounts of cargo and personnel around the Pacific Ocean.

"They tackled the logistics problem of the Pacific by having a lot of tails to put equipment in and move it," he said. "We could have something like that. . . . We need a lot of tail numbers to be able to get the small bits of equipment to the various spots that we intend to deploy from."

Intratheater airlift also featured prominently in the Air Force fleet during the Vietnam War. The Air Force operated a fleet of about 150 de Havilland C-7A Caribou aircraft, which could transport about 6 tons of cargo or 26 troops.

The modern version of the concept builds on a wave of investments by defense companies and startups in electric-powered cargo aircraft, autonomy and airspace management.

MASTER SGT. CAILA ARAHOOD/U.S. AIR FORCE

Manassas, Virginia-based Electra.aero, for example, is developing a nine-passenger or 2,500-lb. cargo transport for the commercial market but also is working with the Air Force to incorporate military requirements.

"We remain focused on supporting the contested logistics mission with a right-sized aircraft for Agile Combat Employment to facilitate the movement of cargo and personnel at tactically relevant ranges with significantly reduced operating costs and minimal sustainment footprint," an Electra.aero spokesperson tells Aviation Week.

Air Mobility Command, meanwhile, is working with several companies, including Merlin Labs and Reliable Robotics, to enable single-pilot and autonomous operations of existing mobility aircraft, such as the Boeing KC-135 Stratotanker.

The U.S. military also plans to begin experimenting with cargo delivery flights in civil airspace. Starting in June, the electric-powered Skyways V3, an autonomous cargo aircraft, is planned to transport loads up to 15 lb. about 50 mi. from Grand Forks AFB to Cavalier SFS in North Dakota. The flights are sponsored by Project Ultra, a collaboration among the Navy, Air Force and the Office of the Secretary of Defense.

FABIO FACCO/LEONARDO HELICOPTERS

The AW249 flew low through a valley in its natural habitat during a recent demonstration by the Italian Army, which expects the aircraft to play a key role in its future battlefield doctrine of multidomain operations.

ITALY'S PHOENIX RISES

> AW249s ARE SET TO ENTER ITALIAN ARMY SERVICE IN 2027

> LEONARDO ENVISAGES USING AI TO REDUCE WORKLOAD

Tony Osborne Vergiate, Italy

Forty years after developing Europe's first dedicated attack helicopter, the AW129 Mangusta, Leonardo is flight-testing its successor.

The 8.3-metric-ton, twin-engine AW249—christened the AH-249A Fenice (Italian for "phoenix") by its Italian Army launch customer—is almost twice the weight of its predecessor and will be equipped, the manufacturer says, for a very different kind of battlefield.

Just as development of the then-Agusta-built Mangusta helped prepare the Italian rotorcraft manufacturer to produce a new generation of dual-use utility helicopters that have taken the commercial medium-helicopter market by storm, Leonardo officials say work on the clean-sheet AW249 will help the company prepare for aircraft that could emerge from NATO's Next-Generation Rotorcraft Capability project and beyond.

Unlike the Cold War-era Mangusta, which was designed as a missile-carrying rotary-wing tank destroyer and later adapted to combat counter-insurgencies in Afghanistan and Iraq, the AW249 design aligns with the Italian Army's new doctrine of fighting near-peer adversaries in a multidomain anti-access/area-denial environment, Alessandro Alfonso, Leonardo Helicopters' AW249 program manager, tells Aviation Week.

"This helicopter needs to operate in congested, contested, connected and confused environments," Alfonso says. "So we have considered the design and integration of solutions in the AW249 architecture that allow interconnectivity, interoperability and multidomain operations integration from the beginning."

Formally unveiling the AW249 at the Eurosatory defense show in Paris in June, Italian Army Chief of Staff Gen. Carmine Masiello described it as a "system and not just a helicopter."

Perhaps it is no wonder, then, that the Italian Army has kept the AW249 under a thick veil since first contracting its development through the New Exploration and Escort Helicopter program in 2017. That contract called for the development and production of an initial four AW249s, paving the way for army batch orders for up to 48 helicopters; first deliveries are planned for 2027. Production will take place at Leonardo Helicopters' main facilities here, alongside its commercial offerings.

Following a first flight in August 2022, two AW249s are now supporting flight testing, with some 500 flight hours completed. Another development aircraft is scheduled to fly before year-end, and a fourth is set to fly in early 2025.

The first aircraft to fly was the third prototype—which happened to be ready first. Each prototype has a specific development scope. Only in final production aircraft will the full aircraft systems be installed and realized.

Nonetheless, the AW249 has already completed hot-and-high trials in Spain and Southern Italy and fired unguided rockets. It recently participated in an Italian Army demonstration in the Alps, too.

At the heart of the helicopter's requirements is a need to outperform the Mangusta in all areas—most notably range, payload, speed and survivability. Doing so required a "larger, heavier aircraft," Alfonso says.

Development of the AW249 has been focused around six key pillars: interoperability with allies, maneuverability, lethality, weapons precision, sustainability and supportability.

To keep costs down and reduce developmental risk, Leonardo made use of the proven AW149 dynamic system, including the main gearbox, tail-rotor system and five-blade main rotor system. Because the dynamic system's 50-min. run-dry capability—that is, without oil—had already been demonstrated, there was no need for an iron bird to test it. The company did, however, make minor improvements to the gearbox to enhance reliability and aircraft survivability.

Engineers then wrapped a new airframe around the dynamic system. As with other Western attack helicopters, Leonardo has opted for a tandem seating configuration in a long, narrow fuselage, continuing the design trend started by Bell's AH-1 Cobra.

Two General Electric (GE) CT7-8E6 turboshafts mounted high on the rear fuselage provide some 2,500 shp and are assembled by GE Aerospace-owned Avio Aero in Italy. The turboshafts have been modified for improved one-engine-inoperative and maximum continuous power performance. The Italian Army selected the engine in part for the commonality

Anatomy of the **AW249**

The 8.3-metric-ton, twin-engine AW249 is designed to operate in "contested, connected and confused environments," Leonardo says.

LEONARDO HELICOPTERS

1 | Airframe
The AW249 follows the traditional narrow fuselage of other attack helicopters that makes it harder to spot. Leonardo says the slab sides can help reduce the rotorcraft's radar cross-section.

2 | Dynamic System
Since the main gearbox and much of the dynamic system were borrowed from the utility AW149, development of the AW249 benefited from lower risk and costs.

3 | Cockpit
Leonardo designed a larger, cooler and more comfortable cockpit for the AW249 crew, reflecting the longer missions they may need to perform compared with those on the Mangusta.

4 | Gun/Optical Targeting System
The trainable, three-barrel M197 gun is one of two elements the AW249 retains from the Mangusta. Above it will sit the future electro-optical targeting system.

5 | Sponsons
The sponsons house avionics equipment and ammunition for the chin-mounted 20mm gun.

6 | Stub Wings
Each stub wing features four hard points for weapons and wingtip mounts for air-to-air missiles, such as Raytheon's Stinger or the new MBDA Vshorad weapon.

7 | Engine/Auxiliary Power Unit
The AW249 is powered by a pair of 2,500-shp General Electric CT7-8E6 turboshafts and equipped with a Safran Power Units auxiliary power unit.

with other types in its inventory, including the NHIndustries NH90 transport helicopter. Still, Leonardo does not discount the potential of integrating another engine, particularly after having invested in the certification of the Safran Aneto-powered AW149/AW189. The helicopter also has a Safran Power Units (Microturbo) auxiliary power unit.

The AW249's stub wings feature four hard points—two on each wing—for guided missiles and rocket pods. The wings are plumbed for external fuel tanks to supplement the internal fuel load of 1,800 kg (4,000 lb.). Air-to-air missiles can be mounted on the stub wingtips.

Sponsons along the lower fuselage hold many of the avionics systems as well as the ammunition for the helicopter's chin-mounted 20mm M197 gun. The AW249 can carry 500 rounds of ammunition for the gun, 200 more than the Mangusta.

The M197 was retained from the Mangusta, as was the Rafael Spike missile system. The AW249 may be able to carry as many as 16 Spike-ERs due to the helicopter's increased payload capacity. The AW249 could carry longer-range versions of the weapon as well, which would increase the aircraft's standoff capabilities.

But Alfonso says the AW249's major technological improvements will be under the skin.

In the cockpit, Leonardo has opted for 10-in.-wide mission information displays for both the pilot and gunner. Lateral displays on both sides show engine data and master caution warnings. The helicopter can be flown from both cockpits, but the gunner's flight control is a side stick cyclic whereas the pilot's cyclic is situated between the legs. The gunner's position features a game-console-like controller for the optical sighting system.

Each crewmember wears an advanced helmet-mounted sight that stereoscopically presents on the visor relevant data fused from night vision, electro-optical targeting, obstacle warning systems and flight data. The setup improves crew situational awareness and operational safety in degraded visual environments. Development of this system is in progress, but Leonardo has not divulged the identity of the suppliers. Neither has it identified suppliers of the planned optical-targeting system to be mounted on the nose, like on Boeing's AH-64 Apache and Bell's AH-1Z Viper.

Leonardo also plans to install an electronic warfare and defensive aids system that fuses data from radar, missile, laser and hostile fire indicators. This system would defend the aircraft using a directed infrared countermeasure (DIRCM) system mounted on a fairing under the rear fuselage near dispensers for chaff and flares. Survivability is also embedded

into the airframe, and redundant systems are spread out to reduce vulnerability to enemy fire. Maneuverability was another key requirement contributing to the overall survivability of the platform.

"Ballistic protection is the last solution for us," Alfonso says. "We will use it to protect the crew, but otherwise we are using a combination of redundancy, systems separation and dedicated tests on some critical components to demonstrate the damage tolerance as well as other solutions to reduce the exposure to ballistic damage."

The AW249's key enhancements are in the avionics suite and its embedded battle management and communications system. Leonardo has developed an open-architecture avionics suite that Alfonso says will allow extra capabilities to be added quickly without major modifications. The system can also pave the way for a "significant amount of industrial collaboration," should export customers want to embed tailored options, Alfonso notes.

The AW249 is designed to be able to send and receive voice and data within and beyond visual line of sight, connect with data links, including the NATO-standard Link 16, and downlink full-motion video to ground troops. In addition, the helicopter has the capability to connect through a crewed-uncrewed teaming system to take control of the Italian Army's tactical uncrewed aircraft systems (UAS) and their payloads as well as those of the Italian Air Force's General Atomics MQ-9 Reapers.

A battle management system that allows the crew to work with various platforms around the battlefield will be integrated into the human-machine interface (HMI), the development of which has been carried out in conjunction with the Italian Army. As part of the HMI development, the army installed heat cameras in the AW129 simulator in Viterbo, allowing engineers to understand which tasks stressed crews the most and how to improve the HMI to help them.

Leonardo envisages wider use of artificial intelligence (AI) in the rotorcraft's avionics. The helicopter-maker is experimenting with an AI-enabled feature called the Navigation Aid Tunnel, which will use the aircraft's sensors and electronic warfare suite to designate a flightpath for the crew to avoid adversary threats or geographic obstacles.

The manufacturer plans to use AI to maintain the helicopter and aims to offer predictive, on-condition maintenance once the AW249 is in service. Health and usage monitoring systems are already scooping up data to improve engineers' understanding of the behavior of onboard components.

The inclusion of AI in the AW249 is one of the drivers for the growth headroom Leonardo has factored into its design. Because of the computing capability onboard, engineers also have included a powerful environmental control system to keep the pilots and electronic systems cool in the heat of the Italian summer. Such use of AI aligns with Leonardo's outlook on the future of its products. CEO Roberto Cingolani stated in March that AI algorithms, cloud-computing networks and electronic systems were "the glue" at the heart of all the company's products (*AW&ST* Mar. 25-April 7, p. 34).

Although the AW249 is still in flight testing, the Italian Army has begun defining a road map of additional features it would like to add, partly prompted by the evolving security situation, including the Russia-Ukraine war. Among them: an anti-UAS capability and the ability to guide long-range ammunitions, such as artillery rounds and rockets, and to control air-launched effects and loitering munitions.

"The Italian Army is taking a new approach," Alfonso explains. "This is not just about destruction of the enemy but also about creating dilemmas and making the adversary lose time."

Leonardo has high hopes for AW249 exports: Although the company sold the Mangusta only to Turkey, Ankara has since exported the helicopter to several countries, including Nigeria and the Philippines.

Now that the Airbus Tiger is out of production and European leaders are calling for greater defense sovereignty and less reliance on the U.S., Leonardo believes the AW249 can find a niche as the only European attack helicopter available for export—and arriving just in time to meet requirements in several countries. The manufacturer has identified markets in Europe, the Middle East and Latin America where the helicopter will have export appeal, but it faces increasingly stiff competition, particularly from the U.S.-made Apache and Viper.

"We're confident the AW249's characteristics and possibilities represent a highly competitive value proposition also for the international market," Leonardo Co-General Manager Lorenzo Mariani said at Eurosatory in June.

FABIO FACCO/LEONARDO HELICOPTERS

A prototype AW249 maneuvered hard inside an Italian valley, showing off its dummy weapon load of air-to-air and air-to-ground missiles as well as guided and unguided rockets. Beyond land operations, Italy plans to operate the type from navy ships, just as it had done with the Mangusta.

The Bell FLRAA gives the Army a new rotorcraft with nearly twice the speed and several times the range of the UH-60.

BELL

FLRAA 2.0

> MAJOR UPGRADE HIGHLIGHTS THE UNIQUE ACQUISITION PATH FOR THE U.S. ARMY'S FUTURE LONG-RANGE ASSAULT AIRCRAFT

> VERSION 2.0 FOCUSES ON SENSORS AND COMMUNICATIONS

> REQUIREMENTS ARE SET TO BE FINALIZED NEXT YEAR

Steve Trimble Washington

The U.S. Army's next rotorcraft is six years away from entering service, but requirements for the first major upgrade are already being developed.

In the past, the Army's pursuit of a "Version 2" less than two years after awarding Bell a contract to deliver the baseline version of the Future Long-Range Assault Aircraft (FLRAA) might have raised eyebrows.

But Army leaders describe the Version 2 plan as a feature of the FLRAA acquisition strategy, not a bug. If the modular, open-systems approach (MOSA) works as advertised, the Army's next rotorcraft should be far easier and cheaper to upgrade than the Sikorsky UH-60 Black Hawk fleet that it is replacing.

"This [upgrade strategy] was the whole basis for FLRAA," Brig. Gen. Cain Baker, the Army director of the Future Vertical Lift Cross-Functional Team, told reporters at an Association of the U.S. Army (AUSA) event in September.

"The architecture inside of that aircraft is [designed in a way] that you could advance it and upgrade it over time without creating major modifications to the platform," Baker said.

Army aviation officials have launched a process to finalize the Version 2 requirements document. A final draft is expected to be circulated to Futures Command and the Army's headquarters staff in about a year.

That timeline aligns with a fielding schedule for Version 2 around 2034, the year that the baseline version of the FLRAA was originally scheduled to enter service. In 2019, however, the Army accelerated the FLRAA fielding date to 2031, knowing some advanced capabilities would not be ready.

Familiar with the difficulty and cost that come with the traditional approach to advanced technology upgrades, past Army leaders preferred to extend development schedules as long as necessary to pack as much capability as possible into the baseline version. The Army adopted the MOSA framework on FLRAA to break that cycle.

The baseline FLRAA entered the engineering and manufacturing development phase in August. That milestone came more than a year and a half after the Army eliminated Lockheed Martin's bid from the competition, citing Lockheed's lack of responsiveness to the Army's questions on details of the company's plan to comply with MOSA requirements.

Following Lockheed's disqualification, the Army awarded a $1.3 billion contract in November 2022 to Bell to deliver a FLRAA virtual prototype, which is due for delivery by year-end. The First Unit Equipped of the physical version is expected to follow in 2031. Bell's design is based on the V-280 Valor, a second-generation tiltrotor.

The speed and range promised by the FLRAA is the key for the Army to realize its vision of future warfare based on penetrating deep into enemy territory, distributing small units to wreak havoc behind enemy lines. The 300-kt.-capable FLRAA is replacing the 170-kt. Black Hawk while offering several times the unrefueled range. But the 2030 version of the FLRAA needs upgrades to make the most out of its performance. The aircraft is expected to operate at maximum speed as low over treetops or waves as possible.

The new mission stands in contrast

to the standard flight profile flown by Army aviators over the past two decades. Army pilots who are accustomed to flying missions at higher altitudes in order to reduce their vulnerability to short-range, shoulder-fired missiles will be expected to adapt to a new flight regime. The standard Army rotorcraft pilot will need to master the high-speed, low-altitude flight profile generally reserved for the elite special operations community.

To help future FLRAA flight crews make that adjustment to a riskier flight profile, Army officials plan to rely on a suite of upgraded onboard sensors, plus long-range communications systems.

"We're looking at how you bring on technologies and capabilities to offload pilot requirements into the cockpit," Baker said, "and how you put an ability to communicate over longer distances."

A request for information (RFI) published by the FLRAA program manager at the end of last year detailed several specific sensors on the Army's shopping list.

At the top of the list are sensors capable of detecting wires and obstacles in the FLRAA's flightpath. The Army also is interested in sensors that can overcome visual problems in bad weather, allowing the crew to see through smoke, dust storms, fog, clouds, snow and rain. A terrain-following and terrain-avoidance sensor—hallmarks of the special operations aviation fleet—also are of interest. And the Army wants a 360-deg. sensor suite that works in all degraded visual conditions.

The FLRAA Version 2 planners also are exploring an improved array of communication systems. The focus is on multi- and single-band software-defined radios with beyond-line-of-sight reach. The package includes high-, very-high- and ultra-high-frequency radios; the ultra-high-frequency ones would be capable of linking to satellites, such as the Navy's Mobile User Objective System. Battlefield data networks, including Link 16, Tactical Common Data Link and Bandwidth Efficient-Common Data Link, also made the list in the Army's RFI.

A key focus for the Army are multifunctional systems that package multiple upgrades into the same "box." If Version 2 requires a unique box—or line replaceable unit—to achieve each new capability, the upgrade could create a new weight and integration challenge for the FLRAA.

"What we don't want to do between Version 1 and Version 2 is redesign the aircraft," Baker said.

Army and industry officials have been preparing for this opportunity, along with the unique requirements imposed by a MOSA-based upgrade program. This approach promises to speed up and simplify the integration of new technologies, but only if the standards have been put in place to define the interfaces between the FLRAA flight computer and the new sensors and communication systems.

New sensors could help FLRAA flight crews adapt to a much faster and lower flight profile.

CAPT. WILLIAM DERRICK/U.S. ARMY

Anticipating the need for standards, the Army and industry started an architecture collaboration working group a few years ago, Army Program Executive Officer for Aviation Brig. Gen. David Phillips told journalists at the AUSA event.

"That architecture collaboration working group was to help us define those standards and interfaces so it wasn't just something we came up with separately from industry," Phillips said. "So they've come to the table and helped us define a component specification model for a new system."

The group aims to eliminate the need for adaptors and middleware, features necessary only in the absence of compatible hardware and software interfaces.

But the MOSA policy changes the traditional relationship between the Army and industry.

"It lowers the bar for competition because now that industry partner comes in with that new capability, and that sensor, for example, is already designed to that standard," Phillips said. "That is a much faster and affordable integration."

A lower bar for competition means the supply chain for the FLRAA also must adapt. If it works, the MOSA policy promises to break a vendor's grip on a subsystem through the life cycle of the platform. That could present unexpected consequences. The same policy that gives the Army freedom to make changes to the FLRAA configuration also denies a long-term revenue stream for suppliers, which was often necessary to justify the upfront investment in the advanced technology in the first place.

"There is a tension there from the older ways of doing business with the newer ways of doing business," Phillips noted.

If a MOSA policy presents challenges, it also creates opportunities. The approach could incentivize companies to continue investing in upgrades, knowing the path to selection for nonincumbents has become easier.

More than 1,000 representatives of suppliers and other service branches attended a closed Army aviation conference on MOSA during the summer, showing that industry is embracing the concept, he said.

"What we've seen is a lot of early adopters and people that really are engaging with us," Phillips said.

Staying Power

> U.S. SPECIAL OPERATIONS FORCES PLAN BLACK HAWK UPGRADES

> A MULTIYEAR CONTRACT FROM THE U.S. ARMY AND FOREIGN DEALS ADD TO THE UH-60M BACKLOG

U.S. ARMY PHOTOS

Brian Everstine Washington

Engine replacements, life support upgrades and new weapons integration are planned to keep the U.S. Army's Black Hawk fleet relevant for decades to come.

The U.S. Army's UH-60 Black Hawk fleet is showing all the signs that come with aging, needing lots of work to offset the reality of being 50 years old. But unlike its human operators at that age, the utility helicopter is likely to emerge smarter and more powerful and independent as it exits middle age.

The most ubiquitous military helicopter in service is undergoing an overhaul in the next decade intended to give the UH-60M, the current version in production, a more powerful engine, fly-by-wire capability and a new avionics architecture as well as enhanced self-protection equipment to deal with threats on the modern battlefield. The Army expects to keep the UH-60 in service until around 2070, even though it canceled the UH-60V upgrade—which included a digital cockpit—this year.

Near-term plans include structural enhancements, an upgrade to a 60-kVA generator to deliver one-third more power and a degraded visual environment sensor, according to the Army. The service also continues to work with the Defense Advanced Research Projects Agency (DARPA) to advance technologies that could lead to an optionally piloted Black Hawk.

A centerpiece of the Black Hawk modernization is dealing with legacy avionics issues through the Modular Open Systems Approach, a Pentagonwide effort to make it faster and cheaper to upgrade platforms as new electronic subsystems become available. The Army has embarked on a three-phase program that is scheduled to last beyond the decade to update the helicopter fully. The service aims to address obsolescence issues in the next few years.

The digital enhancements also are designed to enable the Army to deploy from the Black Hawk what it calls "launched effects" uncrewed systems or weapons. The Army first launched an Altius 700 uncrewed system from a Black Hawk in late 2023.

In addition to enhancing the system's lethality, the service also plans to bolster its survivability. The Army recently tested a new laser for the Common Infrared Countermeasures self-protection system used by the Black Hawk as well as the Boeing AH-64 Apache and CH-47 Chinook fleets. The Jupiter Laser, due for fielding in 2026, is designed to defeat advanced threats. The Army demonstrated the laser's ability to defeat a missile in a test this year at the White Sands Missile Range in New Mexico involving the countermeasures system installed on a suspended aircraft.

A key component to extending the life of the Black Hawk is an engine upgrade. The service has decided to use the GE Aerospace T901-GE-900 engines initially destined for the now canceled Future Attack Reconnaissance Aircraft program to upgrade the UH-60 and AH-64 Apache. GE delivered two of those engines in June to the Army to validate the turboshaft for use on the UH-60M.

The engines are intended to be used for ground test runs on a Black Hawk leading to flight trials within about a year. The powerplant, due to replace the GE T700, was developed under the Improved Turbine Engine Program and should deliver a 1,000-shp increase in performance.

The platform remains central to the Army's effort to determine if it can pilot future rotorcraft optionally. The Black Hawk-related work emerged from Sikorsky's Matrix autonomy management system that was tested on several aircraft, including the S-76 Sikorsky Autonomy Research

Aircraft and UH-60 Black Hawk Optionally Piloted Vehicle. The company flew an uncrewed Black Hawk under DARPA's Aircraft Labor In-Cockpit Automation Systems more than two years ago.

That work also is laying the foundation for optionally piloted operations using the Future Long-Range Assault Aircraft that is built around the Bell V-280 Valor second-generation tiltrotor and eventually due to replace the Black Hawk.

The U.S. Army has taken delivery of the first T901 engines to advance the eventual reengining program for the UH-60 Black Hawk.

The Army's new aviation plan also canceled the Future Attack Reconnaissance Aircraft, which would have taken the role of U.S. Special Operations Command's MH-60 Direct Air Penetrator (DAP). This means the Army's 160th Special Operations Regiment will keep flying the DAP—a heavily armed version of the Black Hawk—longer than planned. Some expected DAP upgrades include a new inlet barrier filter, installation of the RTX Silent Knight terrain-following radar, a new nose door, improved sensors and communications upgrades, and modernized armor. The 160th's Black Hawks are the only variants of the type with the GE YT706 engine, and Special Operations Command is looking for ways to improve its reliability and efficiency.

As part of the Army's overhauled aviation plans, the service is planning another multiyear buy of Black Hawks. It could cover as many as 255 helicopters starting in 2027,

according to a July announcement. That order would add to a lengthy backlog for Sikorsky, which includes new UH-60Ms for Australia and MH-60R orders from Norway and Spain, along with additional HH-60Ws for the U.S. Air Force and potentially new MH-60Ts for the U.S. Coast Guard.

The Black Hawk also remains popular abroad, despite its age. This year, Sweden said it would buy a dozen UH-60M Black Hawks, adding to the 15 already in service, as the country looks to phase out the European NHIndustries NH90 tactical transport. Greek lawmakers also this year approved the purchase of 35 Black Hawks, and Austria signed a contract for a dozen of the rotorcraft over the summer.

Ubiquitous Lift

- THE PENTAGON IS THE LARGEST BLACK HAWK CUSTOMER
- USE CASES INCLUDE ANTI-SUBMARINE WARFARE AND COMBAT SEARCH-AND-RESCUE

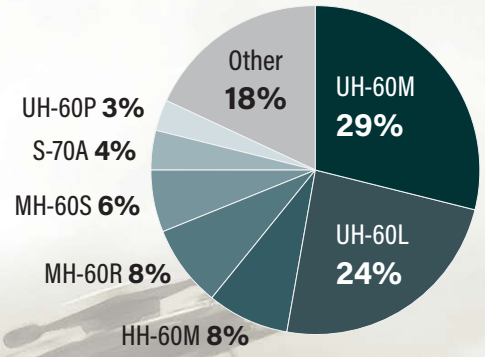
Craig Caffrey London

When the U.S. Army began developing a new utility helicopter in the late 1960s, the program faced the unenviable task of replacing arguably the most storied rotorcraft to date, the UH-1 "Huey" of Vietnam War-era fame. While Bell Textron's UH-1 still holds a sales lead over what became the UH-60 Black Hawk, the Sikorsky helicopter—now owned by Lockheed Martin—has surpassed its predecessor in other ways. Its use cases span troop transport, submarine hunting, special operations and armed assault.

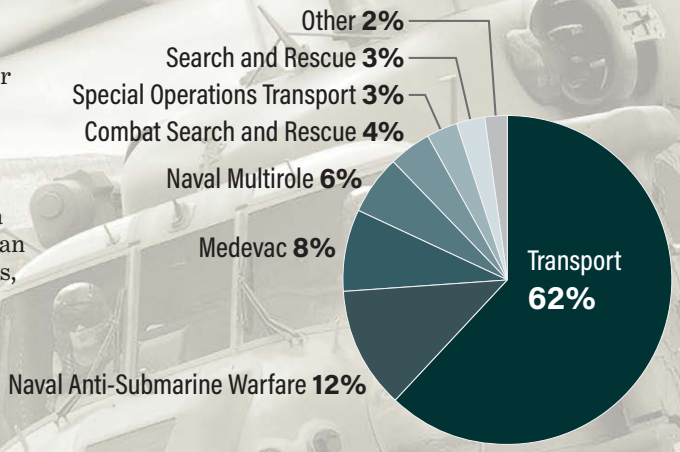
Despite being developed by the Army, the H-60 is also the most numerous naval helicopter in service around the world. While the Defense Department remains the type's heaviest user 50 years in—with the Army, U.S. Navy and U.S. Air Force embracing the platform for a myriad of applications—the Black Hawk also has won a loyal and growing customer base abroad. With an orderbook that is likely to stretch into the 2030s, there is every chance its global footprint may expand further in the coming years.

Black Hawk Global Fleet

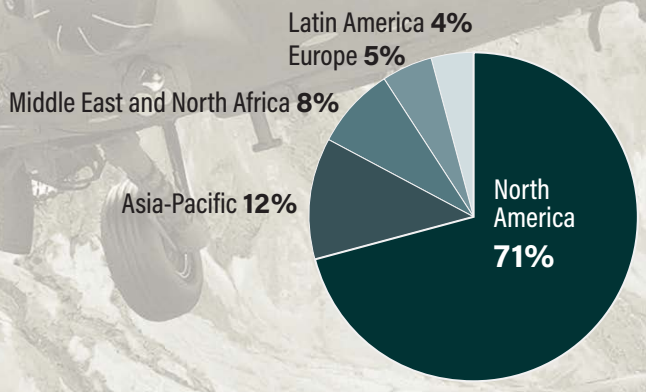
By Type



By Mission



By Region



Biggest Black Hawk Fleets

By Operator Country

Source for all charts: Craig Caffrey/Aviation Week Intelligence Network

BACKGROUND IMAGE: LOCKHEED MARTIN

Spinoffs and Specialties of Sikorsky's Black Hawk

- THE COMPANY IS CONTINUING MATRIX DEVELOPMENT WITH THE UH-60 DEMONSTRATOR
- THE AIRFRAME APPEARS TO HAVE INSPIRED CHINESE Z-20 HELICOPTER DESIGN

Tony Osborne London

Since its first flight in 1974, Sikorsky's S-70/UH-60 Black Hawk has spawned dozens of variants and is as famous and ubiquitous as the aircraft it was designed to replace, Bell's UH-1 Huey.

Thousands of Black Hawks have served and continue to do so in a multitude of missions across the globe—from battlefield logistics hauler and aerial firefighter to armed gunship and extractor of special forces behind front lines.

Adapted models such as the SH-60 Seahawk hunt submarines from aircraft carriers and warships. A commercial version, the S-92, that uses essentially the same dynamic system as the Black Hawk but with a new airframe, flies everyone from petroleum workers to world leaders.

The Black Hawk's design has also inspired imitators, with the airframe of China's Harbin Z-20 platform a clear example. The People's Liberation Army used the S-70 extensively from the 1980s until military exports to China were halted.

Throughout its life, this rotary-wing workhorse has also been adapted to test and prove technologies—some publicly, others less so.

Here are some of the more interesting Black Hawk modifications, trials, developments and spinoffs that have piqued Aviation Week's interest over the years:

Robot Hawk For the last decade, Sikorsky has been considering putting a switch in the Black Hawk cockpit labeled 2-1-0—two pilots, one or none. It was finally able to make that happen in 2022 with the Matrix technology, demonstrating it for DARPA's Aircrew Labor In-Cockpit Automation System (ALIAS). After dozens of flight tests with a safety crew onboard, Sikorsky demonstrated a fully autonomous mission from engine start and takeoff to mission, then landing and engine shutdown. Controlled from a tablet computer, the autonomy software can follow a preplanned mission but is able to handle contingencies and replan the flight to avoid obstacles and threats detected by onboard sensors, such as lidar.

Sikorsky has fitted the Matrix system to a UH-60A and an S-76, and the technology has also been tested on fixed-wing aircraft such as the Cessna Caravan and the ATR 72.

Stealth Hawk Mystery remains about the mysterious remains left behind in Abbottabad, Pakistan, after Operation Neptune Spear, which killed al-Qaida leader Osama bin Laden in May 2011. Special forces destroyed much of the wreckage of the highly modified stealthy Black Hawk that crash-landed into bin Laden's urban compound, but they left behind the tail rotor, stabilizers and part of the tail boom, which revealed the extent of the modifications made to the aircraft. While efforts to reduce the radar cross-section of rotorcraft are not new, the extent of the modifications on the Abbottabad Black Hawk were much more extensive than those seen previously on types such as the Boeing-Sikorsky RAH-66 Comanche.

Since then, little has been heard of low-observability efforts around the Black Hawk, except for publication of imagery online of what could be an early iteration, albeit focused on electronic warfare. That aircraft featured extensive modifications to the upper fuselage and main rotor head to reduce radar reflections (*AW&ST* May 16, 2011, p. 34). While such technology is unlikely to find widespread use, it showed that such modified helicopters could still be used in extreme high-threat environments.

Radar Hawk In the late 1970s, the U.S. Army's Standoff Target Acquisition System aimed to develop an airborne radar to detect ground targets on the battlefield. This system, then being developed by Motorola, would be carried by a heavily modified Black Hawk with a large rotating antenna beneath the fuselage. Plans called for the purchase of some 120 EH-60s equipped with the system. However, cost increases with the radar system resulted in the project's termination in 1981. Considerable lessons nonetheless were learned for the next generation of ground-moving-target-indicator-equipped (GMTI) aircraft, including the Northrop Grumman E-8 Joint Stars aircraft, which was in U.S. Air Force service until last year.

AVIATION WEEK ARCHIVE

The U.S. Army wanted to adapt the Black Hawk to carry a GMTI radar developed by Motorola, as this artist's concept from the late 1970s illustrates.

Turkish Hawk When describing the international footprint of the Black Hawk program, Lockheed Martin executives refer to its production in the U.S. and Poland, but rarely do they mention Turkey. Turkish Aerospace Industries assembles a Black Hawk called the T-70 that is equipped with a locally developed avionics suite and self-defense systems. The T-70 is also being equipped with locally assembled landing gears, gearboxes and dynamic components. Some 109 are supposed to be built in Turkey, with 38 already built or in assembly. However, license approvals for the balance are being withheld due to sanctions over Turkey's acquisition of a Russian air defense system.

Widespread Drone Ops Drive U.S. Army Airspace Reforms

> POLICY AND TECHNOLOGY CHANGES ARE UNDER REVIEW

> A PERMISSIVE DRONE LAUNCH POLICY IS FAVORED

Steve Trimble Washington

Part of the U.S. Army is trying to determine how to field thousands of hand-launched drones and ground-launched effects to small units as quickly as possible. Another part of the Army is meanwhile grappling with the resulting challenge to airspace management.

The U.S. Army plans to field thousands of small hand-launched drones, such as the Skydio RQ-28A short-range reconnaissance quadcopter.

WAYNE V. HALL/PENNSYLVANIA NATIONAL GUARD

"I think the one thing for me, in the short time that I've been back in Army aviation, that concerns me is our airspace management," Maj. Gen. Clair Gill, commander of the Army Aviation Center of Excellence, said at the Association of the U.S. Army's Hot Topic seminar on army aviation in Arlington, Virginia, in September.

The skies above future battlefields will be crisscrossed by drones and other autonomous flying platforms launched by every echelon, from privates at the platoon level to generals at the division level.

"As I think about putting manned systems in that airspace, we've got a real challenge," Gill said.

To be sure, the Army knows how to safely operate uncrewed aircraft systems (UAS) and crewed helicopters, thanks to its more than two decades of experience in combat. But the volume and diversity of future platforms, along with a permissive approach to operations, creates a completely different problem than Army aviators faced in the past.

Traditional airspace management procedures are highly restrictive to drone operators on the battlefield. "I'd have to call up a [restricted operating zone coordinator] and then take a nap until my airspace was approved," Col. Nick Ryan, the Army's UAS capability manager, quipped at the seminar. "Then I could put [the UAS] up in this tiny little constrained area just to maybe look over that tree, and then I have to bring it back down immediately."

Lessons from the wars in Ukraine and around Israel suggest that such safety-driven restrictions are obsolete.

"They are free to shoot whatever they want, launch whatever they want, because that's as fast as they're seeing targets," Ryan said. "And if they don't, either that target is going to move or they're going to be targeted and shot before they can do something about it."

Likewise, the Army's small units will need a similar, permissive approach to airspace access for small drones and launched effects, he noted.

But battlefield airspace could become even more complicated. Army aviation crews flying at low altitudes in helicopters will have to worry more about collision threats than friendly drones.

"We're talking about us launching our systems," Anthony Crutchfield, Boeing vice president of army systems and a former Army aviation branch commander, said at the seminar. "I will tell you, there will probably be a lot more to worry about coming the other way, and we're not going to command and control that."

Some proposed solutions are circulating internally. Brig. Gen. Matt Braman, director of Army aviation, proposed a set of procedural reforms in August at the service's Aviation Industry Days Expo at Fort Novosel, Alabama.

Braman's proposal divides the airspace into five levels. At the lowest, the Army's crewed rotorcraft would operate from the surface to 150 ft. above ground level, where they are least exposed to enemy detection.

Above that are three layers of airspace categories for UAS and loitering munitions. The smallest UAS would operate in a layer 150-1,000 ft. above ground level. Tactical UAS and loitering munitions would roam the skies at 3,000-8,000 ft. Larger UAS, such as an AAI RQ-7 Shadow, would take a slice of airspace at 8,000-10,000 ft. General Atomics Aeronautical Systems Inc. MQ-1C Gray Eagles would occupy the airspace at 20,000-24,000 ft. The proposal also splits airspace above 20,000 ft. with crewed Air Force and Navy combat aircraft.

These procedural controls would be augmented by new technologies, such as DARPA's Air Space Total Awareness for Rapid Tactical Execution flightpath planning software and the Army's Integrated Mission Planning and Airspace Control Tools software suite, Braman said. Eventually, these tools—combined with autonomous see-and-avoid technology on future UAS—would evolve airspace management from a deconfliction approach to seamless integration, he added.

Braman's proposal is a starting point. As major UAS, loitering munition and launched-effects programs move forward, the Army intends to use procedures and technology to transform airspace management radically.

"We're flipping everything on its head, including how we envision the future of airspace management, airspace integration and trying to make it as permissive as possible, still within how the Army would do it," Ryan said. "So that private who needs to launch a drone to do something in that moment before the target moves has the ability to while we're still protecting the manned assets, which are our most critical assets, that are flying through the air."

ASTROSCALE U.S.

Why Orbital Maneuvering Is Top of Mind at U.S. Space Command

> SATELLITE MISSIONS ARE COMPROMISED BY FUEL SUPPLY

> REFUELING AND ADVANCED PROPULSION TECH IS STILL YEARS AWAY

Vivienne Machi Los Angeles and **Robert Wall** London

Western military space leaders are waking up to an uncomfortable reality: On-orbit threats to their space systems are here, but the ability to counter them may be a decade away.

Beijing has demonstrated proximity operations around some of its defunct spacecraft and operational Western satellites, military and civilian officials say. China also has launched satellites with robotic arms that the U.S. Defense Department has warned could be used to engage other spacecraft. Moscow has performed "nesting doll" operations where a smaller spacecraft emerges from a main satellite.

"We now face concurrent and accelerating threats in, from and to space," Gen. Stephen Whiting, leader of U.S. Space Command, warned at the Defense in Space Conference in London in late September.

Whiting and other Western space leaders are calling for greater investment in "dynamic space operations" to monitor spacecraft better in nonstandard orbits and thwart a potential adversary's ability to track, target, disable or defeat friendly assets. France is also pursuing in-orbit maneuvering systems to safeguard its satellites, and Germany is considering a similar effort (*AW&ST* Sept. 30-Oct. 13, p. 21)

The U.S. Space Force for about a decade has been operating the Geosynchronous Space Situational Awareness Program satellites, which are capable of sustained maneuvering on orbit and are designed to help the Defense Department track human-made objects in space more clearly than is possible from the ground. But the once-classified spacecraft are constrained by a limited fuel supply, and one satellite reached the end of its lifespan and was deactivated in 2023.

The Space Force "must operate until missions are complete, not until the fuel we launched with is depleted," Whiting said.

Space Systems Command has made "a modest investment" into space mobility and logistics capabilities, says Lt. Gen. Philip Garrant, the command's leader. It plans technology demonstrators to help inform requirements for dynamic space operations systems that can "maneuver without regret," he said in a Sept. 18 media briefing.

The Space Force has tapped Astroscale U.S. to build a prototype satellite that could refuel other spacecraft on orbit.

In 2023, the command awarded Astroscale U.S. a $25.5 million contract to develop and build an in-space refueling spacecraft with a demonstration planned for 2026. The vehicle is being designed to travel directly to geostationary Earth orbit (GEO) with a full fuel load and would transfer hydrazine to a client spacecraft.

But Space Systems Command sees a 5-15-year gap before satellites can independently maneuver on orbit, Garrant said. In the meantime, he is focused on retrofitting legacy spacecraft to make them more resilient, "before these systems inherently do it themselves," he added.

For Whiting, as a combatant commander, that is too long. "We need these systems delivered on accelerated timelines at scale," he said, noting that on-orbit refueling and advanced propulsion technologies are already showing promise.

"I certainly recognize building some of those capabilities at scale and across multiple constellations will take years," he told reporters. "But we think there might be opportunities earlier than that to help us to have sustained space maneuver."

Currently, the orbital regimes where satellites operate—in low Earth orbit (LEO), medium Earth orbit and GEO—are distinct, Whiting said. But future threats will maneuver between them, he added, requiring new ways to respond. That is not a trivial technical challenge. LEO satellites operate at altitudes of around 300 mi., and those in GEO orbit at more than 22,000 mi.

The Space Force's Commercial Space Office is seeking options for maneuverable satellites that can operate in GEO and plans to release a request for proposals in early 2025.

The program is modeled after a similar effort to procure commercial satellite communications (satcom) services in a proliferated LEO constellation, Col. Richard Kniseley, who oversees the project, told reporters during the Air and Space Forces Association's Air, Space and Cyber Conference outside Washington. It is open to mission areas including satcom; position, navigation and timing; and weather assets.

The Defense Department is also modernizing ground systems to enable future dynamic space operations. The Space Rapid Capabilities Office (RCO) is investing $1 billion over the next 5-7 years in a cloud-based infrastructure to replace two legacy platforms built to support positional satellites: the Enterprise Ground Services and the Ground Command, Control and Communications systems.

The Space RCO established the Rapid Resilient Command and Control (R2C2) program in February 2023 in partnership with Space Systems Command, which will primarily support new satellites built to protect and defend on-orbit assets, Col. Greg Hoffman, senior materiel leader for the office's space acquisition delta, tells Aviation Week.

"Some of those satellites will have to move dynamically," Hoffman says. "Sometimes they might flee or scoot. Sometimes they might move into a protection scheme. R2C2 is what enables that."

The effort has resulted in a prototype that was built early this year. That infrastructure transmitted 11 commands to an on-orbit Space Force satellite in August, with each command acknowledged by the spacecraft. It also demonstrated rendezvous and proximity operations in a simulator.

Through R2C2, the Space RCO wants to acquire software systems in bite-size pieces for regular delivery of satellite operations capabilities to on-orbit mission partners. It is scaling that capability and recently awarded 20 small businesses a cumulative $12 million in initial delivery orders to help awardees familiarize themselves with the current prototype's architecture and government processes.

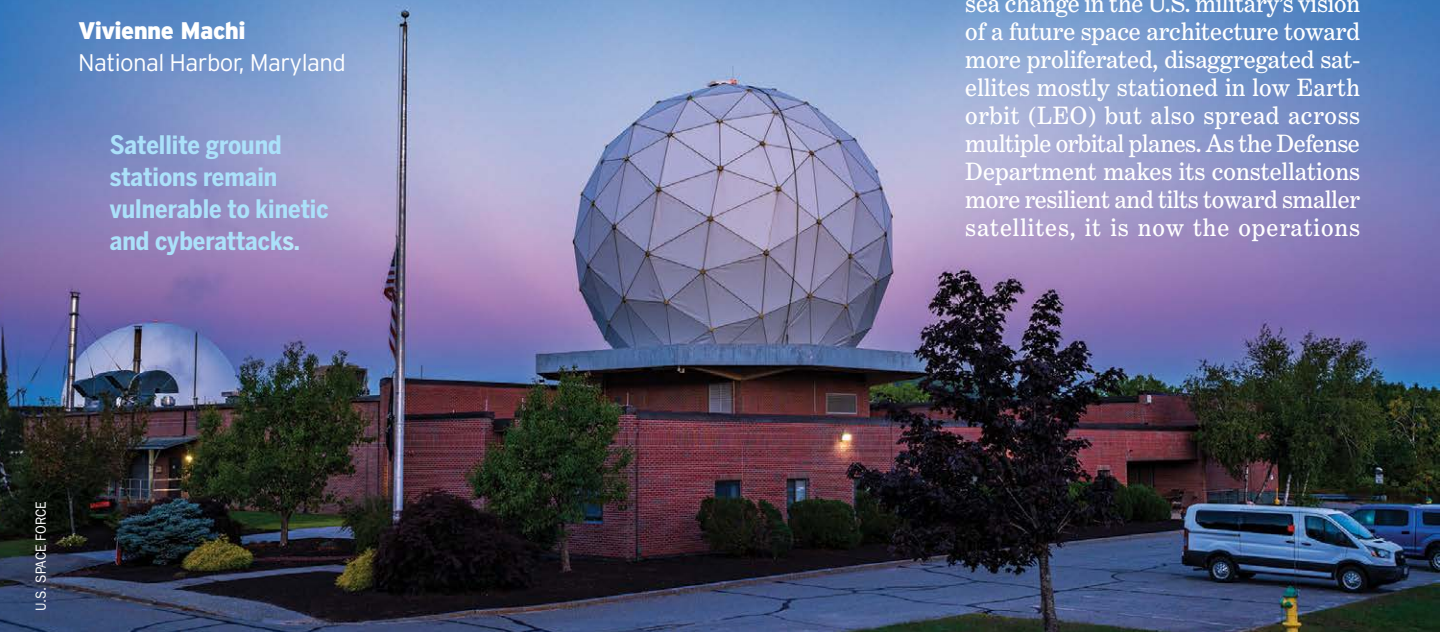
The ground system is scheduled to transition out of prototyping and support limited on-orbit operations in the spring of 2025, Hoffman says.

How the Satellite Industry Envisions More Resilient Ground Stations

- PROLIFERATED CONSTELLATIONS DRIVE THE NEED FOR RESILIENT GROUND STATIONS
- SYSTEMS INCLUDE MOBILE TERMINALS, ON-ORBIT PROCESSORS

Vivienne Machi
National Harbor, Maryland

Satellite ground stations remain vulnerable to kinetic and cyberattacks.



U.S. SPACE FORCE

At the 2017 Halifax International Security Forum, then-Air Force Gen. John Hyten asserted that as head of U.S. Strategic Command, he would no longer support the development of spacecraft that he considered "large, big, fat, juicy targets."

With those words, he launched a sea change in the U.S. military's vision of a future space architecture toward more proliferated, disaggregated satellites mostly stationed in low Earth orbit (LEO) but also spread across multiple orbital planes. As the Defense Department makes its constellations more resilient and tilts toward smaller satellites, it is now the operations

centers back on Earth that make juicy targets for kinetic or cyberattacks.

"If you look at our architecture, one of the big focal points is the ground stations," Rob Atkin, vice president of classified space systems at General Atomics Electromagnetic Systems Group (GA-EMS), said on Sept. 16 during a panel discussion at the Air and Space Force Association's Air, Space & Cyber Symposium here. "We have very few of them. Everybody knows where they are. They are obvious targets. You take those out, we're sort of hosed, right?"

General Atomics is building a radio frequency ground station in a "nontraditional location" in the continental U.S. to support spacecraft that it is building for a government customer and that are scheduled to launch in 2025, Gregg Burgess, GA-EMS vice president for space systems, tells Aviation Week. The company invested its own capital in the ground station and developed the requirements to place it in that specific location, in part to avoid interference with other operations, Burgess says.

But General Atomics is also developing transportable optical ground terminals for sea and land. "While they will take a bit of infrastructure to put in, they can be moved to different locations, [and] they're relatively affordable," Burgess says. "Once we've developed the first one, we could manufacture them in quantity to provide diversity of location."

Burgess says the company's internal investments are responding to the U.S. government's expansion into optical communications in space. This is most visible in the Space Development Agency effort to field a proliferated, interconnected LEO satellite constellation as well as in the Space Force's enterprise space terminal program, in which General Atomics is one of four vendors developing a laser communications terminal prototype that could go on future U.S. military spacecraft.

Lockheed Martin's approach to ground system vulnerability is to move more operations onto spacecraft. The company is developing a satellite operations center with both ground and on-orbit data-processing capabilities and produced a high-fidelity digital testbed that includes flight-representative hardware and real operational processing, says Paul Koether, tactical space program director at Lockheed Martin Space.

The testbed will help transition missions with legacy ground systems to cellphone levels of processing and help troubleshoot problems inherent to proliferated systems prior to on-orbit deployment, he says. The defense prime is currently ground-testing the system.

Companies expect ground stations will proliferate and have smaller footprints.

U.S. NAVY

"It allows us to model [intelligence, surveillance and reconnaissance] systems and do the onboard processing, the real-time tracking and the data-sharing between those nodes like they were a constellation in space," Koether says.

Lockheed Martin plans to deploy this capability onto current programs of record that involve proliferated satellite constellations, he adds.

Moving more of the control segment into space helps address ground station vulnerabilities to cyber and kinetic attacks and potentially reduces the scope of personnel needed to operate the site, he says. It also supports a smaller, more distributed operational footprint on Earth.

Lockheed packed the testbed onto a single server rack and performed simulations of sensor orchestration at the July 29-Aug. 13 Pacific Dragon exercise, Koether says. The biennial exercise, hosted by the U.S. Navy 3rd Fleet around the Hawaiian islands, sought to improve coordination among participating forces in tracking and intercepting ballistic missiles.

Kratos Defense approaches ground station resiliency from two angles: adding a proliferated network of sites with smaller footprints and building a lower-cost capability than the traditional large antennas, says Robert Winkler, vice president of corporate development and national security programs.

"You can take an antenna, put it on a 7-Eleven somewhere and start controlling satellites with it," he says. "That ability to democratize the telemetry, tracking and command capability, by leveraging the cloud in particular, opens up a lot of avenues." The company also provides traditional antennas with the same proliferated ground station.

Kratos has developed OpenSpace, a fully virtualized ground system capable of remote operations with the same connectivity levels to perform data transfers or telemetry, tracking and command operations as one with a fixed location. The system has been demonstrated onboard a company Humvee and can be strapped on a tactical vehicle, placed inside a tent at a forward operating base or attached to the back of a CONEX box, Winkler says. "It has an antenna on the top of it, and it's running the same stack as you would get out of either a commercial or a military teleport, wherever in the world," he says.

The UK Raises the Bar on Its Military Space Ambition

- CHINESE SPACECRAFT MANEUVERED NEAR A BRITISH SKYNET MILITARY SATELLITE
- CONTRACTS ARE IMMINENT FOR JUNO AND OBERON DEMONSTRATION SATELLITE

Robert Wall London

The UK is revamping its military space efforts as it tries to become a bigger player in the domain despite a challenging fiscal environment.

The changes are spurred in part by the growth in more affordable low-Earth-orbit satellite offerings and by a sense of urgency as space becomes a more contested realm.

The UK's military space roots date back to the days of the Moon landing, albeit largely focused on communications. But by 2022, the UK said it aimed to become a "meaningful space power." Maj. Gen. Paul Tedman, head of the UK Space Command, says the armed forces are raising the bar, with the ambition "to become a competitive space power." Such an approach will require "more resilient architectures, disaggregates, dispersed," he said at the Defense Space Conference 2024 in London.

SURREY SATELLITE TECHNOLOGY LTD.

The UK launched the Tyche Earth-observation demonstration satellite on a SpaceX Falcon 9 in August.

Air Chief Marshal Rich Knighton, UK Royal Air Force chief of the air staff, echoed the message. "Progress has not matched the rates of change we've seen from our potential adversaries, or frankly, our ambition," he said at the event.

The threat to vital UK space assets is growing, Knighton warned. On Aug. 10, a Chinese SY12-02 spacecraft maneuvered around the Skynet 5A UK military communications satellite and came within 116 km (72 mi.) of it, he revealed, adding that "this sort of activity is becoming increasingly common."

Although the UK tracked the threat, the incident highlighted that space control needs to be the top priority for the country's military space efforts. The country might need to establish what he called a space defense center to control, protect and defend space capabilities, he said.

The ambition comes up against a difficult financial reality. The UK has pledged to increase defense spending to about 2.5% of GDP, but what that will mean for space and other investments is uncertain amid a defense review that will not provide clarity for months. The government is also expected to conduct two wider spending reviews that will shape how much money is available for defense in the near term.

Some program decisions are already on hold pending the outcome of the review. The UK has embarked on a major overhaul of its military satellite communications. In March, the Babcock International Team Aurora took over running the Skynet program as the UK transitioned from a public finance initiative contract for Skynet 5 to the government-owned Skynet 6 program. The first of the Skynet satellites is due to be ready in late 2026 or early 2027, slightly slowed by supply chain issues, Barry Austin , the UK Defense Ministry's head of satellite communications, said at the Defence in Space Conference 2024 in September.

The UK is also in talks with Airbus and Lockheed Martin about either providing up to three wideband satellites, to be ready around 2030, or negotiating with sole bidder Thales Alenia Space for a narrowband satellite due for service entry in 2028-29. Plans are contingent on the outcome of the reviews.

The UK's nascent efforts to develop its own space-based intelligence collection, after decades of largely relying on close ties with Washington, are meanwhile reaching an inflection point. In August, the UK launched an electro-optical Earth-observation satellite, called Tyche, part of several low-Earth-orbit operational concept demonstrators.

A wideband radio-frequency (RF) detection satellite, Titania, is due for launch in the summer of 2025, missing its 2024 launch goal. Contract awards are due soon for the Juno satellite, an enhanced electro-optical satellite, and a cluster of 2-3 Oberon synthetic aperture radar (SAR) satellites.

The demonstrators are essential to the UK's Istari program to build the satellites and ground infrastructure for an operational system by 2031 to provide multisensor, wide-area Earth-observation capability. The goal is to have a constellation where RF satellites eventually could be used to cue SAR spacecraft or electro-optical ones to validate target information.

The Defense Ministry is nearing a "programmatic inflection point" that will guide funding decisions for the rest of the decade and thereafter, says Group Capt. Ben Sharp, deputy head of capability for intelligence, surveillance and reconnaissance at UK Space Command.

The UK will likely include commercial services in its architecture. Sharp said any acquisitions will go through spiral development to add new features as required; for instance, the UK has not made multispectral or hyperspectral sensing part of its ambition, though that could change.

A key point to developing and defining what comes next is likely to take place next year, when the UK Defense Ministry plans to convene an Istari gathering for early market engagement on its plans. Sharp said the UK would present the outlines of its technological and acquisition approach to the overall architecture to elicit industry feedback.

How the U.S. Can Stay Ahead of China in Space-Based Sensing

> REPORT SHOWS BEIJING IS LEADING IN MULTIPLE SENSING AREAS

> U.S. PROVIDERS SAY REGULATIONS MUST LOOSEN

Vivienne Machi Los Angeles

In May 2022, the National Reconnaissance Office awarded its largest-ever commercial imagery contracts, spanning 10 years and worth billions of dollars, to three providers.

The Electro-Optical Commercial Layer was lauded as a historic expansion of the agency's acquisition of commercial imagery. Two years later, as the National Reconnaissance Office (NRO) prepares to operationalize a new proliferated constellation of imaging satellites by December, commercial providers warn that a constrained regulatory environment is allowing adversaries to outpace the U.S. in remote sensing services.

The NRO has launched three out of six missions this year to build a new satellite fleet that will provide "reasonably high-resolution imagery of the Earth at a high rate of speed," NRO Director Chris Scolese said during an event at the Center for Strategic and International Studies (CSIS) in Washington on Oct. 3. The goal is to ensure the U.S. has persistent surveillance of any area on Earth, he stated. "Now you can't hide because you're constantly being looked at," Scolese added.

The NRO's investment in commercial imaging will augment this constellation and other agency assets, Scolese said. This mirrors investments across the U.S. defense sector in companies providing imagery, data and analysis from space-based assets.

But U.S. companies warn that the government's regulatory environment is putting a stranglehold on its ability to work with nontraditional partners, and that is causing it to fall behind adversaries like China.

A recently published report lays out the state of commercial remote sensing capabilities around the globe, rating publicly available services over 11 categories including electro-optical, synthetic aperture radar (SAR), hyperspectral, multispectral and infrared imagery. The top three services in each category were "awarded" Olympics-style medals in gold, silver and bronze.

The report— conducted by CSIS, Taylor Geospatial Institute, Taylor Geospatial Engine and U.S. Geospatial Intelligence Foundation—took inspiration from a similar Olympics-themed evaluation issued by the National Geospatial-Intelligence Agency in 2021.

PLANET LABS

Commercial remote sensing is one dimension of a broader space competition between the U.S. and China.

While not all-inclusive and only reflective of systems that were operating by July 1, the report paints a picture of how quickly China has caught up with the U.S. over the last three years: Beijing "won" 14 total medals, five of which were gold, while Washington won 12, four of which were gold.

"If there's no greater wake-up call to the U.S. and its allies, it's seeing the amount of Chinese flags up there on the medal list," Matt Tirman, president of Earth-observation provider Satellogic, said at an Oct. 1 CSIS event in Washington.

While the National Oceanic and Atmospheric Administration has implemented licensing reforms in recent years to allow U.S. companies to sell their products better overseas, national companies remain hamstrung by export control regulations that limit them from competing against Chinese offerings on the global market, providers said at the Oct. 1 event.

"The system that we could export today under the current guidelines, there would be no interest for that whatsoever," said Todd Master, chief operating officer for SAR provider Umbra Space. "It would be a very low-resolution system that would be irrelevant to most countries' interests."

The national security sector needs to consider commercial providers as more of "an early partner" rather than an add-on capability so those companies can invest in the areas with most demand, said Mark Mozena, vice president of government affairs for Planet Federal, a subsidiary of Planet Labs.

The Earth imaging provider, known for its Dove cubesats, recently launched two new constellations: one called Tanager, providing hyperspectral imaging, and a high-revisit, high-resolution fleet called Pelican.

"Those constellations, and the size at which we will build them out, will be dependent on the market signals that we receive and who sends us those market signals," Mozena said.

The real-time tracking of Russia's 2022 full-scale invasion of Ukraine demonstrated the value of commercial data and other space-based assets, and nations around the world are looking for sovereign capabilities or access to commercial services. "In the absence, sometimes, of clear demand signals from the U.S. government, then those are the ones that we will be designing to," Mozena said.

ULA's Vulcan Nails Cert-2 Orbit Despite SRB Nozzle Issue

- THE NEW ROCKET IS SET TO LAUNCH A PAIR OF GEO SPACE SITUATIONAL AWARENESS PROGRAM SATELLITES
- SIERRA SPACE'S DREAM CHASER RESCHEDULED FOR 2025

Irene Klotz Cape Canaveral, **Mark Carreau** Houston and **Vivienne Machi** Los Angeles

United Launch Alliance's new Vulcan Centaur rocket conducted an unintended extra demonstration of its capabilities during the second demonstration flight ahead of missions for the U.S. military.

UNITED LAUNCH ALLIANCE

ULA's second Vulcan Centaur rocket lifted off from Cape Canaveral SFS on Oct. 4.

About 12 sec. after liftoff from Cape Canaveral SFS on Oct. 4, the nozzle on one of the rocket's two Northrop Grumman Graphite-Epoxy Motor 63XL Solid Rocket Boosters (SRB) was released, resulting in a loss of thrust and a modest reduction in total impulse. Tracking cameras showed sparks and what appeared to be debris flying off the base of the right-side SRB about 37 sec. into the flight, followed by an immediate change in the shape of the booster's exhaust plume.

"It looks dramatic, like all things on a rocket," United Launch Alliance (ULA) CEO Tory Bruno wrote on social media site X after the launch. "But it's just the release of the nozzle. No explosions occurred.

"Nozzles can't really 'explode,'" he added. "They can liberate, as this one did. On a large, nonvectorable SRM [solid rocket motor], this results in a loss of thrust and a modest reduction in total impulse. [It] rarely presents any catastrophic risk to the SRM itself, because the pressure vessel is not involved."

The 72-ft.-long SRBs separated from the vehicle about 20 sec. later than expected, according to a prelaunch flight timeline, leaving the rocket's core stage—powered by a pair of Blue Origin BE-4 engines—to send the rocket beyond the atmosphere. Stage separation, ignition of the Centaur upper stage and shutdown after its initial burn likewise occurred about 20 sec. later than on the nominal timeline.

The SRB anomaly required the system to use less than 20% of the available performance excess allocated for mission contingency, ULA wrote in an email to Aviation Week. "Orbital insertion was perfect," Bruno noted on X.

The 202-ft.-tall Vulcan Centaur rocket lifted off from Space Launch Complex 41 at 7:25 a.m. EST to begin the Certification-2 (Cert-2) mission. Initially, ULA hoped the mission also would provide launch services for Sierra Space, which is preparing its Dream Chaser winged spaceplane for a debut cargo run to the International Space Station.

But the Dream Chaser would not have been ready to fly before ULA had to complete Vulcan certification in time for a higher-priority National Security Space Launch (NSSL) mission this year. Instead of the spaceplane, ULA flew a nondeployable, 3,366-lb. mass simulator outfitted with instruments to test technologies to expand the capabilities of the rocket's Centaur V upper stage, including the ability to support space operations lasting weeks to months. The Dream Chaser was rescheduled for launch on another Vulcan in 2025.

Cert-2 featured about 30 min. of Centaur V operations following first-stage separation, including a second firing of its Aerojet Rocketdyne RL10C engines that served to reorient the vehicle for a simulated primary payload release and to demonstrate the ability to restart in space—a requirement for upcoming NSSL missions. The Centaur V was then put into a solar-orbiting disposal orbit.

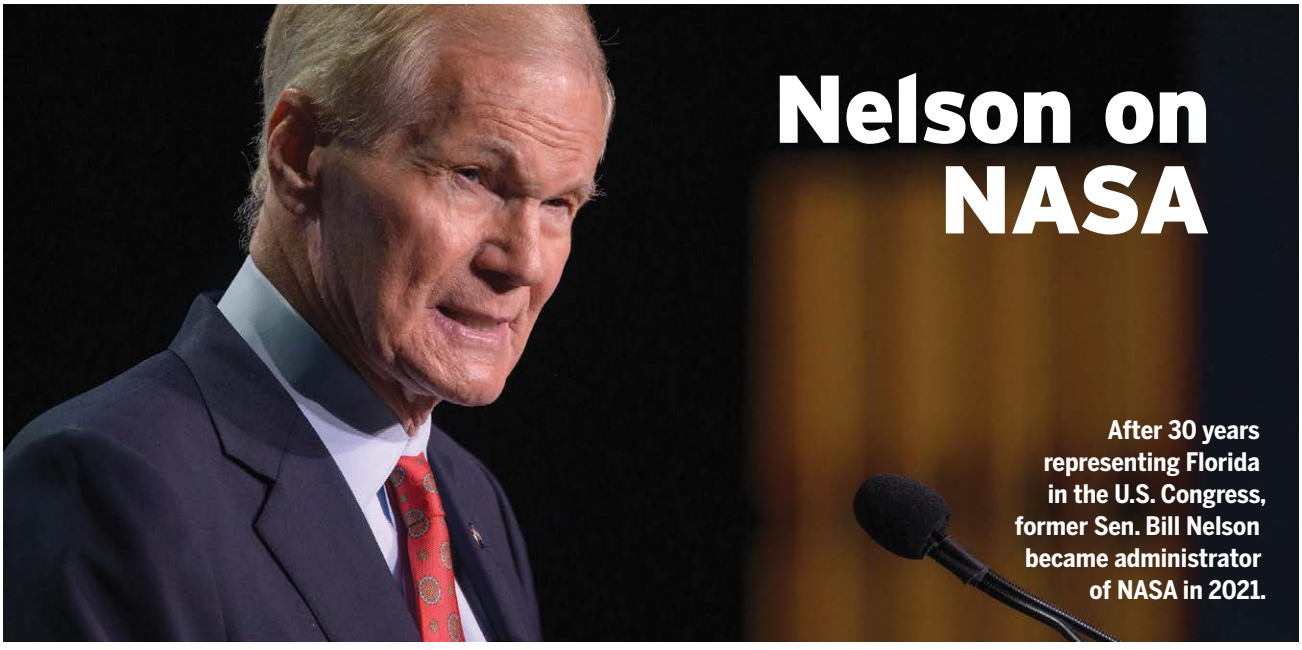
The company's initial assessment of Cert-2 operations is expected to take about two weeks. "The anomaly investigation is underway, and when the team determines root cause, we will assess mitigations required prior to next flight," ULA said.

In a statement after launch, Space Launch Delta Commander Brig. Gen. Kristen Leigh Panzenhagen, executive officer of the U.S. Space Force's Assured Access to Space program, said the service had started its review of Cert-2 performance data.

"We look forward to Vulcan meeting the certification requirements for a range of National Security Space missions," Panzenhagen said.

In the December time frame, Vulcan is expected to launch USSF-87 for the Space Force and carry two Geosynchronous Space Situational Awareness Program (GSSAP) satellites to orbit, according to the service's Space Systems Command.

The GSSAP sensors can characterize and inspect objects in geosynchronous Earth orbit to support missions including flight safety, freedom of navigation and on-orbit anomaly resolution. The U.S. military has launched six GSSAP spacecraft since 2014, one of which was deactivated in 2023 after reaching the end of its life span. Two additional space vehicles are scheduled to launch around 2027.



Nelson on NASA

After 30 years representing Florida in the U.S. Congress, former Sen. Bill Nelson became administrator of NASA in 2021.

BILL INGALLS/NASA

Like many at NASA, **Bill Nelson** has spent his career in public service. But unlike the engineers and scientists he oversees as agency administrator, Nelson spent the bulk of his 50-year career in the U.S. Congress, representing Florida in the House and later in the Senate. That, as well as a 1986 guest flight aboard space shuttle Columbia—the last mission before the Challenger accident—shaped Nelson's views on the changing international arena NASA now navigates and the agency's growing reliance on commercially provided services. Nelson, who has served as administrator of NASA since 2021, spoke with Aviation Week editors **Irene Klotz**, **Joe Anselmo** and **Michael Bruno** on Oct. 2.

AW&ST: **You've lived through the Cold War, the fall of the Soviet Union and the melding of the U.S. and Russian human space programs that culminated in the International Space Station (ISS) partnership. With the station operations due to end in 2030, what do you see happening in the future?** I have been very pleased about—but also very sensitive to—how it is good for our two countries to have a point of contact where we are working cooperatively together and have been ever since 1975 with the Apollo-Soyuz mission. There is value in continuing that. With the ISS, clearly that is a necessity because you can't operate the station unless you've got the Russians and the Americans working together. It has kept us together under very difficult circumstances, with [Russian President Vladimir] Putin rampaging all over Ukraine. Am I concerned in 2024 for something that is going to occur when the ISS program ends? I have a lot to think about, and I'm not worrying about that.

The ISS recently hosted the Boeing CST-100 Starliner Crew Flight Test. Considering the problems the program has encountered, do you think NASA could have done something differently so that 10 years down the road Boeing would not still be trying to get this vehicle operational? Well, I bear some of the responsibility because [former U.S. Sen.] Kay Bailey Hutchison and I are the authors of the 2010 bill that set up the commercial program of NASA. That was very successfully implemented with the SpaceX Falcon 9 and Dragon, though they had their rough starts to begin with as well. That's part of bringing a commercial aspect to NASA spaceflight—you allow room for the creativity, ingenuity and outside expertise of private industry to get in the mix, with NASA overseeing it. That approach worked very well with SpaceX and then had some hiccups with the Boeing Starliner. This has been an evolutionary process, the creation of a new kind of relationship—like our international participation and partnerships, such as the lunar pressurized rover with Japan and the different components on the Gateway [planned lunar-orbiting outpost in support of the Artemis program]. That helps offset the cost.

Is NASA getting its money's worth for what it has invested in the Starliner program? As soon as it becomes operational, we will. I gave the new Boeing CEO, Kelly Ortberg, a courtesy call before we publicly announced the decision to fly Starliner home without crew. I wanted to be straight up with him and also get a sense from him about their willingness to continue.

I do believe he's going to continue on the Starliner. And of course, we need that second access to space.

Traditionally, NASA has operated big programs under cost-plus-award fee contracts, which support the NASA workforce and some of the field centers. Does that need to change? Do you need the standing armies and the multibillion-dollar Artemis architecture in this new era of emerging capabilities in the private sector? We are trying to make an arrangement with commercial and international in a way that was never contemplated before. It has worked very well with the SpaceX Falcon 9, and we have optimism on the commercial lunar landers. It's not a black or white answer to your question. It's an evolutionary concept of trying something new which will be more efficient, cost less and be faster, and if we get anywhere near that, then we've succeeded.

Is the Artemis architecture flexible enough to stand down from the Space Launch System (SLS) rocket and Orion spacecraft if SpaceX's Starship becomes an operational system? You are making an assumption that I do not agree with: that these private companies will replace NASA and Artemis.

If they can do the job with less money and less overhead, should they? All I know is there is only one [Moon-/Mars-class] rocket flying and that is the SLS. The others are not off the ground and haven't orbited yet, so I've got to take it one step at a time. Go back to commercial crew and cargo to the space station. SpaceX would never be where it is had it not been for NASA, which made investments early in the program and as SpaceX was blowing up Falcon 1s. I don't see the implied question you posit coming into being—and if it does, it'll be several years down the road. By then, things will have evolved and matured, and who knows? At that point, we may be building the big propulsion system to take us to Mars.

How and when do you see NASA making the kind of structural change, if need be, to adapt as the years and decades go on? As a far-reaching, far-sighted analogy, NASA has already demonstrated that and so much in science and exploration, such as the James Webb Space Telescope and the two dozen climate spacecraft that are giving us a composite understanding of what's happening to the Earth and its climate. NASA has been way out in front of a lot of others.

Now, having said that, change is hard, but you see the changes that are occurring. Take the last Norm Augustine report—he's done three of these, and Norm knows what he's talking about. He basically said that if NASA were a business, what it is doing is preparing itself to go out of business. Why? Because we're not investing in the infrastructure and in the people the way we should.

We are taking immediate steps to turn that around. I go up to the Hill and I beg for $5 billion worth of infrastructure, and I don't get it. The only way I get it is when a storm happens and the roof is leaking. NASA is saved right now by virtue of people wanting to work here. People will come here and stay because of the work environment that they love. But for the future, you've got to invest in your people, and you've got to change some of these old buildings that are being patched with chewing gum and baling wire.

Do you think the election will affect the budget environment that NASA now finds itself in? Absolutely, but I'm not going to get into partisan politics. NASA is a nonpartisan place. In that respect, we're like the Defense Department. I serve at the pleasure of the president.

Is NASA doing enough to help the aviation industry with its sustainability challenge? We're doing what we can with a budget that's only about $1 billion per year. I think we're showing some promise with the high fuselage and thin wing, which brings you efficiencies of flight. You can put a bigger fan jet engine, and between the two you should be able to get about 30% fuel savings. That will be huge on the most trafficked mid-range, single-aisle commercial airliner. We put in more money than Boeing did on this, the X-66. The same with our financial incentives to [electric vertical-takeoff-and-landing vehicle] startups. Combined, these projects are going to give us what some call sustainability. I call it greater efficiency of aircraft so that you rely less on fossil fuels.

"NASA is saved right now by virtue of people wanting to work here."

Is the X-59 going to fly this year? It should. I haven't heard that it's delayed. It's been behind schedule.

Does China represent a threat to U.S. leadership? Chinese supremacy is what they're trying. In the South China Sea, China is going into other peoples' territorial waters—including the Philippines'—and paving runways and digging out harbors for their military ships and suddenly claiming that that is theirs. I don't want that to happen on the south pole of the Moon. I don't want China to get there before we do with astronauts and as a result say, "This is ours, stay out," when, in fact, if we have found water in abundance it becomes a very valuable resource on the Moon.

Do you think that could happen? Do you have confidence that NASA, with Artemis II and III and the whole lunar architecture, will be able to have that kind of presence on the Moon ahead of China? Let me separate that into two questions. First question is: "Do I think that China will try that?" I've always found that you can tell about where a fella is going knowing where he's been, and China has clearly stated that modus operandi. Your second question is: "Are we going to make it to the south pole of the Moon before China?" The answer to that is "yes."

Do you have any schedule concerns over Artemis III being dependent on unproven systems such as the Human Landing System (HLS)? I have a lot less concern

after the very successful flight of Artemis I, but of course I have concerns about the schedule. There are some things that are out of our control and in the private sector itself. For example, some of the HLS delay is when Blue Origin loses the first round of competition and then sues. That delays everything for six months. There are delays with some of the environmental concerns and the fact that maybe the FAA doesn't have enough people to process everything that's on their plate. That causes delays on the new [HLS] Starship and its development. The FAA is even questioning the primacy of the space mission for Launch Complex 39A at Kennedy Space Center. I've read the law, first passed in 1972, as well as the legislative congressional intent that says the space mission is the prime mission. Others defer to that. That is written in the law.

Does that have any implications for the environmental issues SpaceX is facing in Boca Chica, Texas? I'm not mixing the two in my description here. Hopefully for flying Starship at 39A, that is going to be resolved pretty quickly if they'll go and read the law. But it's another example about delays.

Do you have any concerns about the state of the commercial space industry? Do you think it's healthy? There are going to be starts and stops, and there already have been. This is what startups are all about, particularly startups that don't have a billionaire behind them. It's part of the free market. This is to be expected.

Do you have any concerns about the supply chain feeding into NASA, not because of startups, but just in general? The short answer is "no," and the longer answer is, "why?" Because if there is a business case to be made, it will come.

What about in cases where there's not a business case, like for the Mars Sample Return mission? It is the responsibility of government to go and retrieve the samples and to continue to search for life. That is a financial responsibility of the government. The problem was that what the agency had come up with to do Mars Sample Return was going to break the bank, and it was going to be way too late. It was going to cost $11 billion, and we weren't even going to get the samples back until 2040, and so I pulled the plug on it. I made that decision thinking that what we could do is go out to the centers, private industry and universities and generate new ideas for how you could get the samples back earlier and cheaper than $11 billion. I think this might end up being a win-win.

Would you be willing to try that same approach to the goal of sending astronauts back to the Moon? See if industry has other ideas of how to accomplish that without the price tag of the SLS, Orion and Gateway? We have plenty of incentive to send astronauts to the Moon to prevent any competitors from suddenly getting there and saying, "This is ours."

Let's try this again: In these days of precious budget dollars, are you OK with how much NASA is spending on the SLS, Orion and Gateway programs for Artemis? I wish it could be cheaper, but when you develop technology to do hard things, it's going to cost money. I'm always looking to how we can do it cheaper, and that was one of the ideas that Kay Bailey Hutchison and I had in 2010 to get commercial partners—so that you could share the ingenuity, the ideas and the cost. That's also why we are reaching out into the international community to share the ideas and cost on Artemis, such as the Japanese rover, parts of Gateway and the European service module on Orion. There are other reasons also, such as bringing people together across international boundaries.

WANG QUANCHAO/XINHUA

There was a time that working with the Soviet Union and then Russia seemed inconceivable. Do you imagine that we'll ever get to the point where China and the U.S. will cooperate in space more than what is going on now? I hope so, but right now they've pretty well expressed their intent—and usually when they express it publicly, they end up doing what they have expressed. Their actions in the Indo-Pacific theater are another indication.

You've had this long career associated with space. Are you disappointed that the last 25 years have been more about evolution than revolution? I'm exhilarated. I'm very fortunate as a country lawyer to be given some measure of leadership over a bunch of wizards.

NASA Unfurls and Tests Its Newest Solar Sail

> NOAA IS INTERESTED IN A "SPACE WEATHER BUOY"

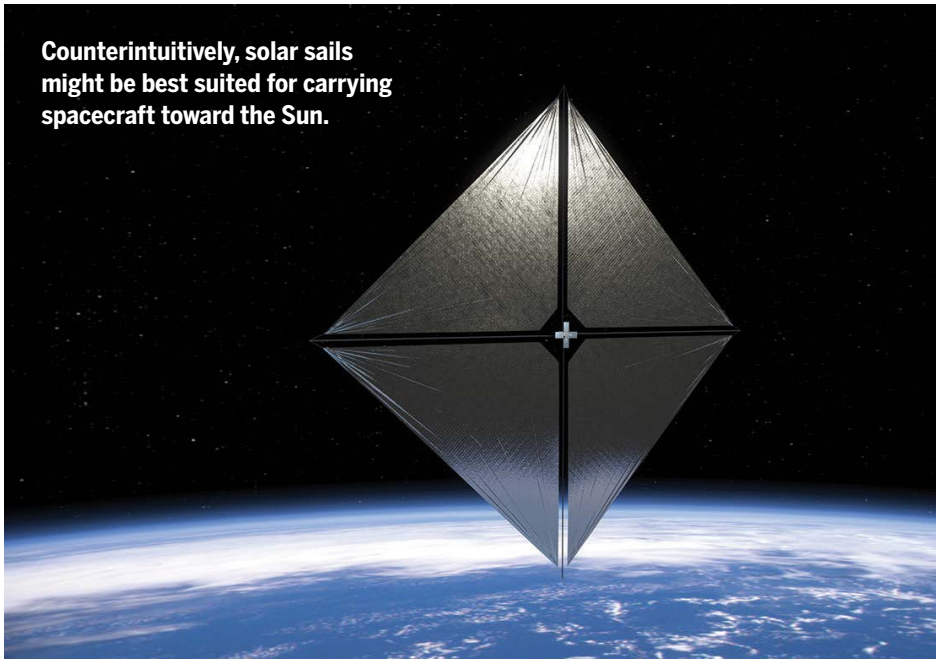
> THE PROPULSION TYPE OFFERS ACCELERATION THAT IS CONTINUOUS BUT INITIALLY SLOW

Garrett Reim Seattle

Sailing across the known universe on beams of light is about as romantic as the space industry gets.

But while the whimsical dream of harnessing the Sun's photons with solar sails has existed for more than 100 years, the concept has been limited mostly to science fiction by the level of engineers' ability to pack metallic booms into spacecraft that could unfurl and control a sailing canvas.

To overcome that obstacle, NASA has developed a novel expanding tubular boom system made of flexible polymer and carbon-fiber materials that can be rolled up inside a cubesat for launch and then unrolled when deployed. NASA's Advanced Composite Solar Sail System (ACS3) was launched in April and fully deployed in August. The agency has started testing it as part of a 6-9-month demonstration.



Counterintuitively, solar sails might be best suited for carrying spacecraft toward the Sun.

NASA

The ACS3 solar-sail-equipped 12U cubesat was made by NanoAvionics. Its fully deployed sails—there are four arrayed around the spacecraft—cover 860 ft.^{2} (80 m^2), about half of a tennis court.

"The composite boom architecture that we're demonstrating can support up to a 2,000-m^2 sail. It has a lot of range," Justin Treptow-Miller, deputy program executive of small spacecraft technology and flight opportunities programs at NASA Ames Research Center in Mountain View, California, tells Aviation Week. "It makes the overall structure very stiff. You both have a lot of flexion stability, and you have a lot of torsional stability utilizing this composite structure."

The ACS3's solar sails are made of reflective polymer sheets and harness the energy of photons emitted from the Sun to propel the spacecraft in the opposite direction. When light particles hit the sails, they impart momentum; the photons redshift as they reflect and lose some of their energy. The spacecraft maneuvers by angling the solar sail, using reaction wheels, for example.

Solar sails could be particularly useful for non-Keplerian orbits that would otherwise require large, expensive and impractical propulsion systems. NASA sees the type as useful for long-duration, deep space travel. Although solar sails are an initially slow form of propulsion, the systems promise to accumulate momentum over time.

"You don't have to burn propellant, you don't have to have a high-voltage power system, and you don't run out of propellant," Treptow-Miller says. "It enables a very high-reliability, continuous propulsion system."

Counterintuitively, solar sails may be best suited for carrying spacecraft toward the Sun rather than away from it. Solar sails can be used as a sort of drag chute for spacecraft by angling the system so that photons hit the sail and decelerate the vehicle's orbital velocity, allowing the Sun's gravity to pull the spacecraft toward it.

Spacecraft pulled along by solar sails could journey on heliophysics missions for NASA. The National Oceanic and Atmospheric Administration has pondered using a solar sail to maintain a "space weather buoy" between the Earth and the Sun for space weather missions of 3-5 years, Treptow-Miller says.

"Think of it as a propulsion system to pace along with the Earth," he explains. "The sensor could be between the Sun and the Earth and provide that early warning system for coronal mass ejections that would be coming at the Earth."

The ends of a solar sail's composite booms would also offer a place, far away from the electromagnetic interference of a spacecraft's electronics, for a highly sensitive magnetometer to detect incoming geomagnetic storms—a phenomenon that can disrupt Earth-based communications systems and power grids as well as orbiting satellites.

Although solar sails have been theorized by physicists and imagined by science fiction authors for decades, the first solar sail system, the Ikaros (Interplanetary Kitecraft Accelerated by Radiation of the Sun), was launched by the Japan Aerospace Exploration Agency in 2010. In the years since, only a handful of solar sail spacecraft have been launched.

Treptow-Miller says advances in carbon-fiber manufacturing may make the type more practical. A NASA Ames Research Center team is currently observing how the ACS3's carbon-fiber booms and reflective polymer solar sails behave in space, and the team plans to attempt orbit-raising and -lowering maneuvers before year-end.

OCTOBER 2024

InsideMRO™

TOP 10 MROs

Next-Gen Engines

Europe's MROs Prepare

The AI Balancing Act

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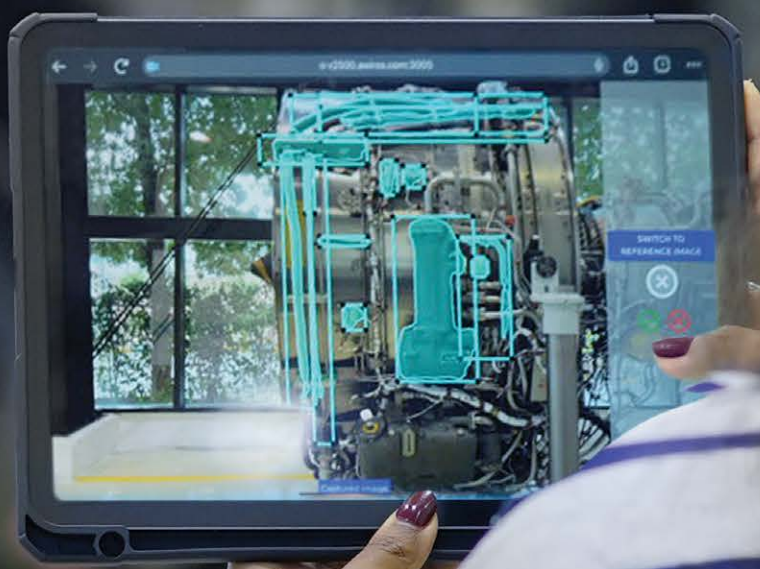

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MAINTENANCE CHECK

It's Back!

The wait ends! You asked for it, and here it is—*Inside MRO*'s popular biennial Top 10 MRO feature, which examines airframe maintenance labor hours from 2023.

For the MROs that participated, thank you for your efforts and transparency.

Our team considered resurrecting this popular feature last year, but we did not think the global airline market had recovered sufficiently in 2022 to use that year as the new baseline—especially in the Asia-Pacific region, where the market was still restricted due to the COVID-19 pandemic.

But 2023 seemed to be a solid enough year to serve as the new baseline, so here we are!

We contacted the world's biggest airframe MROs and asked them to provide their airframe maintenance labor hours, without line maintenance, and with and without parent company numbers if they are affiliated with an airline. We also asked for their total MRO hours (including airframe, component and engine) and revenue because most big airframe MROs offer multifaceted work packages.

Compiling this feature is always hard—partly because the data we ask you to provide can be difficult to extract. On top of that, several people who provided the data in 2019 are no longer in the same position, so we lost institutional knowledge about this project.

We do not base this survey on information found in quarterly presentations or regulatory filings. We need you to provide exactly what we need, and we trust it is accurate.

Even though I feel I need a vacation after completing the Top 10 project, I am glad we do it because it provides a barometer for the industry. I usually provide a more analytical view of how the numbers have changed, but given that we have a gap of five years, a few of which were tumultuous, I have included less analysis this time.

In the next survey, which will come out in 2026, we will use this one as the baseline. So onward and upward.

Inside MRO (previously named *Overhaul & Maintenance*) has been publishing the Top 10 MRO survey every other year since 2001. It started in *Overhaul & Maintenance's* June 2001 issue by ranking the "Top 10 North American Airframe MRO Companies," both civil and defense. Timco, part of Aviation Sales Co., won the top spot with 5.4 million labor hours. Goodrich MRO Division followed with 4.5 million, and Boeing Airplane Services came in third with 3 million. (For aviation history buffs, you will find the first two still in the survey, but in different forms.)

In 2007, we questioned whether we should include component and engine MRO labor hours, too. We now include "total MRO" to capture airframe, component and engine labor hours. In 2009, we added annual revenue figures. We have evolved so this survey continues to be a business barometer for the MRO industry.

How did we do? I welcome your feedback and hope to see you at MRO Europe.

—Lee Ann Shay

"2023 seemed to be a solid enough year to serve as the new baseline, so here we are."

Access *InsideMRO* Online
Go to: AviationWeek.com/MRO

Highlights

Airbus Services Predicts Recycling Growth

Airbus expects the market for aircraft dismantling and recycling to grow considerably over the next 20 years.

The OEM hopes all the used serviceable material generated will alleviate the supply chain pain the industry is experiencing due to parts shortages, high parts prices and aircraft delivery delays.

In its 2024-43 Global Services Forecast, the OEM predicts that the dismantling and recycling market will see a 7.5% compound annual growth rate (CAGR) over the 20-year period as nearly 19,000 older-generation aircraft are replaced, generating around $52 billion in used serviceable material. Airbus noted that there are more than 100 global dismantling and recycling service centers—including its recently opened Airbus Lifecycle Services Center joint venture with Tarmac Aerosave in Chengdu, China—and it expects this number to triple by 2043. The OEM forecasts global demand for around 500 aircraft teardowns annually over the next 20 years.

AIRBUS

Airbus' latest forecast projects that the number of global dismantling and recycling service centers will triple by 2043.

Airbus expects global MRO services demand to grow at a 3.5% CAGR, reaching $290 billion by 2043 from $150 billion in 2024.

StandardAero Aims To Raise $1.1 Billion in IPO

StandardAero announced the launch of its initial public offering (IPO) process on Sept. 23, seeking to raise $1.1 billion at a valuation of up to $7.5 billion.

Backed by private equity giant Carlyle Group and Singaporean sovereign wealth fund GIC, the aircraft engine maintenance specialist decided to go public in line with Carlyle's preference. Carlyle had explored selling StandardAero but was seemingly underwhelmed with the bids it received.

Filings for the listing show that funds affiliated with Blackrock, Janus Henderson Group and Norway's $1.8 trillion sovereign wealth fund have signaled interest in buying shares of StandardAero at the IPO price.

StandardAero's decision to go public comes less than a month after its acquisition of military MRO provider Aero Turbine from private equity firm Gallant Capital for an undisclosed sum.

EFW Resumes A380 Support

ST Engineering and Airbus joint venture Elbe Flugzeugwerke (EFW) is reentering the Airbus A380 heavy maintenance market after securing a "multimillion-euro" contract with UK long-haul startup Global Airlines and signing firm contracts for 2025 with several other unnamed airlines.

EFW originally began supporting the A380 in 2013, performing around 50 heavy maintenance work packages in Dresden for customers, including Air France, Emirates, Lufthansa and Qantas. It later extended its offering to include full cabin modifications. But EFW's A380 services came to an abrupt halt with the COVID-19 pandemic.

Under the contract, EFW will perform Global Airlines' heavy airframe maintenance, along with all the airline's scheduled maintenance, mandatory inspections and component replacements. Global Airlines plans to launch operations in June.

Contracts

AFI KLM E&M was selected by **Cambodia Airways** to provide Airbus A319/A320 component support.

Airinmar extended its repair cycle management services agreement with **Singapore Airlines.**

Asia Pacific Aircraft Component Services was selected by **Magnetic Trading** for repair services and warehousing.

Boeing signed a new agreement with **Haeco** to supply spares and consignment parts to support its global MRO services.

Honeywell signed a $1.1 billion **VietJet** contract to provide avionics and auxiliary power unit maintenance programs for the airline's Airbus A320s/A330s. The deal includes Honeywell's Flight Efficiency system to provide emission reduction and fuel-efficiency monitoring across the fleet.

Lufthansa Technik Shenzhen signed a **Cebu Pacific** contract to maintain Airbus A320ceo/A321ceo airframe-related components.

Pratt & Whitney has signed a 17-year **AirBaltic** contract to provide its EngineWise maintenance services program for the airline's geared turbofan engines.

SR Technics extended its CFM International CFM56-5B maintenance agreement with **Cebu Pacific** to support about 25 aircraft.

StandardAero was selected by Turkey's **Corendon Airlines** to provide CFM International Leap 1B maintenance in San Antonio.

Turkish Technic was selected by **Garuda Indonesia** to provide Airbus A330 and Boeing 777 component support.

Contract Source: SpeedNews

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Too Much Risk?

The FAA is evaluating risks posed by incorrectly assembled rudder parts that may be installed in hundreds of Boeing 737s after the NTSB issued what it termed "urgent" recommendations spotlighting the problem.

SEAN BRODERICK/AW&ST

At issue are 353 SVO-730 rudder rollout guidance actuators supplied by Collins Aerospace starting in February 2017. The actuators contain sealed bearings that were not assembled correctly, the NTSB said in a recommendation letter detailing the issue. The mistake makes the actuator more likely to get wet inside and freeze at altitude. That in turn can jam the aircraft's rudder system.

At least three in-service incidents have been linked to the condition. An August Multi Operator Message from Boeing said that while the issue does not pose an immediate safety threat, the airframer intends to develop a plan to remove the questionable parts.

In a Sept. 30 letter to FAA Administrator Mike Whitaker, NTSB Chair Jennifer Homendy took issue with Boeing's response and said she was "disappointed" in the agency's lack of action. Her letter revealed that 271 of the suspect parts may be in service on aircraft operated by as many as 40 non-U.S. carriers. In addition to the inventory sent to Boeing, Collins shipped another 75 directly to operators as spares, adding an aftermarket angle to the safety risk.

The board urged the FAA to scrutinize the risk the parts pose and to determine whether they should be removed from the fleet, as well as to develop an appropriate response plan that involves non-U.S. regulators.

Investigators discovered the problem while probing an in-service report for a February incident involving a United Airlines 737-8. The pilots reported jammed rudder pedals during a landing rollout at Newark Liberty International Airport in New Jersey following an otherwise routine flight from Nassau, Bahamas.

SVO-730 actuators are part of the 737's fail-operational autoland system with rollout guidance. The system is required for approval to conduct Category III B low-visibility landing operations. United's 737s do not fly Category III B operations, but it took delivery of nine aircraft built for the highly restrictive operational approval but later reconfigured to match the airline's needs.

United's actuators were electrically disabled but remained mechanically linked to the rudder system. The airline was not aware they were installed, the NTSB said.

The board has not determined why the manufacturing error occurred, but information released in the recommendation letter suggests relocated production may have played a role. Deliveries of the incorrectly made parts began just after Collins moved its manufacturing facility from Melbourne, Florida, to Mexicali, Mexico, with all of the problem actuators made in Mexicali.

Part of the NTSB's urgency stems from concerns about risk posed by the actuator combined with Boeing's pilot guidance on handling a jammed rudder. The airframer tells pilots to "overpower" jammed or restricted rudder controls, the NTSB said, but the amount of force needed to free a frozen rudder actuator could introduce new hazards.

Boeing and Collins calculated a frozen actuator requires about 87 lb. of rudder-pedal force to move. "However, this amount of force applied during landing or rollout could, in clearing a jam or restriction, also result in a . . . sudden, large and undesired rudder deflection that could unintentionally cause loss of control or departure from a runway," the NTSB said.

The board also suggested Boeing's jammed rudder guidance is not specific enough. "[Only] general procedures for jammed or restricted flight controls are provided in the Boeing 737 Airplane Flight Manual and Flight Crew Operating Manual, and the rudder rollout guidance actuator is not mentioned as a potential source for a jam or restriction in the rudder control system," the report said.

The NTSB's concerns led it to take two rare steps beyond its FAA-focused suggestions: issuing recommendations directly to Boeing and marking them as "urgent."

Most NTSB recommendations go to a regulator that can use its legal authority to mandate changes. But in some cases, the board will go directly to the companies involved. The board said Boeing should determine what pilots could do "besides applying maximum rudder pedal force" to free a seemingly stuck rudder, and ensure operators are aware of the scenario.

"A jammed or restricted rudder scenario could become even more concerning [with] a high-crosswind or an engine-out condition," the board said. This, it added, is "not only because the amount of rudder available to respond to these conditions might be insufficient to maintain control of the airplane if the jam is not cleared—but also because excessive rudder input may result if the jam is cleared by responding with Boeing's mitigation."

The FAA said it plans to "convene a corrective action review board based upon the NTSB's interim recommendations and determine next steps." It also confirmed that United is the only U.S. carrier with the affected parts, all of which have been removed. The United scenario suggests some operators may have them without realizing it due to customer delivery reshuffling and other orderbook changes.

Boeing stated that it is reviewing the recommendations. "[We] are working with our supplier to develop additional guidance to address the potential condition," the company added. "We will keep our regulator informed of our progress. We will also ensure flight crews have the appropriate operating procedures."

—Sean Broderick

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ARSA UPDATE

Finding Intelligence

A POPULAR JOKE ABOUT ARTIFICIAL INTELLIGENCE compares its risks to those of natural stupidity. The implication is that humans have caused so much trouble that it cannot be worse to turn decisions over to the machine.

FAA standards for uncrewed aircraft systems still put human responsibility at the forefront.

PEACHAYA TANOMSUP/ALAMY STOCK PHOTO

In aviation, human competence is essential to the safety rules governing design, production, operations and maintenance. Air-breathing individuals are granted authority either collectively or individually to perform, supervise and/or approve for return to service the work performed on civil aircraft under Part 43. Owners, operators and pilots carry responsibility for safe operation under Parts 91, 121, 135 and others while flying equipment manufactured by "persons" subject to the rules.

Even Part 107's standards for uncrewed aircraft systems put human responsibility front and center: §107.12 requires FAA certifications for remote pilots in command of such aircraft. While no person is on the aircraft, the human is a required part of the system directing its flight.

ARSA has written about the excitement caused by new and "emerging" technologies, which regularly exceeds the attention that should be given to exciting equipment established in non-aerospace fields before it "emerges" for us. Machine learning tools can simplify tasks, improve analysis and remove burdens from the humans bearing responsibility for safety. What AI cannot do is take on direct responsibility, which the rules vest in the "persons" certificated or authorized by the FAA.

Rather than seek artificial replacements for humans, the industry's challenge is to improve the lives of individuals on whom system safety relies. A 2021 report accepted by the FAA's Safety Oversight and Certification Advisory Committee (SOCAC) provided a road map toward that investment. Still the only official SOCAC output, the analysis was produced by the body's Workforce Development and Training Working Group, which had been charged with developing standards of knowledge and skills for government personnel overseeing aviation certificates.

"The Federal Aviation Administration (FAA) and industry must develop an aviation safety workforce that can accommodate and respond to modern oversight methodologies and technology," the report's executive summary said. "To aid that goal, the SOCAC Subcommittee Working Group examined strategies and methods for attaining knowledge and critical thinking skills to support current and future aviation safety duties."

The result of that examination was a tiered system of knowledge assessment for regulatory compliance, technology and professionalism. Across these disciplines, effective training ranges from beginning to advanced knowledge and provides specific in-depth experience for those with relevant job responsibilities. The report projected knowledge retention using a "cone of learning" model—from minimally retained reading of information to combining mental and motor skills to ensure the fullest understanding and memory of a lesson.

It is fun to joke about human frailty. And, kidding aside, artificial tools can be a great help. But finding and bolstering natural intelligence is vital to aviation safety.

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

European Expansion

Airbus forecast to capture most of Europe's MRO market over the next decade

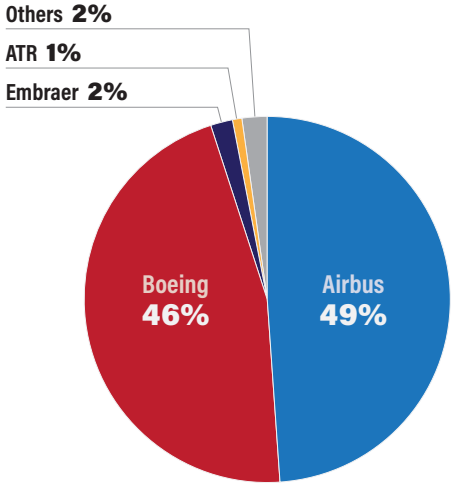
Christian Albertson

Commercial MRO demand for the European region is projected to surpass $343 billion through 2034 with more than 62,000 MRO events, including over $74 billion in line maintenance requirements, according to the 2025 edition of the Aviation Week Network's Commercial Aviation Fleet & MRO Forecast.

The forecast projects how the world's aircraft fleet and aftermarket will evolve over the next 10 years. The commercial aircraft fleet is expected to grow to 10,300 aircraft in 2034 from just over 8,000 in 2025. This will translate to an increase in MRO demand. Required MRO work for commercial aircraft is expected to have a compound annual growth rate of 3.2%.

The forecast projects that Europe's MRO market will be dominated by Airbus aircraft, which account for a 49% share. Boeing aircraft are expected to claim the next highest share at 46%. The aircraft expected to require the largest amount of MRO are the Boeing 737-800, followed by the Airbus A320 and A321neo.

MRO Events Through 2034
By Aircraft Manufacturer



Source: Aviation Week Network 2025 Commercial Aviation Fleet & MRO Forecast

Air Europa

Amid parts shortages and scarce slot availability, Air Europa Chief Technical Officer **Pedro Macias Dominguez** *talks with* **James Pozzi** *about how its maintenance division is tapping into partnerships while considering internal investment to help overcome hurdles.*

What is the dynamic between Air Europa and Globalia Maintenance? Air Europa Maintenance is purely an entity with a European Union Aviation Safety Agency Part 145 organization, a [Continuing Airworthiness Management Organization (CAMO)] associated with the [air operator certificate] of the airline and an approved Part 147 Training Center where we support our internal training requirements and [those of] our customers. Globalia Maintenance is focused on heavy maintenance activities and operates as the perfect complement to the daily maintenance of Air Europa. The relationship between Air Europa Maintenance and Globalia Maintenance is a strategic partnership to improve our maintenance operations.

Air Europa Chief Technical Officer Pedro Macias Dominguez

As an airline, what does Air Europa look for in an MRO partner? As a customer, Air Europa will always look for the appropriate slot, with the right turnaround time and a competitive cost. This is obvious in a way, but it is important to emphasize that what we look for in an MRO are the skills and certification to solve problems that could be found during heavy maintenance. What I am referring to when I say solving problems is having the skills, capacity and know-how to repair and solve corrosion issues, structural repairs, wiring repairs and modifications.

Who are some of your MRO partners and what do they repair? Globalia Maintenance is our main and most important heavy maintenance provider. In terms of engines, for the CFM International CFM56 engine that powers Boeing 737 aircraft, we have a contract for engine shop visits with Iberia Maintenance at its engine shop in Madrid. For components in our two fleets of 737 and 787 aircraft, we work in a structure with different pool providers, depending on the fleet, to have the best performance in each fleet.

Does Air Europa outsource most of its maintenance? In our main hub in Madrid Airport, we have our own line maintenance station with nearly 200 employees doing a fantastic job in our daily operation. I can say the same for our four additional line maintenance stations in Barcelona, Mallorca, Tenerife and Las Palmas de Gran Canaria, where our team is also doing a great job supporting our fleet. As you can imagine, at our destinations in Europe and Latin America we have to outsource line maintenance activities to local providers, as the intention is to cover the on-call maintenance in case of need. As mentioned before, for heavy maintenance activities, Globalia Maintenance, with its two hangars—one in Madrid dedicated to widebody aircraft and another in Palma de Mallorca for narrowbody aircraft—is providing us with all the support for C checks, engine changes and landing gear changes. Globalia Maintenance performs 85-95% of our heavy maintenance requirements.

Has Air Europa experienced a lack of MRO capacity and slot availability in the market? If so, how has this impacted your fleet maintenance planning? It is getting more and more difficult to find specific slots for widebody aircraft and paint slots. These are, I would say, the two more difficult slots to be found. For this reason, it is important to have Globalia Maintenance as a partner

Air Europa Airlines Fact File

HEADQUARTERS: Llucmajor, Mallorca, Spain

HISTORY: Founded in 1986, Air Europa started as part of the British ILG-Air Europe Group, with Spanish banks holding a majority ownership. Initially it operated flights across Europe on Boeing 737-300 and 757 aircraft. Over the following decade, the airline grew its fleet, adding 737-800s in the late 1990s before expanding routes outside Europe. In late 2019, International Airlines Group (IAG)—parent of British Airways, Iberia, Aer Lingus and Vueling—announced plans to acquire Air Europa. After a long period of uncertainty exacerbated by the COVID-19 pandemic, the merger was shelved in late 2021. In August 2022, IAG converted a loan into a 20% shareholding in Air Europa. Both parties looked to revive the deal in 2023, but in August this year, IAG pulled out of a potential acquisition following disagreements with the European Commission relating to antitrust conditions for the takeover.

FLEET: Air Europa operates an all-Boeing fleet of 737s and 787s, with a total of 43 aircraft as of August. The airline has an order in place for 20 737 MAX aircraft, with plans to take delivery of the first three this year from lessor AerCap. The airline's flying destinations include Spain and Europe, South America, North America, the Caribbean and North Africa.

IN-HOUSE MRO CAPABILITIES: Air Europa is a line maintenance, CAMO and Part 147 organization. For line maintenance, the carrier has a third-party business offering that supports 737, 787 and Airbus A330 aircraft. Air Europa outsources most base maintenance to Mallorca-based Globalia Maintenance.

Air Europa outsources nearly all of its base maintenance to Mallorca-based Globalia Maintenance.

AIR EUROPA PHOTOS

for heavy maintenance, mainly in their new hangar in Madrid, specially dedicated to widebody aircraft.

How is Air Europa feeling the impact of parts shortages? These parts shortages are the most relevant problem we have nowadays in our industry, not only for the lack of parts on the market but because of the escalation in pricing due to the low supply and high demand. So we need to be smart to face this situation. As a business, we are working hard with data analysis, checking trend consumption and trying to know in advance the material needs we will have to ensure for our stock and our purchases.

How is Air Europa preparing for the introduction of the Boeing 737 MAX? The 737 MAX is quite like the 737NG operation. All contracts we have for components support are already adapted, taking into consideration the entry into service of the 737 MAX. In our line maintenance and CAMO operations, everything is already prepared just to push the button and get the right certification as soon as the first delivery from Boeing is confirmed. To date, everything for this entry into service is running smoothly.

What technologies is Air Europa looking to invest in for its maintenance operations? Innovation and continuous improvement are one of the main pillars, in our view, of how to develop maintenance operations in an airline. An example of this was in 2021, during the COVID period—we were able to go live with TRAX, which is our main [enterprise resource planning software] in our organization. This meant entering the digital world in relation to all the maintenance processes. Since that moment, we have become paperless. Our line maintenance engineers and mechanics started to sign all the job cards in their tablets. Material management started also to be conducted in real time—the same for planning follow-up from the CAMO department, for instance.

Is the airline maintenance division considering wider adoption of artificial intelligence (AI) tools? Yes, the plan is focused on having AI tools as a solution for material management and strategic purchasing and predictive maintenance. We are currently finalizing our market research to choose the best partners, as these AI projects will be launched next year.

Post-pandemic, the industry has lost a lot of technical experience. What has been Air Europa's experience with this and how has it looked to bridge the talent gap? Our team is the secret to how we managed to leave behind the pandemic times and how we have recovered from it, having positive results in operational performance and from a financial standpoint. The churn in our staff working at our offices as planners, engineers, admins, storemen, purchasers and other roles has been reduced. We have been able to feed our organization with people from the industry who wanted to join us despite the competition in the market. This mix of people is the key aspect of our current strong performance.

Alternatively, what strategies is Air Europa using to attract young people into careers as airline mechanics and engineers? For mechanics, the advantage we have in Air Europa is that we have our apprentice program to train, teach and give them the chance to get the official license B1/2. This assures us of having every year a mechanic promotion. Once working in the airline, young mechanics benefit from an automatic promotion if their aptitude, learning and performance are satisfactory. For engineers, the approach is different, as we start visiting Spanish aerospace engineering universities to let them know about how we work in the maintenance area of an airline. We believe that as students, they lack a realistic view or knowledge about what we do, and it is worth showing how dynamic, how challenging and how many opportunities for a professional career we offer.

TOP 10 MROs

Inside MRO's popular biennial survey returns

Lee Ann Shay

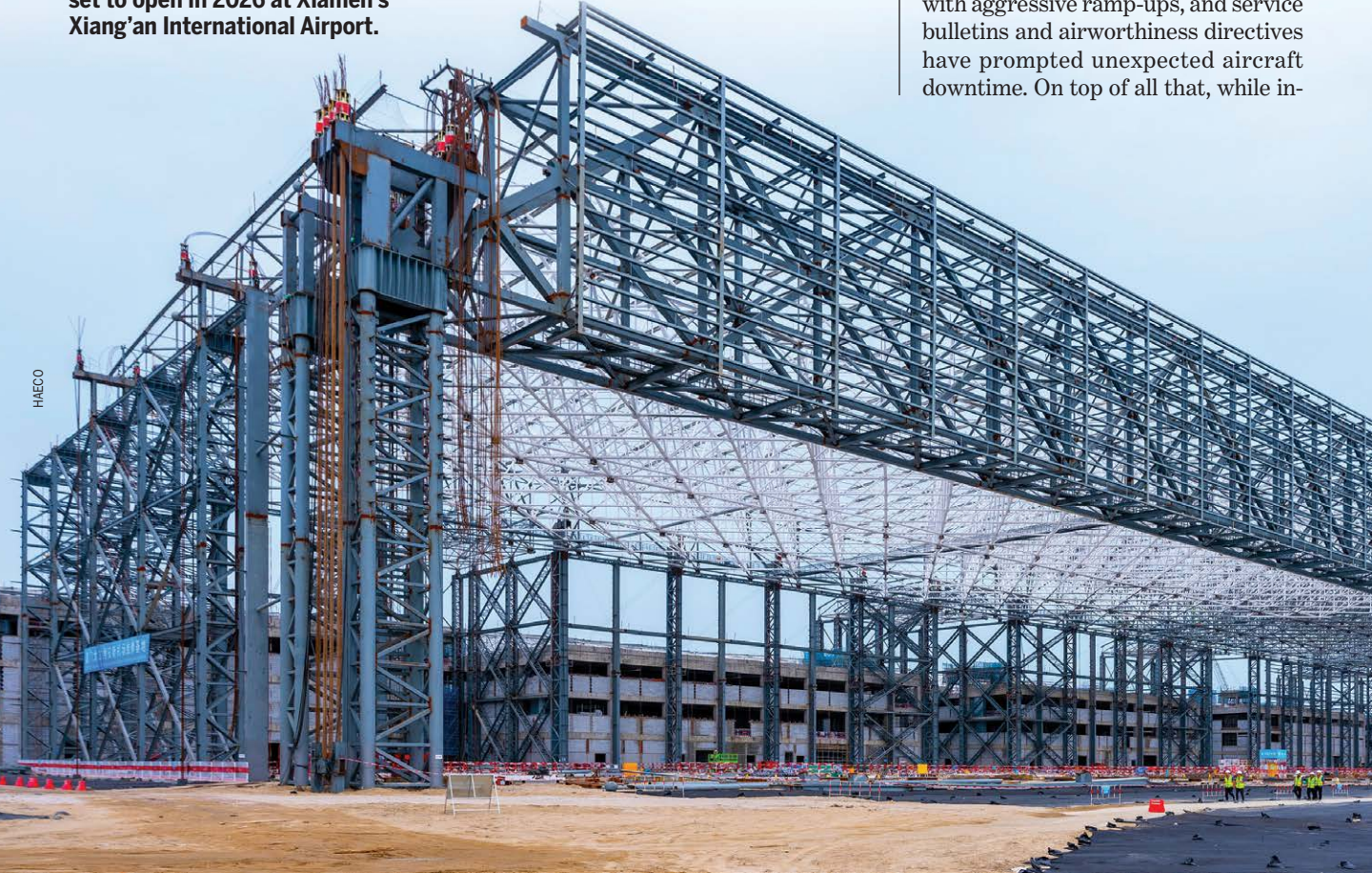
Although it has been five years since *Inside MRO* last published its popular Top 10 MRO survey—and so much in the aviation industry has changed—the top three airframe MRO service providers were the top three in 2019, too. ST Engineering remains the largest airframe MRO, HAECO secures the second spot and MRO Holdings claims the third.

This year's Top 10 MRO survey, based on 2023 data, resets our popular feature, focusing more on what the major players are doing and what changes to expect in airframe maintenance, as opposed to how their numbers have changed since the last survey. As 2023 global airline traffic came close to 2019 levels, it seems like a good year from which to establish a new baseline for this survey, which first appeared in this magazine in 2001.

You will notice two big MROs that usually participate—AFI KLM E&M and Lufthansa Technik—did not provide 2023 figures. However, based on their reported 2023 revenues of $4.7 billion and $7.2 billion, respectively, both probably would make the list. In 2019, Lufthansa Technik produced 5.6 million airframe labor hours and AFI KLM E&M provided 3.7 million (*Inside MRO* May 2019, p. MRO12).

The common theme among MROs that responded to our queries is that capacity is tight. That is not surprising: Passenger traffic demand is strong, airlines have extended the use of older aircraft as OEMs continue to struggle with aggressive ramp-ups, and service bulletins and airworthiness directives have prompted unexpected aircraft downtime. On top of all that, while in-

HAECO is building what it calls the world's largest single-span hangar, set to open in 2026 at Xiamen's Xiang'an International Airport.



HAECO

El Salvador-based Aeroman, part of MRO Holdings, completed 5.6 million labor hours in 2023 and expects to log 6.2 million this year.

MRO HOLDINGS

creased demand for MRO is good, labor and supply chain constraints exacerbated by the COVID-19 pandemic are still causing headaches.

For airframe MROs, "build it and they will come" is no longer a hangar strategy. Securing anchor customers and a labor force to perform the work must come first.

The big are getting bigger through three pathways: increasing capacity, focusing on efficiencies to gain capacity, or both. Each option brings new capabilities.

CAPACITY AND CAPABILITY EXPANSION

Many hangars are under construction, and these will greatly increase airframe maintenance capacity by our next Top 10 biennial survey.

ST Engineering has three new facilities in the works. In the U.S., it is building its third hangar in Pensacola, Florida. The MRO expects to generate an additional 500,000 labor hours annually after the 167,000-ft.^{2} facility, which can accommodate two widebodies, becomes fully operational in the second half of 2026.

In Asia, ST Engineering is building a greenfield airframe MRO with joint-venture partner SF Airlines in Ezhou, China, set to open by 2025. The company also is building another airframe MRO facility in Singapore at Changi Creek, which will add 1.3 million labor hours annually when finished.

To keep up with aircraft maintenance demand, ST Engineering recently added airframe MRO regulatory approval for the Airbus A350 and Boeing 737 MAX, and it is pursuing new approvals for aircraft such as the Boeing 787-10.

MRO Holdings, which operates 91 narrowbody lines at four facilities—the largest being Aeroman with 45 lines—expects to add almost another million labor hours this year, with the same capacity. The MRO has focused heavily on throughput—getting aircraft out the door on time—while maintaining quality, safety and compliance, CEO Greg Colgan said in June (*Inside MRO* June, p. MRO26).

Could MRO Holdings add capacity? Possibly. "We continue to evaluate new strategic investments around capacity and capabilities, focused first on our current customer needs and second on the expansion of our customer base," Chief Commercial Officer Jon Lee says, noting that the near-term focus is developing Airbus A220 and Boeing 787 capabilities while expanding its A330 and Boeing 777 footprint.

Expect Hong Kong-based HAECO's numbers to be higher in our next biennial survey, given that 2023 was still a recovery year for the company as Hong Kong faced longer COVID travel restrictions than North America and Europe. The HAECO Group logged a profit of HK$400 million ($51.5 million) in the first half of this year, compared to HK$63 million in the same period in 2023.

"Looking ahead, the demand for base maintenance is expected to remain stable," a company spokeswoman says, adding that engine output and line maintenance work should increase.

HAECO is building a huge hangar at Xiamen Xiang'an International Airport that is expected to open with the airport in 2026. The company says the new hangar—with 12 widebody and six narrowbody bays—will be the largest single-span hangar in the world, as well as its largest investment to date.

AAR anticipates a single-digit growth rate in airframe maintenance labor hours this year, but that figure should increase after the company expands two hangars.

AAR is adding 114,000 ft.^{2} to its Miami facility, bringing its hangar footprint there to 440,000 ft.^{2} by the fourth quarter of 2025 with a $50 million investment. It also is adding three bays

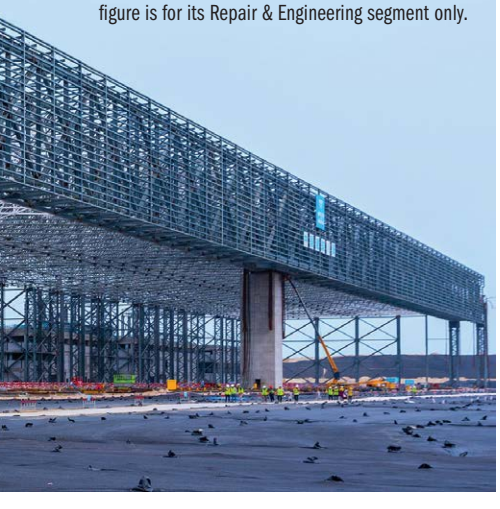
2023 Top 10 Airframe MROs*

	2023 Airframe Labor Hours (Millions)	2023 Total MRO Labor Hours (Millions)	2023 REVENUE (U.S. $ Billions)
ST Engineering, Aerospace	13.8	N/A	$1.5
HAECO Group	11.4	15.8	2.2
MRO Holdings	9.6	9.6	N/A
AAR	5.1	6.8	0.93**
Gameco	4.4	8.5	0.5-1
Ameco Beijing	4	9.5	1.5
Turkish Technic	4	N/A	1.5
Evergreen Aviation Technologies	2.8	3.8	0.38
Etihad Engineering	1.8	2	N/A
Aviation Technical Services	1.6	1.8	N/A

*Includes only MROs that shared information.

**For AAR's 2024 fiscal year, ended May 31. This figure is for its Repair & Engineering segment only.

Source: Inside MRO



to its Oklahoma City facility, expanding that site to 385,000 ft.^{2} when it is finished in early 2026. "We also continued to drive growth in our heavy maintenance hangars out of our existing footprint," John Holmes, chairman, president and CEO, said in June.

Guangzhou Aircraft Maintenance Engineering Co. (Gameco) operates from a 359,000-m^2 (3.86 million ft.^{2}) headquarters facility in Guangzhou that includes three hangars with 31 heavy maintenance lines. It also provides smaller-scale airframe maintenance from shareholder China Southern Airlines' hangar at Beijing Daxing International Airport.

By the end of 2025, Gameco plans to open a new hangar with four lines of narrowbody maintenance at Chongqing International Jiangbei Airport. Expect the company to establish a Comac C919 maintenance capability within the next two years and possibly offer Boeing 777 passenger-to-freighter conversions. For the latter, "preliminary negotiations and technical analysis have been conducted with different [supplemental type certificate] holders," Gameco General Manager Marc Szepan says.

ST Engineering plans to open a hangar at Changi Creek in Singapore.

ST ENGINEERING

Szepan predicts increased demand for widebody maintenance over the next two years as airlines expand their international networks and use larger aircraft to meet passenger demand.

Etihad Engineering recently acquired a widebody hangar in Abu Dhabi, where it is building two new hangars that will add three lines of widebody maintenance, says David Doherty, vice president of commercial. "We have another two phases of development in planning that will take us up to 2030, which will add a further two hangars, adding another three lines of widebody capability and four lines of narrowbody capability," he notes, adding that the MRO also is "looking at international expansion."

TOP 10 MRO METHODOLOGY

To compile this survey, *Inside MRO* contacted 70 MROs around the world to get a barometer of industry trends. The biennial survey asks for the number of airframe maintenance labor hours performed on civil aircraft on an annual basis. If the MRO is affiliated with an airline, the survey asks companies to report both maintenance labor hours performed for its parent, or affiliated airline, as well as those for third parties.

MROs in our Top 10 must have an active third-party business–including airframe MRO–to be included, so if they concentrate on component or engine MRO, for example, they do not figure in this survey. In addition, we separate out line maintenance figures, so those are not included in the airframe maintenance labor hours. Most of the airframe labor hours figures are not publicly available; we rely on the companies surveyed to provide accurate information.

Inside MRO published its last Top 10 MRO report in May 2019 (*Inside MRO* May 2019, p. MRO12). This is typically a biennial survey, but in 2021 the COVID-19 pandemic was still heavily affecting global airline traffic, and we did not feel that had rebounded enough to provide a steady base in 2022.

Hence, at the conclusion of 2023, we felt that year would provide a good baseline from which to resume this important industry survey.

Overhaul & Maintenance (*Inside MRO*'s original name) published its first Top 10 survey in June 2001. Timco (Aviation Sales) took first, Lufthansa Technik second, and Haeco and Goodrich MRO Division tied for third.

2019 Top 10 Airframe MROs*

	Airframe Labor Hours** (Millions)	Total MRO Labor Hours (Millions)	Total Revenue (U.S. $ Billions)
ST Engineering, Aerospace	13.0	Not Disclosed	$1.9
HAECO Group	11.1	13.7	1.9
MRO Holdings	6.7	6.7	Not Disclosed
Lufthansa Technik	5.6	25.0	5.2
AAR	4.9	5.7	Not Disclosed
AFI KLM E&M	3.7	Not Disclosed	4.9
Ameco Beijing	3.6	9.1	0.3***
Gameco	3.2	5.9	Not Disclosed
Evergreen Aviation Technologies	3.3	5.3	1.4
Aviation Technical Services	3.1	3.6	Not Disclosed

*Includes only MROs that shared information. **Includes third-party and parent airline figures, if applicable, but excludes line maintenance. ***Revenue for third-party customers.

Source: Inside MRO

Boeing Shanghai Aviation Services, a joint venture between the OEM, China Eastern Airlines and the Shanghai Airport Group, did not provide airframe maintenance labor hours but said it is building a new hangar in Shanghai that will accommodate four widebodies and two narrowbodies simultaneously. It expects to complete that hangar, with an investment of 850 million yuan ($121.1 million), by the end of 2025.

Evergreen Aviation Technologies (EGAT) in Taiwan intends to expand its heavy maintenance capabilities to include the widebody A350 and narrowbody 737 MAX. Kin Chong, the company's executive vice president of business coordination, sees three MRO services generating the largest growth over the next two years: structural repairs driven by service bulletins and airworthiness directives, supplemental structural inspections and interior fresh activities.

Gameco offers 31 lines of heavy maintenance at its Guangzhou facility.
GAMECO

In Europe, LOT Aircraft Maintenance Services, which completed 572,200 airframe maintenance labor hours in 2023, should post a higher figure in our next survey, too. The company is adding two MRO bases in Rzeszow, Poland, the first of which should start operating in November. That hangar's area will be 9,458 m^2. The second hangar, with 11,500 m^2, should open in December 2025.

While Lufthansa Technik chose not to provide its labor hours, it did say its strategic plan calls for "investing extensively in the expansion of the core business, expanding sites and the international presence in [Europe, the Middle East and Africa]; the Americas; and [the Asia-Pacific region]." That includes establishing a site in southwestern Europe to repair engine and aircraft components.

TECHNOLOGY AND THROUGHPUT

In addition to building infrastructure to gain capacity, MROs are investing heavily in technology to increase efficiency. Watch for a separate *Inside MRO* article on these initiatives, but here are a few that are underway.

EGAT is looking into automation equipment to help reduce turnaround times for labor-intensive paint activities, Chong says.

As part of its focus this year on making throughput times more predictable, MRO Holdings is investing in technology tools across its facilities. This includes enterprise-wide implementation of the SAP S/4HANA financial suite and SAP SuccessFactors human resources management software.

Gameco has many projects, including using automated tool and material delivery systems, as well as smart cabinets for parts and tools. The company also is deploying an artificial intelligence (AI)-driven hangar planning management system, Szepan says.

HAECO has several technology initiatives of its own underway, including exploring whether AI could help with nonroutine tasks and material prediction for aircraft base maintenance, which could shorten turnaround times and free up capacity. It also started a pilot project for drone aircraft inspections in June at its facility in Lake City, Florida.

One of many technology projects in the works at ST Engineering is leveraging AI for operations and increasingly using robotics to automate routine tasks.

AAR, too, has technology programs in the works, including the Digital MRO app that digitizes workflow from initial inspection to signoff, as well as digital task cards (see p. MRO38).

COMPONENT GROWTH

Component repair is a strategic growth goal for several MROs in our survey. This is not surprising given the market's supply chain constraints over the past few years, airlines' desire to minimize downtime and costs and higher margins in component and engine MRO compared with airframe.

Gameco expects surging demand for component overhaul and repair, Szepan says, including a variety of aircraft systems and components such as "avionics, landing gear, hydraulics, pneumatics and accessories."

MRO Holdings anticipates "significant organic and strategic growth in components," Jon Lee says, and Etihad Engineering sees higher demand for component overhaul "especially as the used serviceable material (USM) market continues to introduce additional material," David Doherty says.

Meanwhile, AAR expects component services, thanks to its March acquisition of Triumph Group's product support business, to generate the largest MRO growth over the next couple years.

Aviation Technical Services foresees a bigger need for component services, too. With that in mind, it has combined its component repair, USM and asset trading, and Parts Manufacturer Approval (PMA) design and manufacturing businesses into a single component and engineering solutions team, leveraging these cross-functional groups to provide customers with broader yet streamlined options.

An ATS representative says the company also plans to add A220 and 787 component capabilities, proactively support new airworthiness directive and service bulletin requirements, investigate repair prevention products such as supplemental type certificate programs and develop structural-related PMA to help customers reduce heavy aircraft maintenance costs.

By *Inside MRO*'s next biennial Top 10 MRO survey, scheduled for 2026, several of these capability and capacity introductions should have come to fruition, generating more airframe labor hours. Digitalization rolling out across the industry will offset some of those labor hours, but that is a good thing.

One positive change since the last survey: Airlines are booking longer-term contracts with airframe MROs. Base loading helps these MROs better allocate labor and material, which is especially helpful in today's market. And having longer-term relationships benefits both parties.

Video *Watch the steel roof being added to HAECO's new large maintenance base:* **AviationWeek.com/HAECO-hangar**

Disruptive Dynamics

Early engine removals and new tech adoption spotlighted at Aero-Engines Europe

Lindsay Bjerregaard and **James Pozzi** **Amsterdam**

Shifting engine market dynamics driven by fleet changes, supply chain issues and the potential of emerging technologies are leading maintenance providers to consider new strategies. During Aviation Week Network's Aero-Engines Europe conference in Amsterdam Sept. 10-11, panelists discussed how these factors are affecting their operations.

JASON VERMEULEN/AFI KLM E&M

Onstage at Aero-Engines Europe (from left): James Pozzi, Aviation Week MRO editor for Europe, the Middle East and Africa; Dag Johnsen, Aero Norway chief operating officer; Jean-Louis Forest, AFI KLM E&M senior vice president of group engine product; Maciej Maciejewicz, head of powerplant at LOT Polish Airlines; and Vincent Metz, SR Technics vice president of business development for Europe.

The Aviation Week Network's 2025 Commercial Fleet and MRO Forecast predicts that the next decade will see a shifting dynamic in which shop visits for the CFM International Leap engine start to overtake those of legacy engines by 2033. Although the older CFM56 is forecast to be the busiest in-service engine next year with around 20,000 flying, this number is expected to drop to about 12,500 by 2034. Meanwhile, around 9,000 Leap engines are predicted to be flying next year and more than 30,000 over the next decade.

This dynamic is expected to bring both challenges and opportunities for engine MROs. Jean-Louis Forest, AFI KLM E&M's senior vice president of group engine product, noted that as mature engines such as the CFM56 are still at their peak, the industry will start to see some early removals of new engine types such as the Leap. "The key question is how the capacity and the shops can cope with both of those," he said. "Continuously investing is really important, which is what we have done at Air France, both in Amsterdam and Paris, even during the COVID-19 period. We had to be resilient to save cash, but we didn't cut investment, and I think that was the right decision."

Vincent Metz, vice president of business development Europe at SR Technics, expects these dynamics to cause "a huge challenge for the industry." He said SR Technics' strategy is to "act aggressively," adding new production lines and capabilities and growing the capacity they expect the industry to need. "I think the unreliability of the new platforms basically proves that we will need this capacity maybe sooner than we'd hoped for," he added.

"I think we have probably less than five years to actually get everything set for the new-generation engine shop visits, and the fact that there are some quick turns at the moment may be a liability issue for some constrained networks under OEM control," said Maciej Maciejewicz, head of powerplant at LOT Polish Airlines. "But on the other side, it's an opportunistic way for independent shops to get into the business."

One shop that could benefit is Aero Norway, which focuses on CFM56 services. Chief Operating Officer Dag Johnsen said the company is exploring big investments to cater to Leaps in the coming years, but it is trying to find the right balance. "You don't build a shop overnight," Johnsen said, noting that acquiring the right tooling, test cells and technician experience takes time. Meanwhile, the company must balance new investment with CFM56 services to "keep the lights on," but it is looking at Leap module work and trying to phase in the needed tooling and capability for some special procedures.

However, airlines like LOT are concerned about finding slots for smaller repair issues on these engines. Maciejewicz said he sees a tendency for MROs to turn down work on smaller repair issues because they do not want to disrupt overhaul lines for smaller, less profitable work scopes. "Sometimes it's time-consuming to get the maintenance contract in place, and you don't want to have 10 contracts instead of one for a specific engine," he said. "If you have a provider that can do both heavy and light work scopes, that's very helpful." He added that this could be an opportunity for smaller shops to build capability and take the load off bigger shops.

"Anticipated forecasting for planning removal is key, and there is huge demand from customers to secure the slots and maintenance planning," Forest noted. "When I see the situation today where 15-30% of one aircraft type can be grounded because of engines, it's an incredible situation. It shows that this has to be anticipated now that we see the peak of demand, so it's very important to think about your mainte-

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nance strategy now because that's a turning point of the industry."

AI OPPORTUNITIES IN ENGINE MRO

Artificial intelligence (AI) is one tool that could give MROs and operators a head start in forecasting. Johnsen said Aero Norway is looking at combining AI with its inventory management system to see what parts it needs in stock to avoid gaps. Maciejewicz at LOT also considered the technology's potential for parts issues.

JASON VERMEULEN/AFI KLM E&M

Engine MRO providers at Aero-Engines Europe said they are preparing for the CFM International Leap engine to overtake the CFM56 within the next decade.

"Right now, what we are looking for from our [MRO] providers is the control of vendors, because parts can be either replaced, repaired or exchanged. If AI can help you build a stock of used serviceable material (USM) that will reduce the price and have all the necessary paperwork to back that up, that would be perfect," he said. "Then we would need another AI agent to convince lessors that those parts are good."

However, Metz at SR Technics cautioned that AI could not magically solve the industry's supply chain issues with new-generation engines. "We are in a situation where we try to divide and distribute the scarcity. If you look at the new engines and the drivers behind unpredictability, I really think it requires the industry to also look at our business model," he said. "How do we distribute these new risks over the customer, the operator, the owner, the MRO and the OEM? We should make sure that the risks are addressed to the party most capable of finding solutions, and when we talk about supply chain, it's really about the basics of producing more parts. An AI will only conclude that there is scarcity, which we already know, so we need to make sure that we set things up in a way where we try to make people responsible for the things they can really solve."

PMA/DER LANDSCAPE

Industry openness to parts manufacturer approval (PMA) and designated engineering representative (DER) repairs in the engine segment has continued to increase given the price hikes in the wider component market. With some shops now reporting biannual price escalations of OEM parts leading to a majority cost on an engine repair task, the market for secondhand USM parts also has seen pricing spikes. However, some technical hurdles exist as barriers to increased adoption.

Sebastian Groeger, vice president of strategic business development at Chromalloy, said his company offers approximately 62 PMA parts, most of them airfoils. "Some of them are among the most advanced airfoils, so making these parts and developing them is an expensive process," he said. Groeger discussed the difficulty in obtaining approval from regulators such as the FAA. "The FAA is busy and struggling internally, and explaining a very advanced part is one of our biggest obstacles," he added.

"What is difficult today is to get them approved at airlines," says Christophe Giraud, senior commercial director at AAR, which trades but does not make PMA or DER parts. "Technical teams are very busy, and it takes time to approve a PMA or a DER, but there may not be the structure or the workforce to do it." Giraud added that this is prevalent during a shop visit, when an airline is mindful about turnaround times. "Most of the time, customers say they're not against DERs, there just isn't the time to get approval for this special project," he said.

Giraud noted that lack of material affects availability of critical engine parts, such as on the General Electric CF6-50. "Most of the material found in the market for that [CF6] will be DER repairs for the engine's turbine blades," he said. Chromalloy does well on products related to this mature engine program, Groeger said, pointing out that they become more relevant to engines reaching the second half of their life cycles.

Danilo Colombo, vice president technical-engines at consultancy SGI Aviation, acknowledges the commercial advantage of alternative repairs and states that in some instances, they are 15-20% cheaper than USM parts. In terms of the types of carriers pursuing PMA and DER parts, Colombo said they typically will be flag carriers, which have engineering resources to analyze use of such parts and repairs, as opposed to smaller airlines.

Lessors have long been reluctant to use PMA and DER parts, and Colombo said it would be a step change if more airlines accept DER repairs, which remain a closed loop, in his view. Giraud noted that some lessors are open to such parts and repair alternatives, although not for critical engine parts.

In terms of the relationship between OEM, PMA and DER specialists, Chromalloy's Groeger says this is dependent on the repair it carries out. "DER is a very wide term. There are very simple fixes, and then there are advanced repairs that move closer to a PMA," he said. "We've seen, especially on the easier repairs, that the OEM has been adopting our repairs or developing something similar because the market acceptance was so large." For more advanced repairs, Groeger identified Chromalloy as a competitor to OEMs more than a partner, given its aim to reduce costs.

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Growing Flexibly

Swiss MRO provider prepares for the quick uptick in geared turbofan shop visits

James Pozzi Zurich

SR Technics has added further shop capacity for the Pratt & Whitney geared turbofan aftermarket following the opening of a new overhaul facility here and reactivation of a second test cell expected to come online before year-end.

At a ceremony attended by SR Technics, Pratt & Whitney, Swiss government and local airport leaders in September, the Swiss MRO provider became the 17th active shop in the global geared turbofan (GTF) aftermarket network. SR Technics was granted GTF approval in April 2022 after signing a 10-year agreement to join the aftermarket network for the PW1100G-JM, which powers Airbus A320neo aircraft.

All GTF work at the new 65,000-ft.^{2} facility will be conducted separately from other engine programs to mitigate impact on SR Technics' existing repair and overhaul capability.

The maintenance specialist will focus on full overhauls of the engine and will conduct disassembly, assembly and testing on the PW1100G-JM variant of the engine from its headquarters in Switzerland's capital. In July, shortly before the unveiling of the new facility, the company inducted its first GTF engine and followed that up with several more in August and September.

SR Technics has targeted at least 1,000 engine shop visits over the life of the agreement after the ramp-up period is completed in Zurich. In addition to the GTF, it services CFM International CFM56-5B and -7B, Leap 1A and 1B, and PW4000-94 and -100 engines in the Swiss capital.

Florent Leforestier, SR Technics senior vice president of procurement, who led the industrialization of the GTF program, says he expects overhaul demand for the engine to pick up over the next 3-4 years. Across its portfolio in general, the maintenance provider has seen engine inductions rise steadily over the past few years. With current and future passenger traffic being weighted so heavily toward narrowbody engines, he says this dynamic made the GTF capabilities a natural fit for the MRO provider.

SR TECHNICS

SR Technics introduced plans to undertake at least 1,000 GTF shop visits under its 10-year agreement with Pratt & Whitney.

After a large-scale industrialization effort—the company's first in nearly 20 years since the introduction of the CFM56 program—Leforestier says this was a particularly challenging undertaking, given the learning required for new technologies and processes.

The IT side of the business also needed adjusting, specifically related to SR Technics' SAP enterprise resource planning system.

"We had to adjust this to allow the data format of the GTF program into the business's processes, as it is different to older engine programs," he says. "Everything is linked to that."

This also coincided with a separate IT project of scale. Since the end of 2022, SR Technics has been engaged in the ongoing digital transformation ReSeT initiative, which aims to simplify and transform the company's business operations by moving to SAP S/4HANA, a cloud-based enterprise resource planning software hosted on the Microsoft Azure platform, and incorporating HCLTech's iMRO module add-on for it.

He says all elements of the ramp-up will play out gradually as inductions for other engine programs serviced in Zurich also increase.

"Certainly, we have targets," Leforestier says. "When we are on the cruise altitude of, say, 300 shop visits or so, we have an estimate of 300-400 people that we will need to do that work. Of course, we are not there yet, but we have a sufficient number of people to do the maintenance in the first year."

When it has completed several hundred shop visits, the company expects to grow its team by several hundred


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SR TECHNICS

SR Technics began work to reactivate its second test cell in April. When operational, the test cell will have up to 50,000 lb. of thrust.

people to meet anticipated GTF workflows, Leforestier says.

Over the past 18 months, he says SR Technics invested "double-digit-million Swiss francs" into areas such as tooling, specialist maintenance equipment and reactivating Zurich's second test cell, which had been inactive for several years. It had previously provided testing for Pratt & Whitney JT8D engines.

"We needed a new test cell because we did not have enough capacity for the GTF on top of what we do today," Leforestier says.

While most of the test cell activity will focus on the GTF program, SR Technics will also have the capability to service CFM56-5B and -7B and Leap 1A and 1B engines, with a test capacity of around 200 units per year in total. Leforestier says there are two factors behind the company's decision to bring more test capability back online.

"The first one is to mitigate risk by getting rid of a single point of failure that comes with having one test cell for all of your engine products," he says. "Second, it gives us a bit of flexibility. We're not going to be testing every engine that comes into the shop, but having another test cell gives us an alternative."

Over the next few months, the test cell will undergo a commissioning and correlation phase. "This makes sure all the air flows and everything else meet the OEM's requirements," Leforestier says. By December, he projects SR Technics will be able to test its first GTF engine in the reactivated test cell before the CFM engines are ready, likely in the first quarter of 2025.

Pratt & Whitney plans to remove 600-700 engines for shop visits by 2026 to undergo inspection work, affecting engines powering the A320neo family, A220 and Embraer E-Jets.

SR Technics' participation in the GTF network is part of Pratt & Whitney's ongoing plan to grow the network over the second half of this decade. The U.S.-based engine manufacturer previously outlined plans to have a network of around 30 shops with GTF capability by the end of the 2020s as it seeks more capacity to meet long-term MRO demand.

The introduction of GTF services also adds more capability for the type in Europe at Lufthansa Technik's Hamburg engine shop and Poland-based EME Aero joint venture, Air France KLM Engineering & Maintenance's Paris operation, and MTU Maintenance's facilities in Hanover and Munich, Germany, as well as Zhuhai, China.

Ongoing issues related to contaminated powdered metal, which can cause cracks in part of the PW1000G engines, have led to engines returning for repair earlier than anticipated, putting a strain on some GTF operators. In September 2023, Pratt & Whitney confirmed plans to remove 600-700 engines for shop visits by 2026 to undergo inspection work, affecting engines powering the A320neo family, A220 and Embraer E-Jets. Last month, the engine OEM said groundings and turnaround times remain consistent with its projections.

Just before SR Technics inducted its first GTF, Embraer subsidiary OGMA opened a new GTF facility in Portugal in July, where it expects to service 240 engines annually by 2030.

The Aviation Week Network's Fleet & MRO Forecast projects a strong long-term aftermarket for the GTF program, which will compete in the narrowbody engine market with the CFM Leap engine. By 2033, the forecast estimates that 6,518 engine units will be in-service, and the aftermarket for that year will be worth around $12.9 billion.

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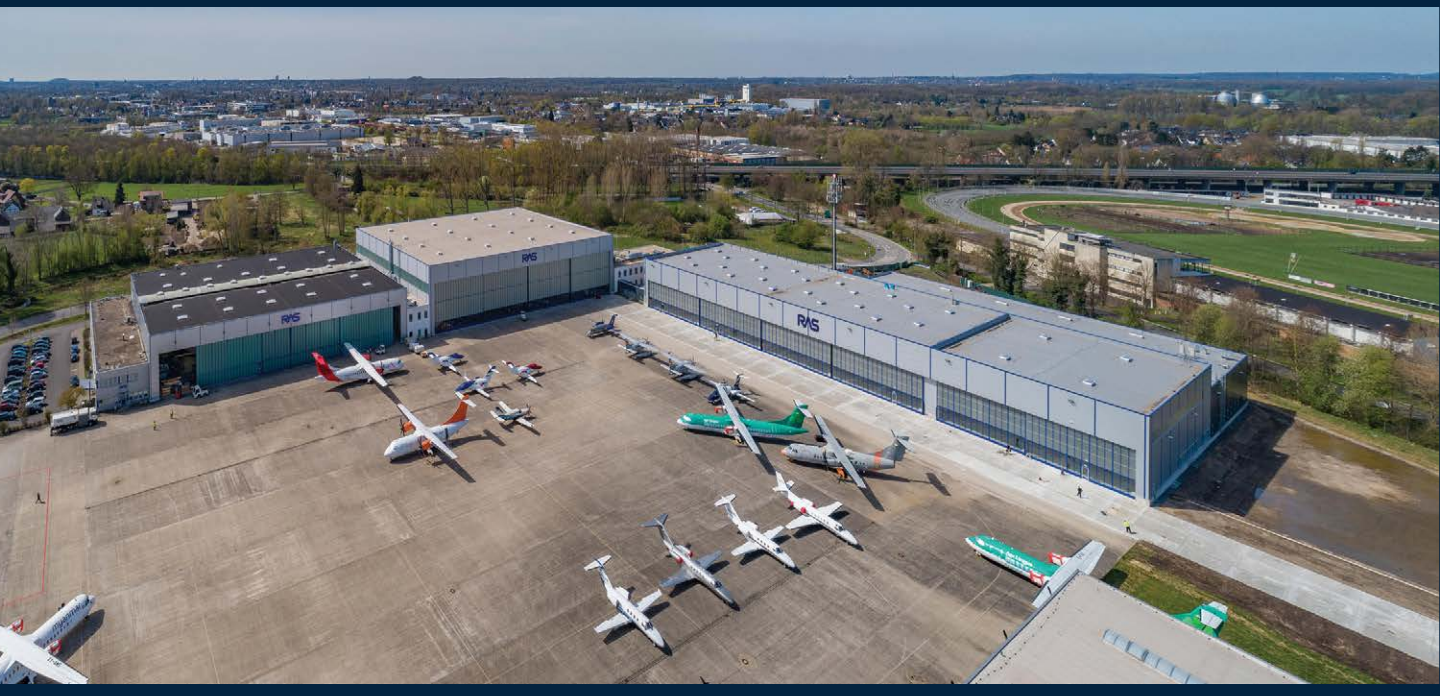

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"Our programs are designed to instill both technical expertise and a passion for aviation," said Tobias Rütter, Training Manager at RAS. "Working for the RAS Group means being part of a supportive team with ample career growth opportunities."

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At RAS, the focus is not only on responding to industry changes, but also on shaping them.

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ROLLS-ROYCE

Going Vertical

Why more engine lessors are adding maintenance and parts capabilities

Rolls-Royce Partners & Finance has offered parts trading capability on engines since 2015.

Alex Derber London

Speakers at Aviation Week Network's Engine Leasing, Trading & Finance Europe event in June suggested that more engine lessors might start integrating MRO and parts services into their platforms to ease transitions, boost material supply and maximize the end-of-life value of their assets.

U.S. lessor and maintenance provider FTAI Aviation has built its platform around an integrated module exchange and engine leasing operation. Yet, this model is not easy to replicate. Alun Roberts, head of engine leasing for FTAI Aviation, said his company is so focused on providing 5,000-cycle CFM International CFM56 engines that it removes 10,000-cycle modules from engines it acquires and bolts on a 5,000-cycle replacement.

Fellow panelist Graeme Crickett, chief technical officer of SMBC Aero Engine Lease, joked that the financial complexities of this arrangement must require FTAI to "give its accountants Valium," with Roberts agreeing that it is a "very interesting and creative model."

"We have a certain book value in that asset, so when we remove an LPT [low-pressure turbine], that LPT will have an assigned book value, which will then be transferred over to the next engine," Roberts said. He also noted that FTAI's engine-leasing strategy meant it preferred to offer lower lease rates in exchange for longer terms and the company taking all the maintenance associated with the engine.

Between FTAI's complex maintenance-leasing model and pure-play asset managers lies plenty of room for lessors to add various levels of technical support to their core leasing offering.

GETTING TECHNICAL

In September, Japanese conglomerate Itochu diversified its commercial aviation business by acquiring Dublin-based Killick Aerospace, which specializes in used serviceable material (USM). In doing so, Itochu became the latest lessor to add aftermarket capabilities to its asset management platform. It noted that Killick fits into its strategy of identifying and investing in "downstream" profit opportunities.

"By creating synergies between Itochu's capabilities and Killick's aftermarket services, the partnership will deliver high-quality, customer-focused solutions that meet the evolving needs of the aviation industry," the Japanese company said.

Itochu also cited an Acumen Consulting report predicting the USM market would grow roughly 50% in the next eight years to reach $11 billion. "Utilizing USM not only reduces costs for airlines but also shortens lead times for parts procurement and supports environmental sustainability," the company said.

While Itochu leases aircraft, engine lessor ELFC made a similar acquisition last year, completing a full purchase of U.S. parts specialist Inav. "Moving into the parts side of the business was a natural evolution of ELFC's model," Joe Hussar, head of portfolio for the lessor, tells *Inside MRO*.

"Prior to entering this business, after monetizing the on-wing value of the engine through leasing, we would sell the unserviceable engine to the wholesale parts market," Hussar says. "By vertically integrating with a parts sub-

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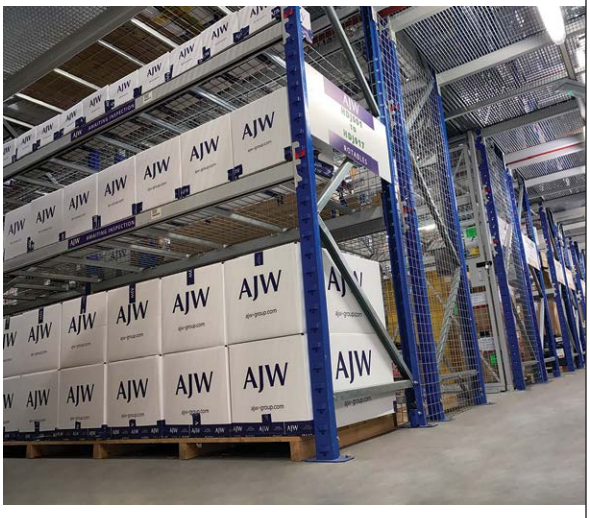
sidiary, we have the in-house ability to capture all possible value out of our asset investment."

Hussar says Inav also enhances the asset management side of the business by giving ELFC a more granular understanding of engine value down to the piece part level. "In addition, having the ability to break engines ourselves was a major advantage during COVID-19 as the liquidity of engines was nonexistent," he says. "Rather than sell the engines at a significant discount or explore a third-party consignment, we were able to break the engines ourselves and have that material ready to go once the market had recovered."

AJW GROUP



AJW Group says vertically integrated lessors have an advantage due to greater buying power.

ELFC competitor Willis Lease Finance (WLFC) has a longer maintenance pedigree, having owned an engine overhaul facility in the 1990s and several other technical services providers since then.

"We have seen the value of combining services and leasing for a long time," WLFC CEO Austin C. Willis says. "Although each of our service sectors has its own unique story, a common thread runs through them all: Our strategy has been to acquire or launch businesses that enhance our control over our products and allow us to manage costs more efficiently—both for ourselves and for our customers."

These cost efficiencies might stem from the cheaper parts that WLFC can provide or from the company taking control of engine maintenance management. "With leasing and services as our core focus, we are often more adept at reducing maintenance costs than airlines," Willis notes.

The company's engine aftermarket capabilities include Willis Engine Repair Center (WERC), via MRO facilities in the U.S. and UK that specialize in swapping modules and repairing engines quickly to avoid expensive and protracted shop visits. "This enables us to bridge engines from one lessee to the next with minimal cost and downtime," Willis says, noting that nonlessee customers take advantage of this service, too.

There is also Willis Aeronautical Services, which feeds USM and modules into WLFC's maintenance operations and external providers. "This facilitates throughput in a supply-chain-constrained environment and enables us to provide a tangible benefit to our third-party customers at WERC," Willis says.

DPA PICTURE ALLIANCE/ALAMY STOCK PHOTO

FTAI prefers to offer lower lease rates in exchange for longer terms and taking on all maintenance associated with an engine.

At lessor Rolls-Royce & Partners Finance (RRPF), meanwhile, one might expect less pressure for vertical integration given the lessor's links to the OEM. However, RRPF Chief Strategy Officer Ben Hughes notes the company sources engine shop visit slots and parts from the OEMs on similar terms to other leasing companies. "We are, however, a significant owner of Rolls-Royce and IAE engine types, so we naturally receive good support from those OEMs," he says.

Furthermore, RRPF has had parts trading capability since 2015, first for IAE V2500 engines and then extended to the Rolls-Royce Trent lines. "Our parts trading experience has generally brought us even closer to our customers and enabled us to create more value for them," Hughes says.

SUPPLY CHAIN ADVANTAGE?

With lead times for many OEM parts still prolonged, difficulties sourcing USM due to fewer teardowns and stretched global engine maintenance capacity, lessors with in-house service capabilities could enjoy an advantage over their pure-play competitors.

"Vertically integrated lessors tend to have an advantage due to their greater buying power, which can result in better turnaround times for engine shop visits and parts repairs," says Tony Whitty, senior vice president of aircraft and engine procurement at AJW. "This enhanced efficiency can be particularly beneficial when MRO capacity and the supply chain are under strain." AJW's services include engine leasing, management of engines on lease for third parties and oversight of shop visits.

"Airlines and aircraft operators are looking for ways to reduce operational costs and improve efficiency," Whitty says. "This has led to a greater demand for integrated service providers, such as AJW Group, who can offer a one-stop solution for parts provision, engine leasing and management services."

Hussar at ELFC also touts the advantages of vertical integration. "We can offer more services to our customer base, such as exchanges of run-out engines for a strong serviceable unit to avoid a shop visit, supplying USM or acquisition of surplus assets our customers may be looking to liquidate," he says. "These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advantages will continue once the supply chain issues are resolved."

"We have seen parts supply delays, which has resulted in us waiting for shop slots to come available and delayed turnaround times," RRPF's Hughes says. "We can mitigate some parts delays because we have our own stock of used serviceable parts internally that we can tactically use to support our own lease engine portfolio as needed. We have also seen customers across most engine types requesting additional spare engine capacity because of maintenance delays that are affecting them."

"Pure-play lessors will always have a role, but those with a services-enhanced leasing strategy can provide real cost savings to customers," Willis of WLFC says. "We believe that this is a value that survives changes in market conditions."

WHY STAY PURE-PLAY?

Not all lessors have pursued vertical integration. Amsterdam-based SMBC Aero Engine Lease (SAEL) is now a pure-play engine lessor, after launching in 2013 as a partnership with engine maintenance provider MTU.

"When SAEL was incorporated, we were somehow involved with teardown, spare parts, module exchange and maintenance through our partnership with MTU," says Roger Welaratne, SAEL managing director. "What we have found is that each of those businesses require very specific expertise and know-how. That is what drove our decision to focus on our expertise."

Now owned solely by Japan's Sumitomo Mitsui Financing and Leasing, the lessor built up a portfolio of roughly 100 engines worth more than $1 billion.

"We have adopted a highly focused approach so far, and I believe being a pure leasing player has been key to making what SAEL is today," Welaratne says. "I also believe that the focused approach was what helped us navigate through the biggest crisis in our industry when we were still a small lessor."

He also notes that while the current supply chain crisis has generally been good for engine lessors, as airlines scramble for spare engines to cover extended maintenance times, it has also brought complications.

"Like everybody in the industry, supply chain issues have significantly impacted SAEL," Welaratne says. "If one of our engines needs to be overhauled, then we face the consequence of long [turnaround times], too. We understand that engine lessors are benefiting from the appreciation of engine values driven by the current environment, but generally, we like more stability."

Welaratne also leaves the door open to a shift in approach. "As SAEL looks into writing the next chapter, we definitely need to look at adjacencies, and we will be seriously evaluating which of those segments are aligned with our strategy," he says. "But we are not going to add different services just for the sake of playing everywhere."

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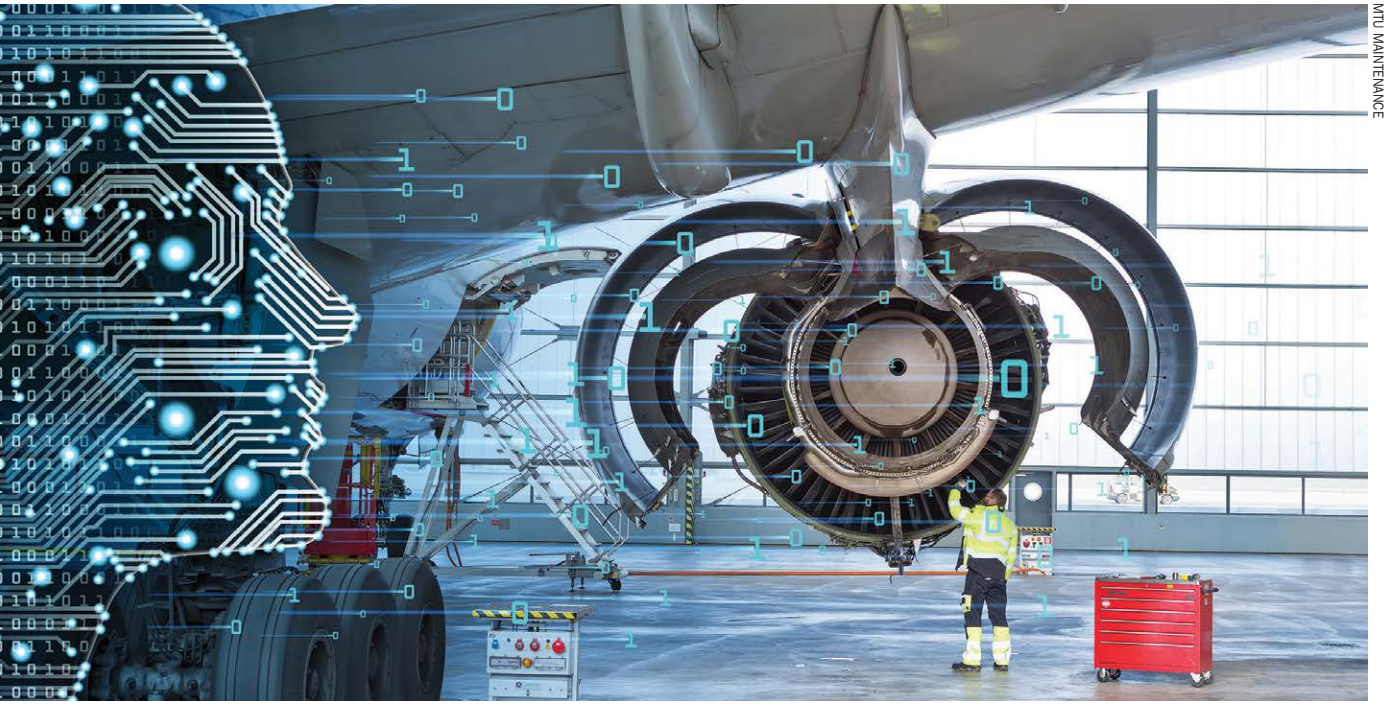

MTU MAINTENANCE

Healthy Advancements

OEMs are improving health monitoring technologies to enhance predictive maintenance

Alex Derber London

Digitalization has been one of the major trends in aviation maintenance over the past two decades, and at its heart lies the burgeoning capabilities of health monitoring systems. Each new generation of aircraft and engines features more sensors than the last. This, alongside new machine learning software analysis, enables analysis of more data points for increasingly accurate preventative and predictive maintenance alerts.

Rolls-Royce, for example, is transitioning its engines and health monitoring systems to a new platform under its IntelligentEngine concept. The system promises an interconnected infrastructure of fleetwide engine data feeds, maintenance technology such as inspection robots and digital twins—the bit-based replicas of in-service engines.

"This allows for an increase in the number of parameters monitored by utilizing the continuous data available, as well as traditional fixed event and fault messages," says Nick Ward, vice president of digital systems at Rolls-Royce. "These new data points combined with situation data allow us to create new diagnostics to prevent potential in-service events."

Health monitoring is also useful for maintenance and inventory planning. This potentially brings great benefits amid the supply chain crisis, as it allows operators and MRO providers to order parts well in advance and get ahead of long lead times, rather than having a heavy check held up by an unexpected fault found with no spare to replace it.

AIRCRAFT MONITORING

While engine OEMs pioneered health monitoring systems, aircraft manufacturers are catching up and using their own technology to create optimized maintenance programs. For instance, rather than sticking to a rigid maintenance planning document, airlines can use service history data to create a customized workscope that better fits their needs and allows for more efficient shop visits and better-timed heavy check intervals.

MTU Maintenance monitors health trends for about 2,000 engines.

Embraer's Aircraft Health Analysis and Diagnosis (AHEAD) platform provides real-time monitoring of critical aircraft systems including the auxiliary power unit, fuel system, bleed, hydraulics, avionics and flight controls across both the E1 and E2 lines.

"Leveraging data analytics and predictive algorithms, the platform provides proactive maintenance, enabling operators to reduce unscheduled downtime," says Carlos Naufel, president and CEO of Embraer Services & Support.

The AHEAD platform can also detect and alert operators of adverse exceedance events, ensuring timely maintenance interventions. In addition, Embraer is evaluating initiatives such as drone-based inspections to enhance the precision and efficiency of maintenance processes.

"Flight data analysis for exceedance events accelerates the identification of

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potential issues, significantly reducing aircraft downtime," Naufel says. "In parallel, ATA reliability trends offer actionable insights for scheduling proactive maintenance, including servicing, before unplanned disruptions occur. By analyzing key system data, operators can better anticipate maintenance needs, optimize aircraft availability and improve overall fleet reliability."

LUFTHANSA TECHNIK

Health monitoring data can be downloaded live, during a flight or once an aircraft is parked.

Airbus says half of its aircraft incorporate health monitoring systems. The newest models report 10 times as many parameters thanks to systems like Flight Operations and Maintenance Exchanger and RMAX, an interface device for downloading huge volumes of operational data from an aircraft.

These systems are more advanced and provide more information than a traditional aircraft condition monitoring system (ACMS), which cannot provide the continuous data needed to inform predictive maintenance.

"We need much more data than ACMS because these ACMS reports have not been designed for predictive purposes," notes an Airbus spokesperson. "To feed efficient predictive maintenance models, we need time series—the continuous recording of parameters at very high frequency—to ensure proper and accurate predictions."

All new aircraft rolling off Airbus lines are delivered with these capabilities, while the technology needed to enable time series reporting is available as a retrofit for older models.

Airbus presents the data and analysis to operators via its Skywise health monitoring platform, which has 10,000 users. Skywise's main function is to allow an airline's maintenance control center to ensure the aircraft's dispatch by anticipating and preparing necessary maintenance actions while the aircraft is still flying. For example, based on continuous monitoring data, an airline might opt to divert a flight to ensure it lands at a location with suitable maintenance resources to avoid an aircraft-on-ground situation. Furthermore, airline technical departments can use the tool for engineering and troubleshooting analysis.

Airbus also feeds the data back into its own product development. "We have reduced by 50% the time it takes to identify a major in-service problem and provide a fix to our customer," an Airbus spokesperson says. "Originally, such a fix was only addressed with a modification of the aircraft, requiring the creation of documentation like a service bulletin, the availability of physical kits and also an approval from the authority."

ENGINE MONITORING

As aircraft manufacturers step up the capabilities of their health monitoring systems, engine-makers are looking to integrate their own dedicated engine health monitoring technology.

"The new high-frequency parameters combined with environmental or situational conditions outside the engine have allowed us to introduce new analytics," Rolls-Royce's Ward says. "We can configure the parameters being recorded to enhance our analytics development. This technique still uses the event-based data and fault message information and combines it all to increase the effectiveness. The speed at which we can detect and alert events is increasing with the new platform and processing we are introducing. Overall, this is supporting extended time on wing and reduced disruption for our customers."

The state of the art for Rolls-Royce is its engine vibration and health monitoring unit (EVHMU), which is being introduced on its Pearl business jet engine before being rolled out to the commercial fleet.

Enabled by a connection to the Internet of Things, the EVHMU can provide instant access to around 10,000 engine performance and health parameters with unprecedented levels of data quality, Rolls claims. Working in conjunction with aircraft health monitoring, the EVHMU system looks at pressure, temperatures and vibrations, but can also monitor the condition of line replaceable units. This enables engineers to remove a part before it develops a fault. The system also provides bidirectional communications, allowing for remote reconfiguration of engine-monitoring features from the ground.

Alongside the hardware installed in engines, software is also advancing. CFM International announced in April that it was using machine learning to enhance the analysis of the data provided by its engines. The system now being used for CFM Leap 1A and 1B engines models data from multiple engine sensors at takeoff, climb and cruise via probabilistic diagnostic and prognostic machine learning tools. These tools then provide targeted alerts based on known engine operating signatures, with CFM touting big detection rate and accuracy improvements.

"We have achieved 60% earlier lead time in identifying preventative maintenance recommendations [and] a 45% increase in detection rates, and cut the number of false alerts in half over the past decade," says David Harper, fleet support director at CFM parent GE Aerospace.

Rolls-Royce also reports fewer false

alerts and more accurate predictions through using machine learning and artificial intelligence (AI) to combine and analyze a greater number of sensor inputs. "We have been able to create new advanced analytics that would not have been possible previously to prevent in-service disruption," Ward says. "With the new platform we can deliver these new diagnostics quicker and with a well-defined success ratio—the obvious limitation being on older engines that do not allow for such granularity in data."

Ward expects more maintenance actions to be generated by sensor data than by physical inspections, thereby promoting efficiencies and time savings in MRO. "The industry has always strived toward this," he notes. "Even with the potential for spurious sensor alerts, physical inspections also attract a risk and cost factor."

MRO VALUE

Like the OEMs, many large MRO providers offer engine health and trend monitoring to optimize maintenance and overhauls for their customers. MTU Maintenance conducts health trend monitoring for about 2,000 engines with WebETM 3.0, its engine trend monitoring tool accessible via the myMTU platform.

"The system observes various aircraft engine parameters, such as exhaust gas temperature, fuel flow, shaft speeds, oil parameters and bleed settings, and detects abnormalities," says Wladimir Bickel, senior manager for MRO digital transformation at MTU Maintenance Hannover. "Any trend deviations are alerted to our expert engineering team, who will assess the data and make qualified recommendations for a course of action to our customers."

One of MTU's main goals is optimizing engine shop visits and holistic engine maintenance management. "The combination of our health monitoring with our fleet management software Cortex, for instance, can generate optimal shop visit scenarios with additional factors such as parts market dynamics, cost structures, utilization and operational conditions, among others," Bickel says.

Like the OEMs, MTU reports the quality of its health monitoring is constantly improving thanks to new hardware feeding more data points and new software taking advantage of machine learning and AI.

"Modern software nowadays allows for the analysis of large data sets and with better performance than we have known it in the past," Bickel says. "We are seeing progress in the aviation industry with respect to sensors, the acquisition of data, additional hardware or means for recording data, the infrastructure for data transmission and the ground-based hardware that relays the collected information.

"The key to improving [engine trend monitoring] methods and engine health diagnoses is to look at a multitude of parameters and their interactions rather than a single or a limited number of them," he continues. "With more and improved data,

we can also apply and derive more complex correlations between different parameters, which leads to better diagnosis."

Of course, engine manufacturers have the advantage of being the primary sources and collectors of health monitoring information. However, Bickel sees such services as complementary rather than in competition.

"Our advantage is that we offer our health monitoring services to a wide range of engine programs so that customers with broader engine portfolios can benefit from a one-stop solution," he says. "In some cases, customers also use multiple platforms to gain insight into the health of their engines or engine fleet."

FUTURE DATA

While engine trend monitoring customers can expect modeling and predictive tools to become increasingly accurate as more data is collected and machine learning algorithms improve, they may also see health monitoring services extend to other parts of the aircraft.

Airbus' Skywise health monitoring platform helps airlines anticipate and prepare necessary maintenance actions while an aircraft is in flight.

Airbus is seeking to mature new technologies that can record deformation and stress. The next generation of aircraft may incorporate structural sensors to warn of impending damage or weakness in wing and fuselage structures. Airframers already use a variety of such sensors in testing, and research has proven the viability of embedding strain gauges into materials such as carbon fiber.

Meanwhile, Bickel at MTU still sees room for more data acquisition within the newest in-service generation of aircraft and engines. "Using sensors does not mean the data is by default also recorded," he says. "However, there is an increasing understanding that data acquisition and recording is important to gain a better picture of engine health. That in turn allows for a more targeted interpretation in case of unusual behavior, which is why MTU uses all applicable data that it can get for engine health analyses."

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AAR Goes Paperless

Digital work cards and processes are rolling out across AAR's facilities

Lee Ann Shay Rockford, Illinois

No "paper escapes"; people following the same processes across facilities; user-focused design that technicians actually enjoy using; enhancing customer communications; saving 538 trees annually and making more money—these are some of the reasons AAR is digitizing MRO operations and adding that functionality to Concourse, the platform the company built for operations and customer engagement.

Today airlines can send AAR 50,000-page paperwork packages for one aircraft C check. The company needs to ingest, print and manage all that. There is a fair amount of institutional knowledge embedded in the process, which does not translate to AAR's goal of having all its MRO facilities act as one when it comes to processes and procedures.

"Our paper-based operation works, but it's inherently inefficient," says Derek Janu-Chossek, a senior product manager.

Because of that, AAR is rolling out a digital MRO process—from the moment an airline delivers the work package to the moment AAR returns the aircraft. Intake of a work package now takes a couple of hours, compared with the days it took with the paper process, Janu-Chossek says.

AAR worked with United Airlines on the pilot program in Rockford, Illinois, through a dual process that showed the digital requirements matched the paper version. United still sent work packages as PDFs, but through a program AAR built using Microsoft Azure and a partnership with ChatGPT, "we digitally take it and split it apart through optical character recognition," Janu-Chossek says. A planner also will validate the output before MRO work begins. Because the program leverages neural networks, the more data that goes through the system, the better it will get.

AAR has worked with Microsoft for several years, but a couple of years ago it signed a "high-level commercial agreement" to develop products jointly using Microsoft technologies, AAR Chief Digital and Technology Officer Rahul Ghai says. This interests the IT giant because "we're putting the technology through hoops it hasn't been [through], especially in the aviation industry," he adds.

AAR started its first paperless line in April at its facility in Rockford and then expanded to two. Its Miami facility is in the midst of digitizing an airframe D check line, says Ryan Campbell, vice president of strategy, planning and innovation. Once that line goes fully digital, which should be very soon, "Miami is going to be off to the races," he adds.

AAR also is starting to roll out a digital line in Oklahoma City. That one is a lighter, four-day check.

"There's a change management component to all of this," Campbell says. "A four-day check allows everybody to just dip their toe into the water, understand how things are changing and be ready for a more robust check."

After that, AAR's Canadian facilities in Trois-Rivieres, Quebec, and Windsor, Ontario, should see their first digital MRO lines in December 2024 or January 2025.

Rockford's first line went through the dual process for four months because both AAR's technical staff and United Airlines' staff needed to acclimate to the new system. However, with each new line added, the process shortens.

The Miami facility has tested various technologies, including aircraft drone inspections, so the site "has really been fast on the uptake of digital MRO," Campbell says. "The training has been pretty seamless, and the user adoption and feedback have been positive."

AAR

AAR technicians are using a new paperless task card system in Rockford, Illinois.

In the bigger picture, AAR strives to become "significantly more digitally enabled," he says. For instance, the company seeks to layer other digital solutions, such as augmented reality for guided aircraft repairs, on top of its digitized MRO operation.

Digitalizing MRO does not only make turnaround times faster; AAR's staff likes it because it is easy to use and increases productivity. "A lot of what we're doing is just giving them the toolset to do everything more effectively and more intuitively and making the job ultimately that much more enriching for everybody," Campbell says.

AAR is deploying 1,500 tablets for technicians to use at its six facilities.

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Intelligent Engine Inspection

As AI grows more omnipresent in maintenance, MROs ponder bringing it up to human levels

James Pozzi Amsterdam

Artificial intelligence tools and programs are beginning to make their mark on the commercial aftermarket as more shops collaborate with specialists in the field to find ways to utilize the technology.

For engine maintenance, MRO providers are tapping into artificial intelligence (AI) tools to aid tasks such as inspections. Yet harnessing the data effectively and improving the overall quality of what is produced remain near-term obstacles.

Three-year-old AI startup Amygda, based in Derby, England, is working to tap large quantities of data generated through engines as well as some of their components such as line replaceable units, CEO and co-founder Faizan Patankar said at Aviation Week Network's Aero-Engines Europe here in September.

"We look to help some of the people closest to those engines and parts, such as the maintenance engineers and technicians, make sense of that data," Patankar said. "AI is one technology that's helping us bring that reliability and efficiency faster to the people who most need it."

Discussing applications to engine maintenance, Patankar described AI as the "parent category." "Underneath that, we have machine learning," he said. "But then again, we have machine learning on different systems." Given the multiplying data volumes used in aviation, he said engines are increasingly producing "unstructured information."

"These are subjects like, what is in your maintenance manuals and [enterprise resource planning] systems?" he said. "Bringing that data together, whether that's text or numbers, and making valuable insights from it is one set."

Another startup is Amsterdam-based Aiir Innovations. CEO and co-founder Bart Vredebregt said the company has worked with MROs, lessors and OEMs for several years with a remit to "get AI into the hands of as many people doing engine inspections as possible." Admitting the concept is so broad that it often leads to confusion about its application, Vredebregt said Aiir's software has become more commonly used in aviation businesses in recent years.

For engine maintenance, Vredebregt identified one effective MRO use case with computer vision, which enables analysis of images and videos to identify and learn objects and people. "We will look at something and try to see what's happening in the image for a task like borescope inspections," he said. "It's dividing cracks or dents into really something easy to understand visually."

When rolling out AI in an MRO shop, Vredebregt said, some studies have shown maintenance-related findings increase significantly. "Part of that is we make it easier to report, so that explains maybe some of the increases," he noted, adding that some of the findings were likely overlooked by suppliers or other third parties.

Arjan de Jong, principal of maintenance and engineering at the Netherlands aerospace center (NLR), said the research institute is using AI platforms for aerospace vehicles, operations and systems. De Jong said the NLR sees AI as something that can "perceive, reason and act."

De Jong noted that the NLR is heavily involved in projects related to robotics and robotic inspections. "In that case, we like to perceive what the condition of a particular part of an aircraft is, reason what is wrong with the part and the anomalies, and then act and give advice about what to do with the part based on the findings," he explained.

De Jong cited the ability of AI to reason as one of its specific advantages. "This makes it also possible to automate certain tasks and even make systems autonomous," he said. "That is an interesting concept because it can also

JAMES POZZI / AW&ST

Onstage at Aero-Engines Europe (from left): Lindsay Bjerregaard, managing editor for MRO at Aviation Week Network; Arjan de Jong, principle of maintenance and engineering at NLR; Bart Vredebregt, CEO and co-founder of Aiir Innovations; Wouter Kalfsbeek, unit leader of big data engineering at AFI KLM E&M; Faizan Patankar, CEO and co-founder of Amygda.

mean that you can do work by machine and that you can leave certain work to the machine, meaning improvement in working conditions for the mechanic, for example."

PERFECT FIT

Wouter Kalfsbeek, unit leader of big data engineering at AFI KLM E&M, said that since he began overseeing AI utilization across the unit 10 years ago, his team has grown from a handful of people to around 40. "The level at which we are using AI today is quite extensive," he said. "In the area of maintenance, it is used for predictions—an area where you can use a lot of AI and also for optimization where we try to make the best use of our assets."

Kalfsbeek described the maintenance industry as a perfect fit for AI predictions. "You have to deal with an enormous number of uncertainties and unknowns," he said, adding that drawing on historical data to start and then real-time data to make better predictions will ultimately lead to improved efficiencies.

One of the major predictive tools AFI KLM E&M has developed in the past 10 years is its Prognos platform for aircraft and engines. "Data is taken from the engines and the systems, and we try to translate that into the understanding of the health of these actual systems and then try to predict how much time that they'll have left until they run into failure," Kalfsbeek said. "Ten years ago we would have thought this impossible, but now we're doing it on an almost daily basis."

Kalfsbeek sees the number of use cases for AI rising and expects this to be even more dramatic over the coming years. Still, he considers relying on data over physical inspections or validations—to the point of using it to extend or even relieve maintenance inspection intervals and initiate maintenance actions—as further off. "That's the Holy Grail, but we're not there yet," he said.

AIIR INNOVATIONS

Aiir Innovations says its AI technology has increased the amount of maintenance-related findings during engine borescope inspections.

Kalfsbeek expressed concern about the quality of the data available. "This is a problem when working with AI, but it depends on what is being worked on," he said. "If you're taking data from sensors on an engine or an aircraft, these sensors are fantastic measuring systems and will ensure high-quality data. But compared to data collected from maintenance processes or transactions moving around the world from different owners—for example, from a lessor to an airline and then to a repair station—the data quality in these instances is often not as good.

"AI can help brush up the data quality, but most of that can be lost," Kalfsbeek continued. "So if a user doesn't invest in the right measurement system for this, it's still going to be quite hard to get the right quality of data to perform AI."

New technology, such as blockchain, is providing some solutions, he added. AFI KLM E&M uses blockchain to collect data over the life cycles of aircraft components and engine parts, enabling it to validate the data from other parties.

De Jong of the NLR also believes that innovation in the sector will continue to accelerate. "If we look at the scientific competitions that are going on in AI and their technologies, then it's amazing and there's a lot more to come," he said. However, he identified one hurdle in MRO inspections with robotics.

"When we build a robot that's going to inspect the aircraft part, we need to make sure that's done properly," he said. "One of the things that we need to provide in the process is that the observation and the diagnosis are indeed correct. We have to prove that a robot can do the same work as a human inspector technician."

In the long term, Aiir Innovations' Vredebregt believes the key to improving the quality of AI systems is to keep training them with more data inputs to make them smarter.

Broader concerns regarding AI "hallucinations" have been exacerbated over the past two years, and those naturally have trickled into the MRO segment.

"The word hallucination comes from the fact that people can use ChatGPT, which sometimes gives answers that are made up, hence the word hallucination is now everyday language," Patankar said. "Having looked at some of the big predictive maintenance platforms, there are hundreds of people who manually review what an alert or prediction is saying before it gets into an organization.

"ChatGPT democratized AI into the hands of the end users," he noted. "And aerospace is now in that phase where the thought needs to be the people using these tools will be the end users—whether that's engineers or technicians. Prediction errors have existed for years, but you just haven't seen them because you've been shielded."


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Doubling Down

FOKKER SERVICES GROUP

Fokker Services Group is expanding its MRO capabilities, workforce and global footprint

Lindsay Bjerregaard Amsterdam

Fokker Services Group has been on a growth and transformation path over the past three years, boosting its MRO capabilities, expanding its global facilities and implementing digitalization and sustainability strategies.

Following the 2021 acquisition of Fokker Services and Fokker Techniek and the businesses' 2022 rebranding to Fokker Services Group (FSG), co-CEOs Roland van Dijk and Menzo van der Beek have worked to approximately double the company's size. FSG has doubled its revenue and grown its global staff to over 1,000, up from around 500 at the time of the acquisition.

According to van Dijk, the pair sought to expand customer relationships as a driver for building up new capabilities. "[The existing customer relationships] were just a little bit underutilized and undermanaged, so we've worked on that side and the capability side," he tells *Inside MRO*. "There was a lot of knowledge and a lot of things that we could build further."

At MRO Asia-Pacific in September, Fokker Services Asia signed a contract to become an authorized service center for Embraer. Earlier this year, Fokker Services America rolled out integrated drive generator (IDG) capability and upgraded its facilities with solar power. Last year, FSG opened a new widebody hangar at Woensdrecht Air Base in the Netherlands that also features solar power and a geothermal energy system.

FACILITY REVAMPS

At Amsterdam Schiphol Airport, FSG has been upgrading its facilities to expand its repair shops, implementing new equipment, technology and design features to boost capacity and improve the environment for staff. One of the first to receive a makeover was the IDG shop, which FSG doubled in size at the beginning of this year. The shop is currently repairing around 60 IDGs a month and FSG wants to grow this capacity by double digits year-over-year.

Van der Beek says IDG capabilities were one of FSG's first investments beyond Fokker aircraft platforms, and in the past few years demand for those services has grown significantly. The decision to build an IDG shop in the U.S. was driven by both demand for more services and customer considerations around sustainability and nearshoring. "We are confident that if we build capability, [customers] are willing to send business there, so we have more or less upfront commitments," he says. "That will be an easy step up for that dual capability, and for the future road map, probably more duplication of capabilities will come forward, especially if we are able to create more volume on fewer part numbers."

Fokker has doubled the size of its integrated drive generator shop at Amsterdam Airport Schiphol.

To make space for the Schiphol IDG shop expansion, FSG relocated a mechanical shop and centralized all logistics activities at its nearby Hoofddorp warehouse. "It was one big puzzle," says Dirk Hanenberg, FSG's director of component services, noting that the facility's projects are using a phased approach to minimize disruption to other repair work there. "We basically had to free up some space, deploy the new setting and then go to the next phase of the reconstruction."

The expanded IDG shop includes more test benches and an automated machine that cleans IDG housings and piece parts. Hanenberg says automation has made cleaning faster and more consistent while also benefiting employee health and the environment, since workers are no longer exposed to chemicals and the self-contained machine reuses 95% of the liquids and solvents involved.

To improve staff experience further, the shop design maximizes natural light, with work benches close to windows and machines in darker corners. The Schiphol shop is working with FSG's Americas facility in LaGrange, Georgia, to share best practices as that location ramps up its own IDG shop.

"Because we are in different parts of the world, we are increasingly using our scale—not just from one location but also what we learn from other locations—to build efficiency," van Dijk says.

FSG is also expanding its Schiphol avionics shop, including new automated test equipment to support the Boeing 737 nose-to-tail program the company launched last year with Spanish airline AlbaStar.

The Schiphol facility's warehouse area was also recently upgraded as part of efforts to improve efficiency.

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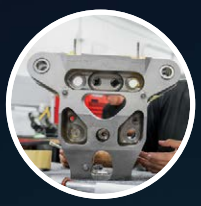
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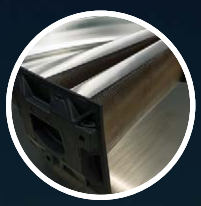
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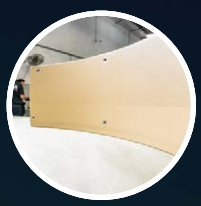
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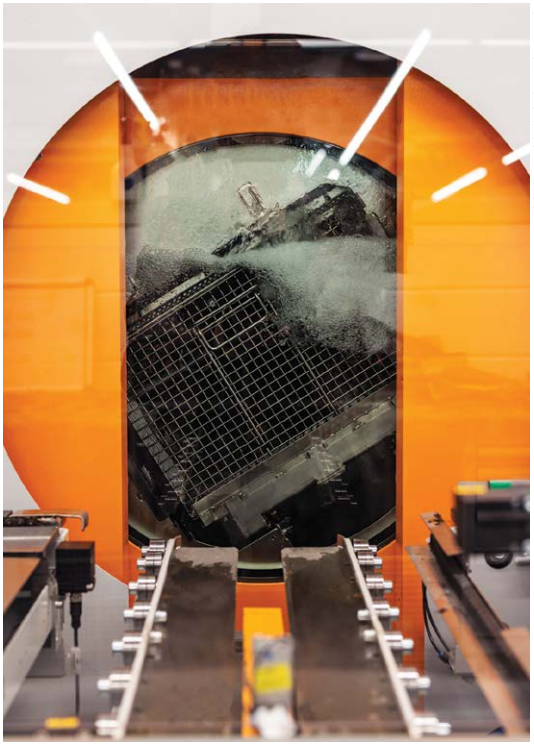
FSG invested in several new technologies, including vertical storage units and a system that allows operators to pick parts for multiple job cards simultaneously. The warehouse also features a pneumatic tube system for AOG part picks that propels required piece parts directly to the repair shop where they are needed. Hanenberg says it previously took an average of 7 min. to deliver parts for every AOG pick; the new system has reduced this to roughly 10 sec.

FSG has similar automation at its Hoofddorp warehouse, including Kardex vertical lift systems, automated parts conveyor belts and new digital processes to handle documentation.

"We're just trying to make the whole process more digital, step by step, so pictures are automatically uploaded to minimize the human part of handling stuff," says Franck Scherer, director of material services. "Compared to what it used to be a couple years ago, it's already well transformed, but there are still ideas and continuous improvement to bring. A lot of [employees] are coming with their own ideas as well, saying, 'Can we do this to make my life a little bit faster and easier?' It's a never-ending process of how to improve the flow."

Van der Beek says FSG started a big continuous improvement program two years ago that is the foundation of these innovations, and the whole organization goes through Lean Six Sigma training. He notes FSG has a dedicated continuous improvement group, including rapid deployment teams for specific issues. FSG's top priorities under this program have been improving turnaround times and on-time delivery.

"We hear from our customers that we indeed make a difference compared to others on turnaround time," van der Beek says. "We have been able to pretty much sustain 10-20% of our standard [turnaround time], and that is because we provision more aggressively on these parts and we have invested in exchanges to support it. We have been very aggressive in recruitment of people and [keeping learning curves short], and all those things are also driven from the continuous improvement initiatives."



FOKKER SERVICES GROUP PHOTOS

This automated washing machine for IDG parts and housings reuses solvents and eliminates fumes.

FSG also receives more offload from OEMs, according to van der Beek. "We now see that we can get significant volume from certain OEMs to manage offload because they can guarantee our performance within that spectrum but still serve their own customers so they don't lose them," he says.

Fokker is upgrading its Schiphol avionics shop as it grows those capabilities.

DIGITALIZATION AND WORKFORCE

FSG uses Pentagon 2000 and Veryon Tracking+ (formerly Rusada Envision) enterprise resource management software, and van der Beek says the company is working to create a suite of additional digital applications that can connect to these programs.

"We have an in-house development group that builds the software, advanced analytics, data factory platform, etc., and the intention is that within one or two years, we are digital in the hangar and in the workshop," he says. "The biggest challenge is the connection between the systems, because no system is completely suitable to get a whole loop into digital, but we're trying to make it happen."

Van Dijk says FSG has observed the MRO industry's workforce juniority challenge, but he sees an opportunity there with digitalization efforts. For instance, he says older, more experienced workers are often less inclined to use digital dashboards and prefer to print out documentation. "If we think about those new employees with a little bit less experience, they're much more used to [technology] and it's much easier to talk to them about it," he says, noting opportunities to use emerging technology such as artificial intelligence.

FSG wants to continue growing its workforce and is involved with many technical schools, including one on-site at its Woensdrecht facility.

"We realize there's no point in trying to get the next mechanic from KLM by offering €10 [($11)] more, because the next month KLM will offer €10 more, and we've got one employee going there," van Dijk says. "The only way, longer-term, that we solve these issues is training the people and getting them interested in this industry. When I was growing up, being in the aerospace industry was kind of like the pinnacle that you could reach, and we believe that we should get that fight back."

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The new hangar is expected to be operational by 2026.

Banking on Bengaluru

Air India breaks ground on a new MRO facility to grow its reach beyond the capital

Swaati Ketkar Bengaluru

Air India is leaving no stone unturned to develop its in-house line and base maintenance capabilities. The airline recently refurbished its widebody line maintenance hangar in Mumbai, and it also plans to build a new widebody hangar in Delhi to cater to the line maintenance requirements of its growing fleet.

"Delhi does not have a widebody hangar," said Sisira Dash, chief technical officer at Air India. "If any Air India widebody aircraft has to undergo line maintenance, we have to send it to Nagpur or Mumbai facilities, leading to added cost for the airline. Hence, the new line maintenance hangar at Delhi will cater to the basic needs of line maintenance as the Air India fleet will soon swell up with the Vistara merger drawing closer. The widebody hangar at Delhi is expected to be operational by 2026."

Speaking to *Inside MRO* at the groundbreaking ceremony of Air India's new MRO facility at Bengaluru's Kempegowda International Airport (BLR), Dash confirmed that the Bengaluru base maintenance facility will be spread across 35 acres and will have three widebody and nine narrowbody hangars.

"We will develop the capabilities in the new Bengaluru MRO starting with C checks on widebody and narrowbody aircraft. This will soon be followed by D checks on narrowbody [aircraft], gradually expanding the capabilities to D checks on widebody [aircraft]," Dash said, noting that the timeline to implement D check capability should take "a couple of years." However, he said widebody D checks may take longer due to their complexity and the availability of skilled labor.

The Bengaluru facility has garnered an investment of 14 billion rupees ($167 million) for the development of Phase I. Speaking during the groundbreaking ceremony, Air India CEO Campbell Wilson said the facility will see further expansion and investment potential, including additional hangars and a new paint hangar.

Air India says the new facility will be equipped with the latest maintenance technology, including overhead teleplatforms, cranes, universal docking systems and the largest vertical

AIR INDIA

Air India CEO Campbell Wilson (center) says further investment in the facility may include additional hangars and a paint hangar.

lift hangar doors in the country.

Once completed, the facility is expected to create about 1,200 new jobs for skilled aviation engineers and support more than 200 small- and medium-scale enterprises in Karnataka through an enhanced supply chain. To generate more skilled labor, the airline also is planning an aviation maintenance training school in Bengaluru starting in 2025.

MRO PARTNERSHIP CONSIDERATIONS

SIA Engineering Co. (SIAEC), the engineering arm of Singapore Airlines, will plan, construct, develop and operationalize the Bengaluru facilities under an agreement signed in May. SIAEC CEO Chin Yau Seng expressed hope to collaborate on more future MRO projects with Air India.

SIAEC's growing presence in India comes on the heels of the recent foreign direct investment approval on Singapore Airlines' $276 million investment in the Air India-Vistara merged entity. Singapore Airlines is due to invest up to $675.42 million after the merger is completed, which is due by Nov. 12. Vistara will operate its last flight on Nov. 11, and then Air India will operate all of its aircraft.

The selection of SIAEC to build the MRO facilities is also a part of Tata-backed Air India's extended plan to develop Bengaluru as its second aviation hub in the country, as the airline seeks to strengthen its operations beyond the capital. BLR achieved its record-high passenger traffic in fiscal 2024 with 37.5 million travelers, 32.86 million of which were domestic and 4.67 million international. The airport also continues to lead the perishable cargo sector in the Indian market with a total throughput of 439,524 metric tons in fiscal 2024, reflecting a notable 7.1% increase over the preceding financial year.

Air India's base maintenance previously was carried out by AI Engineering Services (AIESL), the airline's engineering arm before its privatization. Now, as the general elections in India are over, the privatization of AIESL might take shape soon. Although it is rumored that Air India might bid to take over its erstwhile engineering arm by partnering with Lufthansa Technik (LHT), Air India's recent collaboration with SIAEC has raised questions about its interest in buying AIESL. Now that Air India has found a new MRO partner, experts suggest the airline may ditch the AIESL deal if it is not lucrative enough.

Although Air India has been advancing plans to develop in-house line and base maintenance capabilities, it has also grown deals with third-party MRO providers. It recently signed a 12-year inventory technical management agreement with SIAEC to support its Airbus A320 family fleet, as well as a multiyear total component support agreement with LHT for its Boeing 777 fleet. The airline also has secured a long-term agreement with Honeywell for auxiliary power unit aftermarket support for its new and existing fleet.

African Opportunities

South African carrier Airlink considers adding MRO capabilities

Keith Mwanalushi London

Qatar Airways recently acquired a 25% stake in Airlink, bolstering the South African regional carrier's ambitions to grow operations across the continent. The immediate focus is on aligning networks, schedules and frequent-flyer programs, so it is likely too early to determine the implications of the investment on Airlink's approved maintenance organization facilities and capabilities. However, Airlink's efforts to develop its in-house MRO capability could provide opportunities for more third-party work.

Airlink performs both major and line maintenance. Johannesburg O.R. Tambo International Airport is the airline's main line maintenance base. "All the post-flight checks, defect rectification and scheduled maintenance, A checks, engine changes, [and] landing gear changes are performed on the line," says Morgan Chikurunhe, executive manager at Airlink's aircraft maintenance organization.

The facility also houses backshops, including an electrical workshop for the repair and overhaul of main batteries, generators and other electrical components. Wheel and brake overhauls are performed in a dedicated workshop, with the brakes also part of an airline pool program.

Airlink's outstations at South Africa's airports in Mbombela, Durban and Cape Town perform line maintenance. "Although we have aircraft night-stopping in Durban and Nelspruit [Airport], the two stations mainly attend to defects, perform the postflight and preflight inspections, and [conduct] very little scheduled maintenance," Chikurunhe explains.

Cape Town has become a small hub, with capability up to A checks on the Embraer ERJ 135. The facility performs a significant amount of scheduled maintenance on ERJ 135s and E-Jets, including defects as well as post- and preflight checks. "The capability in Cape Town allows for aircraft to be deployed at the station for significantly longer periods of time," Chikurunhe says.

For major maintenance, C checks are performed in the main MRO hangars, which are also equipped with backshops for composites, painting, structures and trimming. "We are working on bringing more in-house capability on the various

Airlink just leased its fourth E175 and appears to be interested in narrowbody acquisitions.

AIRLINK

switches that we send away for functional checks within the electrical shop," Chikurunhe says. Airlink outsources nondestructive testing but hopes to bring it in-house. The carrier also recently added safety equipment overhaul capability.

Airlink does not plan to perform third-party MRO services. "It's not our core business," Chikurunhe says. "However, on a very small scale and on an ad hoc basis, we will assist other operators as and when they request." He notes that to develop such services, Airlink would need to reach a stage where its fleet is no longer growing, its workforce levels are adjusted accordingly and its facilities are geared to take on the work.


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Sizing Up

Asia Digital Engineering opens Malaysia's largest aircraft maintenance hangar

Lee Ann Shay Kuala Lumpur

Asia Digital Engineering opened an L-shaped hangar on Sept. 26 that can accommodate 14 lines of narrowbody maintenance, making it the largest aircraft maintenance hangar in Malaysia.

The company, which is part of Capital A Berhad like AirAsia, will use the 380,000-ft.^{2} hangar mostly for AirAsia maintenance, but it also could take third-party aircraft, if slots become available. The new hangar will not satisfy growing MRO demand, though, so Asia Digital Engineering (ADE) already is planning another one.

Sepang Aircraft Engineering, an Airbus subsidiary that specializes in A320 and A321 maintenance, sits adjacent to the new facility and in between it and the five-acre plot that ADE is evaluating for the new four-line hangar.

In addition, ADE is talking with the Malaysia Airports Holding Berhad to acquire a 20-acre plot to enable it to build another hangar similar to the one that just opened.

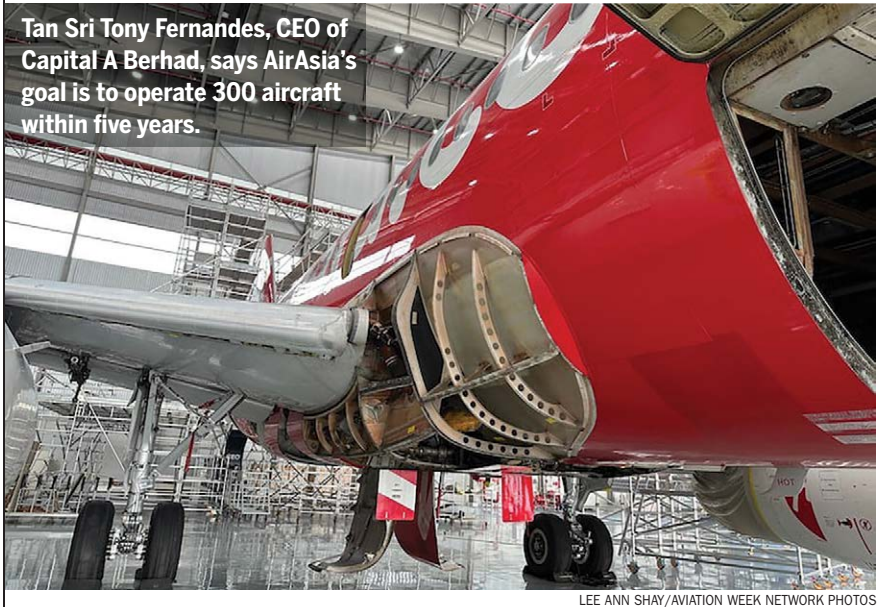
However, Tan Sri Tony Fernandes, CEO of Capital A Berhad, says the company also is looking at alternative sites outside of the Kuala Lumpur area.

"Today is a watershed day," Fernandes says, citing ADE's development of facilities, workforce and competencies as well as digital innovation over the past four years. In addition to the new L-hangar, he points to ADE's internally developed digital services—including the Aerotrade parts marketplace and Elevade, an aircraft health monitoring and predictive maintenance tool.

ADE is setting up various workshops, including composite, sheet metal, cabin interior, upholstery, oven and boiler, and 3D printing at the new facility.

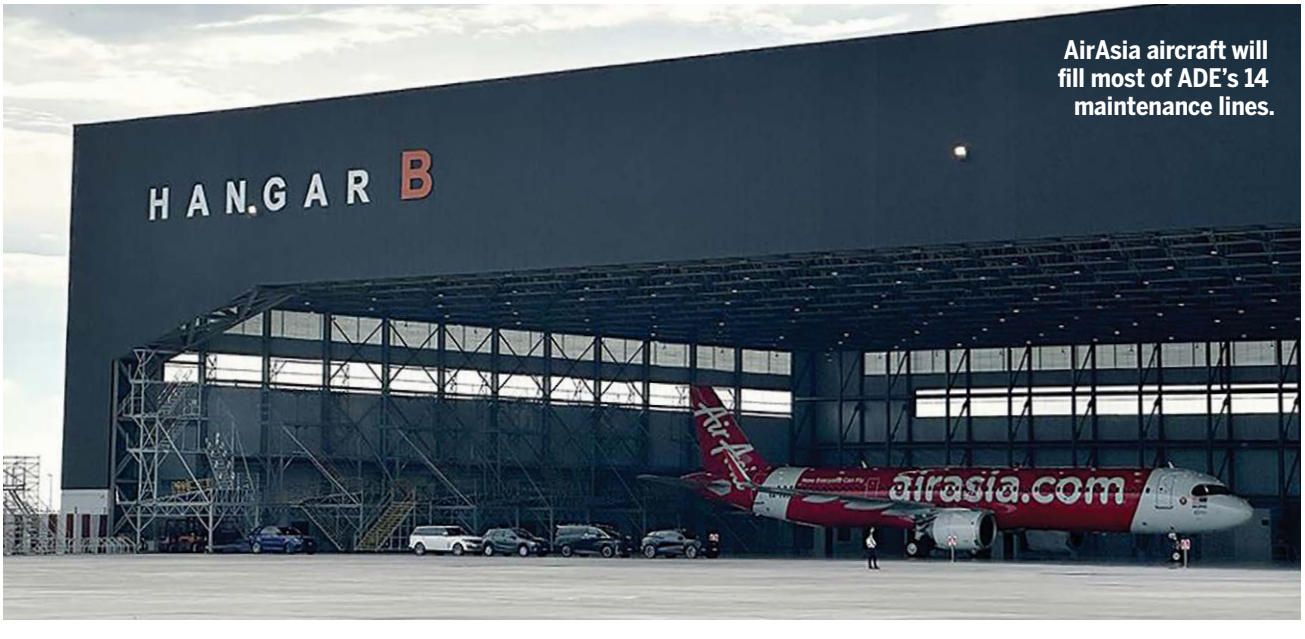
It also will seek additional MRO capabilities to increase ADE's efficiencies, Fernandes says.

Mahesh Kumar, ADE CEO, told Aviation Week that the company is in discussions with an engine shop, but he would not say if it is owned by an OEM or a third-party provider.



Tan Sri Tony Fernandes, CEO of Capital A Berhad, says AirAsia's goal is to operate 300 aircraft within five years.

LEE ANN SHAY/AVIATION WEEK NETWORK PHOTOS



AirAsia aircraft will fill most of ADE's 14 maintenance lines.

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Broadening Horizons

ITP Aero CEO **Eva Azoulay** *talks with* Inside MRO*'s* **James Pozzi** *about how the engine and component manufacturer aims to broaden its capabilities across multiple commercial engine types and eventually grow its aftermarket offerings.*

ITP AERO

Nearly one year after being appointed as CEO of ITP Aero, what are some of your near-term goals for the business? ITP Aero has built solid foundations over 35 years and across several engine programs, such as the Eurojet EJ200 and Rolls-Royce Trent programs, for which we have developed some of the core parts for many years, and most recently, the Pratt & Whitney geared turbofan (GTF), for which we manufacture combustors. Having joined the company last year, I'm looking at how we move forward as an independent company for the first time in our history and how we open doors to go out to the market and offer our capabilities to a broader group. How do we grow not just with Rolls-Royce programs but also with Pratt & Whitney ones? How do we look at a broader spectrum of OEMs where our capabilities can add value? Another big area is the life-cycle part. Before, our ownership structure limited our ability to play on the aftermarket, and this is where we think we have the most value. (Editor's note: Rolls-Royce sold ITP to Bain Capital in 2021.)

Which parts of the aftermarket do you think present good growth opportunities? ITP Aero has around 1,500 engineers and a strong operation that works with most engines, and it's no secret what the engine aftermarket needs in terms of capacity and capability. It doesn't matter which product, whether it's the existing in-service fleet or the brand-new fleets—there is a big need for services. We believe we can provide some of that capability to the market in different ways, whether it's repairs, hospital shop visits or even full overhauls, so we are very focused on growing those aftermarket capabilities.

Was ITP Aero's acquisition of Irving, Texas-based engine parts specialist BP Aero in February an early indicator of this aftermarket focus? Absolutely. We do have a strong footprint in Spain, where we do maintenance, repairs and overhauls, but this work is mostly for the Spanish defense forces. When we laid out our strategy last year on engine component repairs, we looked at building capability and access to specific markets. The U.S. market is a very significant one, but we didn't have much of a footprint there. Acquiring BP Aero gives us access to that market. On the capability side, it gives us hospital shop, component repair and teardown capabilities, while also opening us up to more engine programs in CFM International's CFM56 and Leap engines. This acquisition was about expanding what we can do and presented a very good fit for ITP Aero. We will continue to look at how else we can complement our global footprint while adding more capabilities that enhance our services.

What is the contribution of aftermarket services to ITP Aero's business now? Commercial MRO is a small percentage of the business. We used to do more commercial products, but when the business became 100% owned by Rolls-Royce, the focus toward Spanish defense work grew. But now we are rebuilding our commercial products in not just commercial aircraft engines but also helicopters and business jets. In the past year, we became a designated overhaul facility for MRO of Pratt & Whitney Canada (P&WC) PW200 engines at our facilities in Albacete, Spain, while also servicing General Electric CT7 engines. In business jets, we recently signed an agreement for the midturbine frame and low-pressure compressor modules of the P&WC PW800 engine for the Gulfstream G500 and G600 aircraft. As we continue to rebuild our product line, we aspire to make the aftermarket an increasingly important part of the business.

For commercial engines, much of the future demand will be generated by narrowbody engines, but given the widebody expertise related to Rolls-Royce programs, where will you look to steer ITP Aero's focus? We are talking to all the OEMs, and the fact we already have capability for both widebody and narrowbody segments helps us. We understand the Rolls-Royce customer base especially well, given our parts manufacturing expertise on some of their programs, while also having a deep understanding of the widebody engine market. Similarly, this is the case for the GTF in the narrowbody segment and some of the work we do for manufacturers in business aviation. We will not limit our scope—it's all about where the need is and deciding exactly where this needs to be met geographically, whether that's in Europe, the U.S. or somewhere else. That need could be for full overhauls, and we're looking at that, but we believe that component

repair is a key area not just in the execution of these repairs but also in their development. There's a widespread market of component repair specialists, but there are not a lot of companies out there with access to around 1,500 engineers, which gives us scope to do the development of parts repairs as well as the execution of them.

Will building up your services require more in-house capacity for ITP Aero or will it be able to utilize what it has available? There will likely be a bit of both. At our facility south of Madrid, we run a fairly large MRO facility where we do the Spanish defense maintenance, and have the capacity for more work volumes and could move things around quickly. To build a new MRO facility usually takes at least two years and requires a big investment in equipment and tooling, but we are at least equipped on certain engine programs. Existing capacity is there, and then, as we understand the needs of the market, we will look to make future investments. In addition to the facilities in Europe and the U.S., there is also a facility in Mexico within our network that had its origins in MRO, having carried out maintenance on Pratt & Whitney JT8D engines, and still has a fully operational test cell. Having that broad landscape also gives us access to the skilled labor we need. From an industry point of view, the talent pipeline is the biggest focus when meeting the ramp-ups we need to do—there are thousands of shop visits projected in a very short window of time.

The workforce issue is wide-reaching. What do you identify as the biggest challenge within this pillar of the industry? The biggest challenge relating to talent is not just about how you bring people in but also how you train them fast enough. The traditional model was normally one expert technician training a handful of people, but given the numbers required, that's just not fast enough for what we're going to need for support in the field. The industry needs to think differently about training and utilizing technology as it looks to ramp up its people. As a company, our reputation is strong in Spain, and while still in a competitive labor market, we've done a good job of retaining our talent. In Mexico, it is a more competitive labor market. We've done so much to really feed the ambition of the Mexico facility and make it so much more than merely a parts manufacturing facility. There, we do complex manufacturing and engineering, and supply chain functions with that, and we're even duplicating our castings facility in Mexico. These factors are all advantageous to growing the workforce looking for more than a simple parts manufacturing facility. In the U.S., the labor market is even more competitive, and the BP Aero business has focused heavily on both attracting and retaining talent. For the overall ITP Aero operation, we added around 10% more people last year, and currently we employ around 5,500 people in the business. We expect that number will grow by another 10% this year, so building up the workforce is a big priority.

Expanding Employment

Lufthansa Technik builds out its training and recruitment efforts

Lindsay Bjerregaard Chicago

German MRO giant Lufthansa Technik hopes to hire more than 2,000 workers this year, and it is utilizing several new initiatives to recruit and retain staff.

Recruiting has become more challenging in recent years as the job market has shifted to favor employees. "In the past, our recruiters primarily focused on selecting the right candidates from a large pool of applicants, conducting interviews and making final selections," a Lufthansa Technik representative says. "Today we often need to use headhunters, especially for specialized roles, sometimes even recruiting specialists from abroad."

Lufthansa Technik filled 94% of available apprentice and dual student positions this year.

LUFTHANSA TECHNIK

Lufthansa Technik (LHT) also has started to see the effect of Germany's low birth rates and a trend of high school graduates pursuing university education instead of trades, making it harder for the company to fill certain roles. Additionally, high requirements under aviation law mean many of LHT's new recruits participate in internal training programs before taking up roles on the shop floor.

The company welcomed 339 new apprentices and dual students at its German locations in August. LHT says this number has grown slightly from last year, and it filled 94% of available apprentice and dual student positions.

Women account for 9% of LHT's traineeships and 24% of its dual student positions this year. To continue increasing the proportion of women in its workforce, LHT has started a Women@LHT program focused on gender diversity and equal opportunities at the company. For instance, LHT has formed strategic partnerships with external networks to enhance its visibility as an attractive employer for female job candidates. It is also working to increase the visibility and development of women in the company, with the goal of increasing its proportion of women in senior management positions.

Additionally, the Women@LHT program holds various events, such as empowerment workshops, internal and external networking, and celebrations for special days, such as International Women's Day. LHT hiring managers and recruiters also now take unconscious bias training.

Approximately 17% of LHT's current workforce is composed of women. The company has deployed several other strategies to entice more female job candidates. These include targeted recruitment campaigns that highlight successful women in the company and emphasize career growth opportunities, partnerships with schools and organizations that support women in science, technology, engineering and mathematics and work-life balance initiatives, such as flexible working hours, part-time work options and what it says are family-friendly policies.

LHT also is looking to retain experienced workers who are considering retirement and to leverage the knowledge of retirees from external companies. Its Senior Experts Program allows retirees to contribute their expertise for a maximum period of up to two years to ensure knowledge transfer between generations. It utilizes mixed-age teams where experienced professionals share their knowledge with young workers. The program is available to employees who have completed partial retirement or signed a termination agreement close to retirement and retirees who want to share their professional experience with LHT. More than three dozen senior experts have been hired through the program or are going through the hiring process, the company says.

To appeal to younger generations, LHT is focusing on what it calls "low-threshold application" methods, such as the option to apply for a job via WhatsApp.

"One trend we observe is that younger generations, particularly Gen Z and Millennials, prefer quick and convenient communication methods. They are more comfortable using messaging apps like WhatsApp and are more likely to engage with companies that offer low-barrier application methods," an LHT representative says. "While such platforms don't replace the entire recruitment process, they can help access a wider range of candidates more quickly and move them through the hiring process more efficiently."

Beyond these initiatives, LHT continues to offer apprenticeships for deaf trainees every two years, and it is placing greater emphasis on recruiting international candidates. Although LHT has locations in the Middle East and Asia—two regions that traditionally have a large pool of skilled labor that is often recruited internationally—the LHT representative notes that these locations have not influenced the company's success with international recruiting. Instead, LHT has analyzed which countries have potential candidates and relied on targeted marketing and active sourcing strategies.

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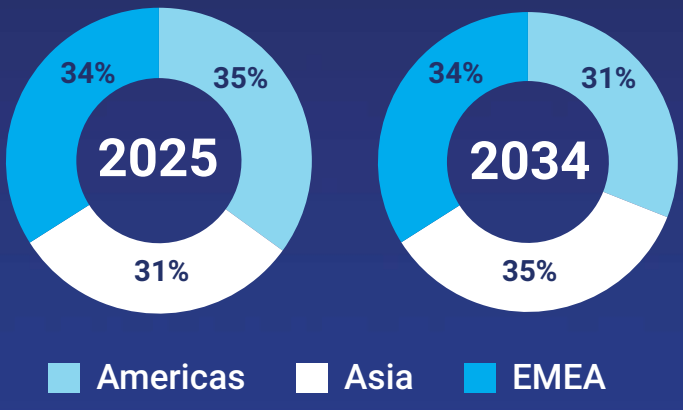

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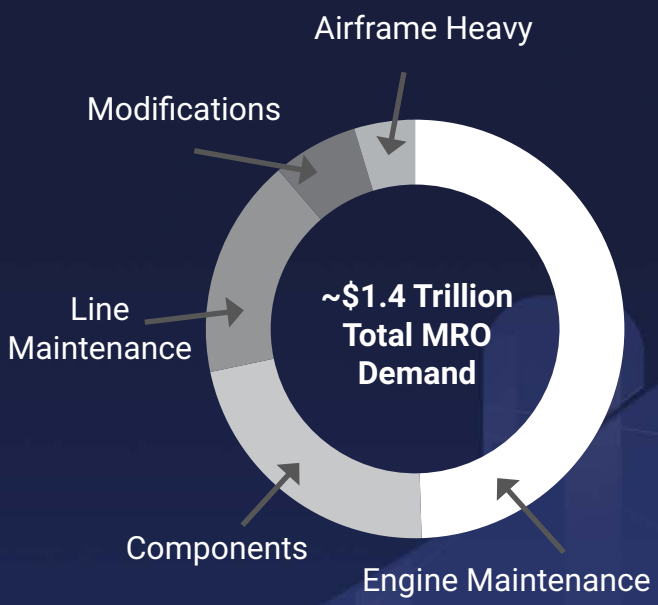

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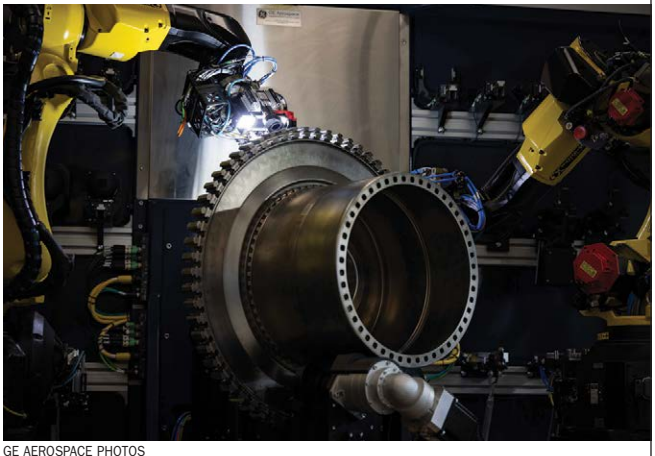
AI Aides

GE launches emerging MRO tech at its new acceleration center

Lindsay Bjerregaard Chicago

GE Aerospace has opened the doors of its new Services Technology Acceleration Center, which is designed to be the launching ground for several new advanced inspection technologies aimed at simplifying MRO processes.



GE AEROSPACE PHOTOS

Opened in September near GE's Cincinnati headquarters, the Services Technology Acceleration Center (STAC) will focus on advanced engine inspection, repair and overhaul technologies that the OEM wants to roll out across its global MRO network. The facility "will serve as a major accelerator for scaling and deploying cutting edge inspection and repair processes to market," says Nicole Jenkins, chief MRO engineer at GE Aerospace.

One of these technologies will be white light robot inspections guided by artificial intelligence (AI) to ease physical strain on GE's technicians while providing consistency and efficiency benefits. Sam Blazek, services technology leader for white light inspection at GE Aerospace, says he previously had to conduct these types of inspections "caveman style" by hand with a flashlight and mirror, needing to move his head, eyes and neck to manipulate these tools and interpret what he was seeing. "Staring at the same part or feature for 8-12 hr. a day can make your head hurt," he says.

The new inspection technology uses two articulated industrial robots outfitted with white light optical scanners to move carefully across the surface of a high-precision part, such as a turbine disk. Instead of requiring a human to interpret defects, such as nicks, dents, scratches and corrosion visually, the system uses AI to capture and analyze data while creating a digital record of the part's condition. Although the technology automates the inspection, technicians still will examine the results on a screen to make the final call about inspection findings and serviceability.

"By using AI and robotics, service engineers can increase the speed and efficiency of part inspections while improving the consistency of their results," says Jon Hootman, engineering director of the STAC. He adds that this is the first time GE has been able to capture all characteristics of a part in service digitally and catalog the data throughout its lifetime in a central repository.

"The beauty is that all of this together now pulls in the entire value stream to eradicate inconsistencies in your interpretation," Hootman says. "[It allows us] to make sure that we are applying the appropriate level of consistency and interpretation to the anomalies in question and give our customers a consistent experience, whether their asset is being overhauled in Malaysia or Brazil."

GE Aerospace's AI-guided white light robot inspection technology eases physical strain on technicians.

GE says the technology could have applications beyond inspection, such as cleaning, thermal spray and blending operations.

The STAC will be the first location at which GE Aerospace deploys a new inspection process for metal parts that uses the same type of technology that museums and auction houses use to identify forged artwork. GE partnered with scientific instruments company Bruker to develop a non-destructive inspection device that uses open beam X-ray fluorescence spectroscopy (XRF) to detect microstructural variations in metal parts. XRF can provide a view of an object's chemical composition, which in MRO can help a technician spot anomalies in a part more easily. Jenkins says the new inspection technology "will allow us to be even more vigilant with verifying the integrity of metal parts."

GE's open beam XRF device detects microstructual variations in metal parts.

In July, GE committed to investing $1 billion over the next five years in its MRO network to support a higher volume of shop visits, reduce turnaround times, upgrade equipment and machines, purchase new tooling, expand and improve facility infrastructure, and accelerate repair technology advancement.

In recent years, GE has developed several interesting robotics and AI-powered technologies for MRO processes. These include a worm-inspired robot that can crawl through the nooks and crannies of jet engine parts to detect defects, AI-enabled fluorescent penetrant and borescope inspections, automated welding technology, and snake-arm robots to provide better access to areas of the engine that are difficult to reach for cleaning, inspection and repair.

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Modern commercial aircraft incorporate tens of thousands of sensors that monitor major systems. Most of these are internal sensors that communicate with each other, but others provide data that can be monitored in real time outside the aircraft to inform decision-making around flight operations and maintenance. Other sensors feed actionable data that is downloaded at the end of each flight.

Given that engines are the most valuable parts of aircraft, the most expensive to maintain and much of an airline's fuel bill, they are the most sensor-rich systems on board. Historically, engine sensors provided critical measurements such as pressure, temperature and speed for engine control systems. Modern aircraft also use them for health monitoring to inform reactive, predictive or preventive maintenance, which has led to a significant increase in the number of sensors in modern engines. At the same time, modern engine sensors need to deliver greater accuracy while staying reliable in the harsher environment of the newest engines, which operate at higher temperatures and pressure ratios than their predecessors.

"The sensors themselves have evolved with technology to deliver higher performance and lower cost, weight or size, or some combination thereof," says David Milne, senior director of program management for engines at Honeywell Aerospace Technologies. He points to precision pressure sensors, which have evolved from complex and expensive laser-welded quartz to simple and rugged piezoresistive elements. "We are also seeing additional or alternate sensors for difficult-to-measure parameters such as oil level, oil debris, noncontact position and fuel flow," he adds.

Within the engine, the size and weight of certain sensors depend on the size of their protective packaging, which in turn has led to an increase in combination sensors, in which multiple sensor technologies are packaged into a single housing. For example, an engine gas-path-indicating sensor system might consist of a combination of temperature and pressure sensors.

"We have seen more combination sensors recently," Milne says. "Our pressure sensors commonly also have integrated temperature sensors, either for calibration of the pressure measurement or for separate purposes. There are also examples of position sensors, either linear or rotary, combined with temperature sensors, such as in bleed valves or similar."

The next generation of aircraft may be equipped with structural sensors to monitor deformation and stress.

Milne also points out efforts to make sensors and their housings more durable with materials like titanium or nickel-chromium superalloys. "For each sensor type, there are specific technologies and materials to improve durability," he says. "For example, diaphragms in pressure sensors are exposed to sensed media, which can be hot, corrosive or contaminated, so special diaphragm coatings are used to maximize the durability of the sensor; typically these don't affect weight, but could add cost."

He adds that modern thermocouple and resistance temperature detector sensors are "very reliable," with a mean time between failure of 1,000,000 hr. or more, although these periods are much harder to achieve with complex items like active, digitally compensated pressure sensors.

SIGNAL TO NOISE

Signals from engine sensors are sent to the full-authority digital engine control (FADEC), or engine health monitoring system, where they are analyzed and their data is stored and utilized by software algorithms for engine control and monitoring. Some of these signals may be further transmitted from the FADEC to the flight deck to provide real-time engine operational displays to the pilots.

The FADEC protects the engine from excessive speed and temperature by monitoring these metrics and taking mitigative actions while also making adjustments to optimize performance. As engine technology has evolved, more sensor inputs have fed into the FADEC, and some of the newest engines, such as the CFM International Leap, have a second FADEC to monitor additional parameters.

Health monitoring systems are also evolving to act on wider sensor input. For example, Rolls-Royce's engine vibration and health monitoring unit (EVHMU) provides instant access to around 10,000 engine performance and health parameters with what the company describes as "unprecedented levels of data quality." The EVHMU monitors pressures, temperatures, vibrations and—in a new development—

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line replaceable units. "This will ultimately enable us to remove a unit before it ever causes a flight disruption," says Nick Ward, vice president of digital systems.

Some engine-makers expect more maintenance actions to be generated by sensor feeds to health monitoring systems than by physical inspections.

"Rolls-Royce is developing improved EVHMU and engine monitoring units to allow for greater data gathering and easier transmission of data from all the latest sensors fitted to our engines," Ward adds. "These improvements will come as we roll out these new components, and we will work with the aircraft OEMs to integrate where possible with their systems."

LUFTHANSA TECHNIK

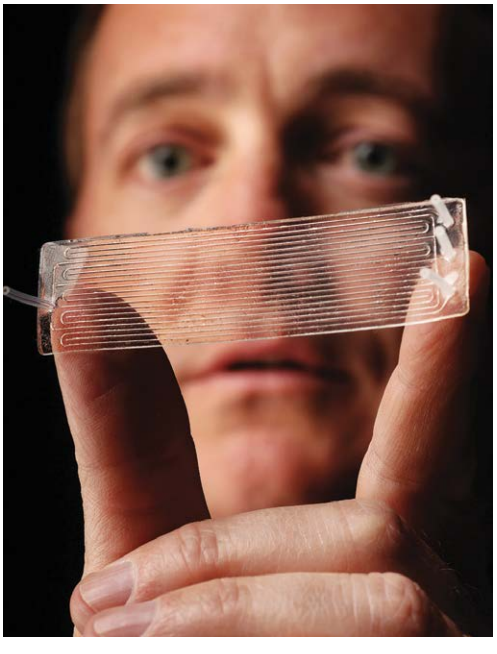
The evolving capabilities of health monitoring systems and the machine learning algorithms that process their data mean more sensor inputs than ever before can be meaningfully analyzed. However, this does not necessarily mean that engines will pack in ever more sensors, says Milne, who notes that advances in software can in some instances reduce the need for hardware.

"In some cases, we have been able to take advantage of sophisticated algorithms and analytics to synthesize parameters rather than measuring them, thereby eliminating sensors," he says.

This may help to mitigate dips in supply. Milne notes that sensors, like many other aircraft systems, have faced supply chain problems. "Sensors that have integrated electronics are exposed to the same challenges regarding availability of foreign-sourced semiconductors," he says. "The CHIPS Act from the U.S. government is addressing this in a positive way and has helped Honeywell expand and modernize our electronics manufacturing capability. . . . Vertical integration gives us more control of our destiny."

Software can also improve accuracy, Milne says, which is important given that it is difficult to achieve big gains in this respect from the engine sensors themselves, which are relatively mature and proven technologies.

"With the substantial computing power in our modern FADECs, we can perform sophisticated calibration and linearization to improve accuracy," he says. "We can also employ sensor fusion of not only multiple sensors, but also synthetic parameters that are generated by onboard algorithms and models."



SANDIA

Air pressure is applied to channels etched into the underside of this CVM device for structural health monitoring.

NEW INPUTS

One relatively untapped use of sensors is embedding them in aircraft structures to monitor stress and deformation of materials like metal and carbon fiber. Most of the major airframers have conducted extensive research and development of the necessary technologies, with many flight hours now logged on pilot programs such as Delta Air Lines' Boeing 737-700s and Brazilian carrier Azul's Embraer 190s.

President and CEO of Embraer Services & Support Carlos Naufel says that the manufacturer's Aircraft Health Analysis and Diagnosis (AHEAD) platform "is equipped with capabilities to detect and alert operators of adverse exceedance events, ensuring timely maintenance interventions."

The Structural Monitoring Systems sensors used in the Delta trials were based on comparative vacuum monitoring (CVM) technology, which applies small, self-adhesive elastomeric patches to the material being monitored. Cracks are then sensed if there is any change to the vacuum pressure applied to the sensor's built-in rows of interconnected channels.

However, CVM sensors need to be positioned at the point where a crack occurs. Another maturing technology is the piezoelectric sensor, which can be used in ultrasonic or acoustic mode in a network design to monitor a larger structural area for damage.

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Rise of Robots

Lindsay Bjerregaard Chicago

1. Engine Innovations

Company: GE Aerospace
Product: (1A) GE Aerospace has developed a range of robotics technologies with applications for MRO, including engine inspections, repairs and cleaning. One of the most recent is artificial intelligence (AI) guided white light robot inspections, which use two articulated industrial robots outfitted with white light optical scanners to detect defects on high-precision engine parts. The system uses AI to capture and analyze data while creating a digital record of the part's condition.

(1B) GE also offers a robotic nondestructive inspection device that uses open-beam X-ray fluorescence spectroscopy to detect microstructural variations in metal parts. The technology—also used by museums and auction houses to identify forged artwork—provides a view of an object's chemical composition, allowing technicians to spot part anomalies more easily.

(1C) Last year, GE developed a wormlike robot called Sensiworm that uses untethered soft robotics technology. Sensiworm can move easily through the nooks and crannies of jet engine parts to detect defects and corrosion, as well as to measure the thickness of an engine's thermal barrier coatings.
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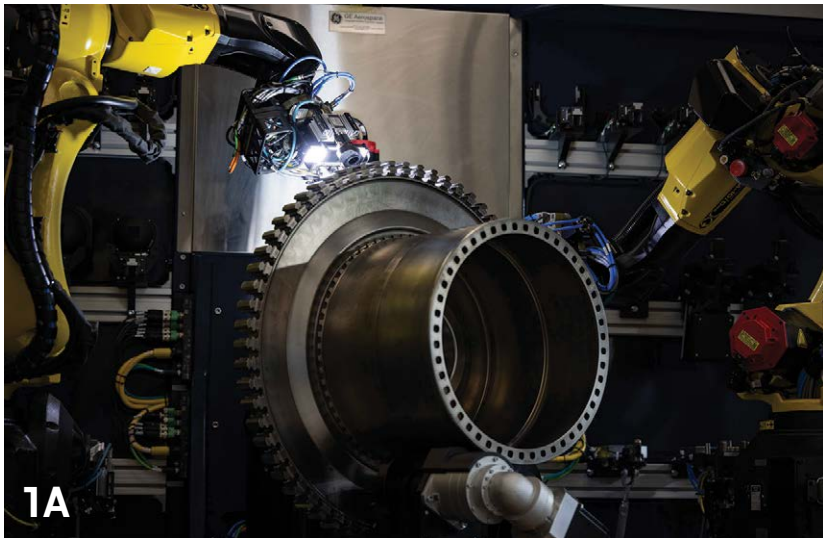
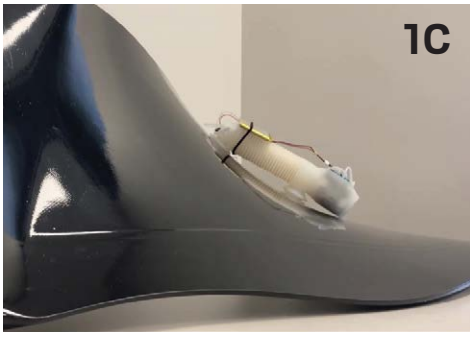


1A-C: GE AEROSPACE



2. Material Removal

Company: Kane Robotics
Product: Kane Robotics develops collaborative robotic (cobot) systems for material removal applications such as sanding, grinding and polishing. Aerospace customers, such as OEMs and suppliers, use these systems for tasks such as removing coatings from helicopter main rotor blades and sanding and polishing aircraft transparencies. Last year, Kane Robotics launched its GRIT cobot for composites sanding. GRIT comes in three sizes to accommodate a variety of jobs, and the system combines AI with visual sensors to automate its accuracy and speed.
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3. Accelerating MRO Processes

Company: **RTX**
Product: Aerospace and defense conglomerate RTX is deploying a wide variety of robotic technologies across its Collins Aerospace and Pratt & Whitney subsidiaries.

Collins Aerospace is using several robotics technologies in Singapore. At its nacelle MRO facility there, the company has created a robotic machine vision system called Spot that works alongside human operators to conduct automatic inventory inspections for Pratt & Whitney PW1100G-JM buildup quick engine change kits. Collins says Spot can inspect 159 items for the kit within 20 min.

(3A) Collins' Singapore evacuation slide and cargo system MRO facility is using an Autonomous Mobile Robot on wheels to transport parts around the shop floor. The company says this has helped reduce turnaround times on these systems by 10%.

(3B) At its MRO facilities in Singapore and Dijon, France, Collins has deployed Automated Optical Inspection (AOI) arms that perform final inspections of integrated drive generators. The AOI automatically captures, identifies and categorizes the generator's features, then summarizes the results and alerts technicians of any defects. Collins says the AOIs have helped reduce final inspection times by 20%.

(3C) Pratt & Whitney's Eagle Services Asia engine center in Singapore is using a robot called Alfred to assemble high-pressure compressor rotors for the PW1100G-JM, which it says has cut assembly time in half. Alfred will soon be joined next year by a robot called Athena that will perform part of the main engine build sequence.

(3D) Pratt & Whitney is using a Receive-in-Check cobot to photograph engine components automatically when they arrive at an engine center. Previously, technicians had to take approximately 60 photos manually with handheld cameras—a process that was prone to inconsistencies in image size, angle and clarity. Pratt says the cobot has reduced the time taken for this type of inspection by 4 hr. per engine and reduced the workload by 90%.

(3E) Pratt & Whitney is also using a robotic arm to stack high-pressure compressor rotors automatically. It says automating this process protects operators from the weight and heat involved in assembly and has shortened processing time by 50%.

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3A-B: COLLINS AEROSPACE

3C

3D

3E

3C-E: PRATT & WHITNEY

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By CRAIG GOTTLIEB

Craig Gottlieb is Accenture's managing director, aerospace and defense.

Generating Advantage

Although generative AI is not a cure-all for MRO, it can create value when deployed thoughtfully

I am all for the odd gimmick. Still, "writing" this column using generative artificial intelligence was a shark waiting to be jumped.

Amid generative artificial intelligence's (AI) grand entrance into our lives and work, typing words into a set of paragraphs may even qualify as a bit rebellious. As with broader society, the aerospace industry is emerging from its early AI encounters with heady views about its possibilities. As technically impressive as generative AI may be, it is important to weigh its influence equally on how work gets done.

First, a definition. Generative AI is a type of AI that can create new content based on patterns learned through sources such as text, images, audio, structured data or computer code. Broadly, generative AI is good at two things: augmenting analytical insights to accelerate action and automating data and text-rich functions. Think of optimizing rotable pools managed in multiple enterprise resource planning (ERP) systems or the automated publishing of technical documents. Given aviation's data wealth, generative AI offers opportunities to critically rethink the workings of the aftermarket value stream. Indeed, Accenture's research suggests that 53% of working tasks within aerospace and defense have the potential for automation or augmentation powered by large language models and generative AI.

How do we even get to a number that big? The opportunity lies in changing how the work of the aftermarket is performed. Take, for example, spare parts planning and inventory management. Today, these functions are often divided across demand, supply and inventory planning as well as organizationally between original equipment and the aftermarket. The effort to bridge these cross-functional divisions in data, process, workflow and decision authority reduces the responsiveness and accuracy of spare parts supply chain decisions and actions.

Creating value through generative AI will strongly correlate to organizations' success in changing how work is done.

Here, generative AI offers a unique ability to cut across data and functional silos to provide natural, intuitive insight to business questions. As demand, supply and inventory insights and recommendations become concurrently available through generative AI, the planning process moves from individually optimizing for these factors to a holistic planning process that could improve part availability by over 10%.

As processes are automated or augmented through generative AI, the work that occurs within those processes starts to look quite different. Analysts can spend less time sourcing data and more time analyzing it. Technicians can identify faults by asking questions rather than combing through manuals and knowledge repositories. The augmentation or automation of processes can redefine how work gets done and the skills we require to do our work.

For example, for a technician using a generative AI agent to identify the response to a fault, the skill of writing a prompt becomes increasingly important relative to the skill of understanding all the systems where faults or answers might be located. Creating value through generative AI will strongly correlate to organizations' success in changing how work is done, building strong cultures around responsible AI and aligning the skills of their workforces to take advantage of more automated, intuitive access to information.

Generative AI promises quite a lot. Yet promises such as fewer silos, faster answers and new ways of work also sound like the promises of wearables, blockchain, integrated MRO and ERP systems, and countless other technologies that the aftermarket has embraced over the past decade. As all aftermarket or IT leaders should rightfully ask, is there anything different here?

There is. The availability of scalable, powerful computers that use generative AI to automate and augment processes across multiple sources of data and applications is a fundamentally different premise than driving process change by consolidating functions into a single software application. Importantly, prior investments in ERP and other technologies are essential precursors for the success of generative AI. A trusted "digital core" is a competitive advantage, but all MROs can begin experimenting with generative AI, particularly in setting the foundation for responsible AI.

As with all technologies, generative AI alone is no cure-all. Getting it right requires both a digital core and the organizational courage to rethink how work gets done across the highest priority areas. Organizations that embrace generative AI create opportunities to gain the marginal time, capacity and predictability that make all the difference in MRO.

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MRO Australasia takes place on November 13-14, 2024, at the Sofitel Brisbane Central, once again supported by the Queensland Government as Host Sponsor. The two-day conference gathers over 360 attendees from across the aftermarket to debate the crucial issues that impact the MRO business in this region. MRO Australasia offers a variety of networking and learning opportunities, including a Meet the Buyers program for airlines and suppliers as well as two evening receptions. The MRO Australasia Showcase, located directly outside the conference room, will enable you to foster new relationships, strengthen existing ones, and expand your reach across the community. Get hands-on with the latest technologies, tools, services, and resources that will translate into solutions and savings for your organization! Learn more at: mroaustralasia.aviationweek.com.

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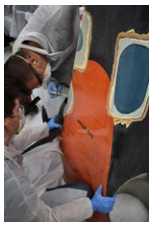

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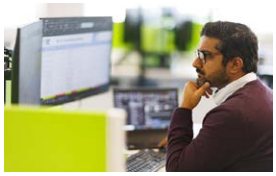

As the aircraft lease extensions dynamic continues for previously scheduled lease returns, the CAMO team are supporting several distressed aircraft, aircraft redeliveries, standalone ARC inspections, aircraft tear downs, and retrieving original delivery documentation and BtB paperwork for key components on an aircraft to mitigate procurement of aftermarket or new component parts with long lead times and high costs.

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Europe's Hera Mission Assesses NASA's Asteroid Deflection Effort

- PROBE HEADS FOR A MARS SWINGBY TO PROPEL IT TO DIMORPHOS
- WHEN HERA REACHES DIDYMOS, IT WILL BE ABOUT 121 MILLION MI. FROM EARTH

Robert Wall London

As the European Space Agency's Hera planetary defense mission embarks on its two-year journey, it may have already validated one of its key objectives: Europe's ability to put together and launch the spacecraft quickly.

The European Space Agency (ESA) on Oct. 7 launched the Hera spacecraft on a SpaceX Falcon 9 along with two cubesats on its way to the Dimorphos asteroid as the second part of the multinational Asteroid Impact and Deflection Assessment project. It marks Europe's first planetary defense mission.

Hera is effectively a scientific follow-up to NASA's Double Asteroid Redirection Test (DART) mission, during which a 1,260-lb. spacecraft struck Dimorphos at 3.8 mi./sec. on Sept. 26, 2022. It demonstrated the viability of a kinetic impact strategy for diverting a near-Earth object. Ground telescopes assessed a change of orbital period, and scientists are now looking to Hera to deliver detailed answers on how the collision caused the asteroid to change its behavior.

ESA also has looked to the roughly $400 million mission to show it can change pace rapidly, said Holger Krag, ESA manager for Space Safety Programs. The agency awarded OHB a contract to build Hera in 2020, and proceeding to launch in four years validated the ability to react quickly, he told reporters ahead of the launch.

"We have learned a lot" working on Hera, said Sabine von der Recke, an OHB official.

ESA faced a somewhat narrow launch window for Hera to be able to rendezvous with Dimorphos, which is expected to occur Dec. 28, 2026. Given the time constraints, ESA opted to launch on the Falcon 9 amid uncertainty about the homegrown Ariane 6's availability when the agency had to make a decision. But with the Ariane 6 now flying, and the light-medium Vega-C launcher due to return to flight before year-end, ESA expects future missions to rely on European rockets, ESA Operations Director Rolf Densing said.

The Falcon 9 took off at 10:52 a.m. EST from Cape Canaveral SFS. SpaceX operated the mission with special permission from the FAA after an upper-stage anomaly during the Sept. 9 Crew-9 mission that successfully delivered two crew members to the International Space Station. The glitch that ESA described as a kerosene leak briefly paused the launcher's operations and sparked an FAA-required investigation, but the agency allowed this launch because it did not involve a second-stage reentry.

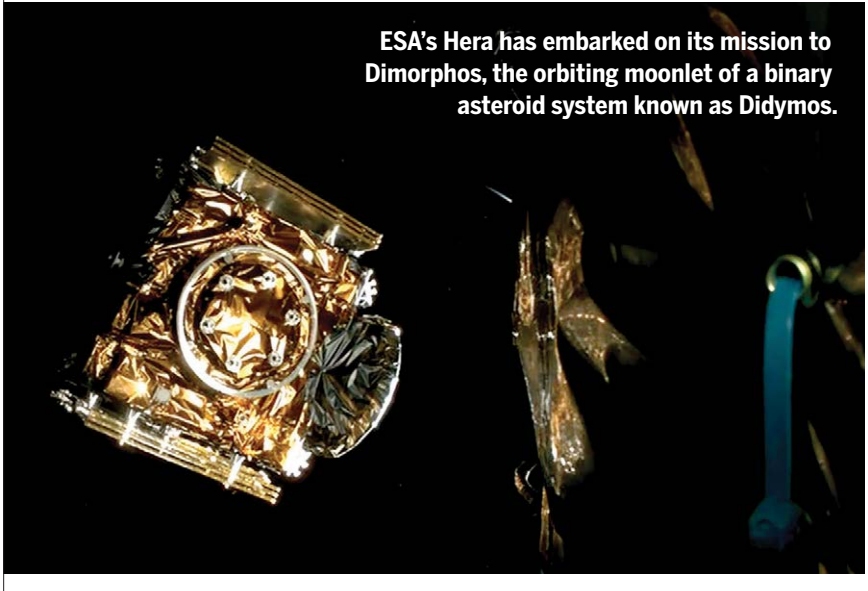
The launch put Hera on a voyage that includes an initial deep-space maneuver in November and a mid-March Mars swingby to gain momentum to reach its target. ESA plans a second deep-space maneuver in February 2026. Hera is due to arrive in the vicinity of the Didymos asteroid system that includes the satellite Dimorphos in October 2026. When the spacecraft reaches Didymos, it will be about 121 million mi. from Earth.

Scientists are hoping Hera will deliver answers about Dimorphos' mass and internal structure and how the DART impact affected the asteroid, including whether it caused a crater or reshaped its body, says Michael Kueppers, Hera project scientist.

After a first phase of remote observation, ESA plans to deploy the two cubesats—Juventas and Milani. The three spacecraft will make progressively closer flybys, down to less than 1 km (0.6 mi.) from Dimorphos.

Instruments on the mother spacecraft include two cameras, which will serve both navigation and science imaging purposes. At the point of the closest phase of observation, Kueppers says the sensors should deliver 1-cm (0.4-in.) resolution. A spectrometer in visible and near-infrared wavelengths is supposed to provide information on the asteroid's composition, while thermal imagers will measure temperature and find physical properties of surface areas. ESA plans to rely on a laser to calculate distances precisely and determine Dimorphos' detailed shape.

The Juventas cubesat is due to land on Dimorphos. Ahead of that event, it is intended to undertake the first internal radar sounding of an asteroid, ESA said, to determine the asteroid's inner structure. Once landed, Juventas is slated to measure the asteroid's gravity field. Milan also is due for an uncontrolled soft landing on the asteroid once its scientific mission has concluded, and the cubesat could provide additional data on Dimorphos' solar dust. The cubesats are designed to relay the data they collect to Hera via an intersatellite link.



ESA's Hera has embarked on its mission to Dimorphos, the orbiting moonlet of a binary asteroid system known as Didymos.

ESA

PLD Space's Vision Could Shake Up European Space

- EU COMPETITIVENESS REPORT WARNS OF SPACE "INVESTMENT GAP"
- PLD'S PLANS INCLUDE EUROPE'S FIRST SUPER-HEAVY LAUNCHER

PLD SPACE PHOTOS

The Spanish space startup plans to make its first Miura 5 orbital launch in 2025 from the European spaceport in French Guiana.

Robert Wall London and **Thierry Dubois** Lyon

As Europe grapples with how its institutions can bolster the region's space ambitions in the face of growing competition, a Spanish startup proposes that it can deliver the innovation governments have not been able to furnish.

Launch service provider PLD Space—which achieved the first launch of its Miura 1 suborbital rocket only a year ago—has quietly been working on plans to develop within the decade Europe's first crewed space capsule, along with a family of heavy-lift launchers. The goal is "to lead the space industry from the continent of Europe," Executive President Ezequiel Sanchez says.

PLD aims to achieve the first orbital launch of the Lince crewed capsule in 2030, CEO and co-founder Raul Torres said at a Oct. 7 event where the company detailed its growth plan. The vehicle is being designed to accommodate four or five astronauts within an 8-m^3 (282 $ft.^3$) space and have a payload capacity of about 5 metric tons to orbit.

The Lince's first tests are planned for 2025, with the goal of achieving a first uncrewed test flight of the capsule using the Miura 5 small satellite launcher in 2028. The operational vehicle would also be designed to transfer humans for future Moon missions, Torres added.

PLD has been working on the concept for about a year, he said. The first orbital launch would likely include three instrumented dummies, stay in orbit about three days and splash down in the Atlantic Ocean or Mediterranean Sea.

In 2022, industry players in Europe such as the European Space Agency (ESA), French space agency CNES and launch service operator Arianespace failed in their lobbying for a crewed flight program. Still, they highlighted that Europe was in a stronger position than many imagined, having mastered most of the required technologies.

"The space sector is suffering from a marked investment gap with its major competitors."

The continent's engineers have experience in life support, propulsion and atmospheric reentry, as well as guidance, navigation and control. The only identified exception was the launch abort system that would separate the crewed capsule from the launcher in case of a problem in the early stages of flight. There, they said, European industry would have to start from scratch.

PLD Space is spelling out its vision at a time when the European Union has been fretting about its competitiveness across a range of industries. In a September report, Mario Draghi, former head of the European Central Bank and former Italian prime minister, put forward more than 150 recommendations to fix the problem, including in space and defense.

"The space sector is suffering from a marked investment gap with its major competitors," the report states, adding that for the past 40 years, investment has been at 15-20% of U.S. levels. The Draghi report recommends that Europe update government and investment rules and coordinate public spending better to create a true single market for space.

In addition to the space capsule, PLD unveiled rocket plans beyond its Miura 5 launcher with the Miura Next, Miura Next Heavy and Miura Next Super Heavy. Those launchers would give Europe a heavy-launch choice beyond various versions of Ariane rockets for the first time.

PLD would launch the operational Lince capsule on a Miura Next rocket slated for its inaugural flight by the end of the decade, Torres said. The two-stage Miura Next would be 60 m (197 ft.) tall with a diameter of 3.5 m. It is being designed to be able to transport around 4.5 metric tons to geostationary transfer orbit (GTO).

About a year or two later, PLD hopes to launch the next version in the family, the Miura Next Heavy, with a 67-m-high core. It would feature two strap-on boosters and the ability to carry more than 15 metric tons of payload to GTO.

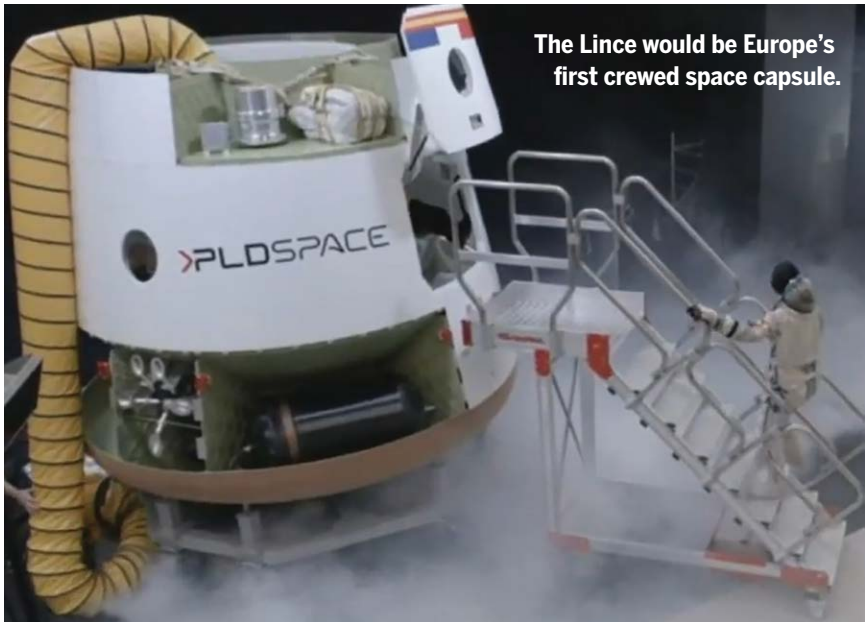
The third member of the launcher family, the Miura Next Super Heavy, would feature four boosters around the core. It would be Europe's most powerful rocket and could be ready to launch around 2033, Torres said. The rocket would be able to lift 23 metric tons to GTO, or log almost 17 metric tons of payload for a Moon mission or 13.7 metric tons for a Mars mission, he said.

But PLD's ambitions could spark tensions in Europe. Even ahead of the company's disclosure, Arianespace CEO Stephane Israel warned about internal competition within the region. "Europe does not need

two heavy launchers," he told reporters in September. Arianespace was the launch service provider for the Ariane 5 heavy-lift rocket and now operates the Ariane 6 heavy launcher.

Before PLD can challenge Arianespace, it still needs to bring its first orbital launcher to market—and to fly its Miura 5. The company plans to make the first qualification launch late next year from the European spaceport in Kourou, French Guiana, with a second due in 2026. The company then plans to increase the launch pace rapidly, with five commercial launches planned in 2026, followed by 10 slated for 2027, 16 for 2028, 24 for 2029 and 30 for 2030.

PLD also spelled out plans to make its rockets reusable to lower costs. The company will introduce recovery with the Miura 5. The booster would return to Earth using a parachute landing system, which the company plans to evolve into a fully recoverable system with rockets landing on ground or a vessel. The Miura Next family would also feature launcher reuse.



The Lince would be Europe's first crewed space capsule.

Ariane 6 prime contractor ArianeGroup is pursuing reusability as well through its acquisition of MaiaSpace, which intends to start commercial operations from Kourou in 2026. However, Arianespace says it has no plans to introduce reusability on the Ariane 6, signaling that such a development would be left for a future evolution of the rocket.

How To Spend It

> AIRCRAFT LESSORS FIND GROWTH AVENUES MORE THORNY

> HIGHER LEASE RATES SUPPORT MARGINS AND ARE HERE TO STAY

> PROFITABILITY HAS RECOVERED THROUGH STRONG DEMAND

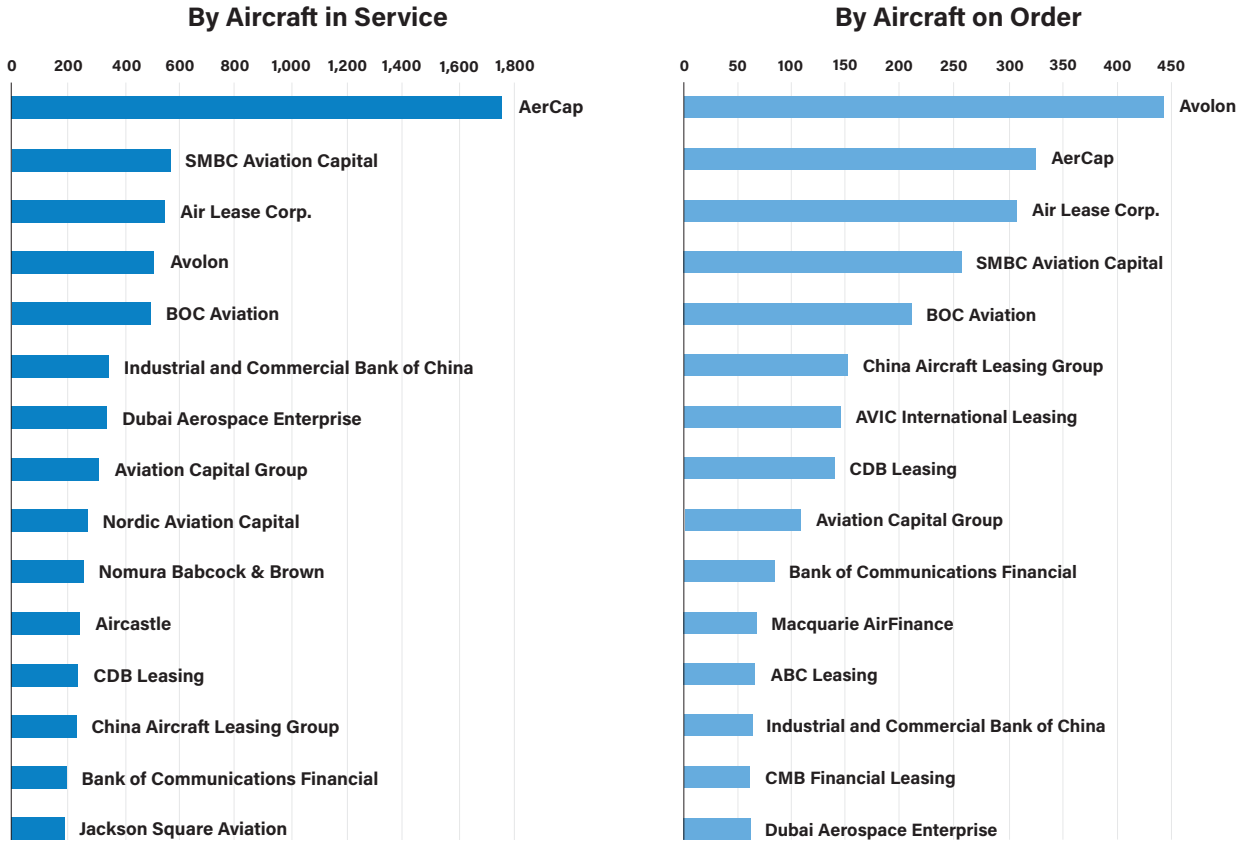
Jens Flottau Istanbul

The big lessors have all been in growth mode for years. Even during the COVID-19 pandemic, thanks to their financial strength, most continued on that path while rescuing a substantial number of airlines through sale-leaseback deals and restructured agreements along the way. But a confluence of complicating factors has made it much harder for even the biggest players to capitalize further on their strengths despite the availability of ample capital.

There are essentially four ways for lessors to grow: direct orders, sale-leaseback transactions, aircraft or portfolio trades between lessors, and finally mergers and acquisitions. "All four are difficult—there are high execution risks, uncertainty on timing and competitive dynamics," Aviation Capital Group CEO Thomas Baker notes. "Growth is getting much harder."

Before anyone feels sorry for the

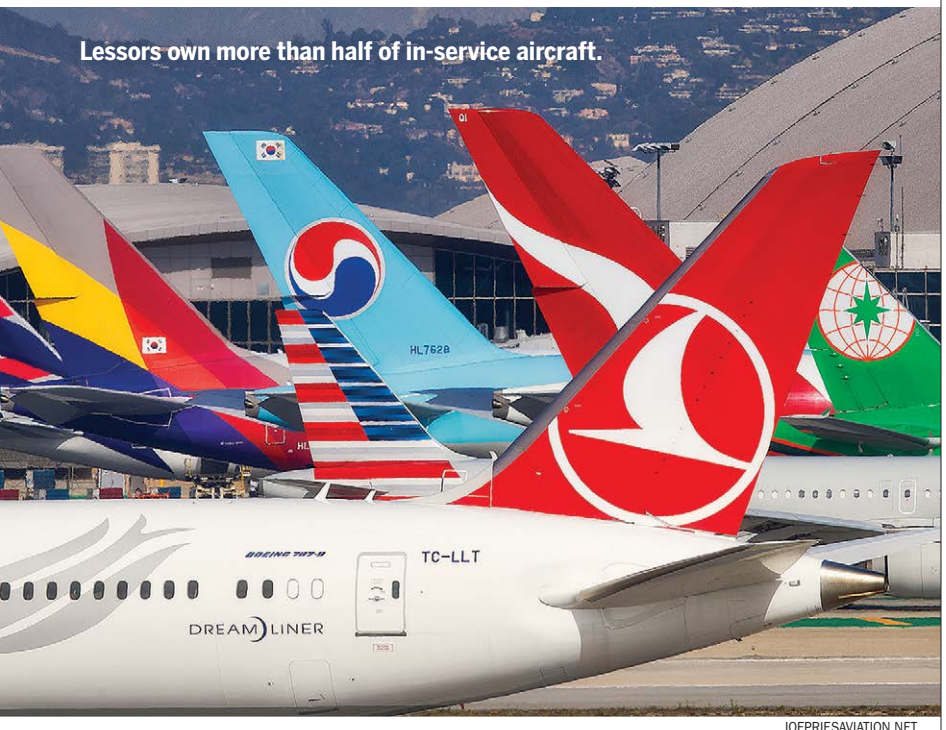
TOP 15 Global Lessors



Source: CAPA - Centre for Aviation Fleet Database

lessors, it is important to add what Baker told delegates at an International Society of Transport Aircraft Trading (ISTAT) event here: "Profitability is easier [to achieve]."

All the major players—among them AerCap, Avolon, Air Lease Corp. and DAE Capital—are achieving good or very good margins. The 2022 loss of aircraft leased to Russian airlines—



Lessors own more than half of in-service aircraft.

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hundreds of which were not returned after additional sanctions against the country were implemented—has been written off, earnings have since recovered and industry hopes to receive billions in insurance claims following a high-profile trial against insurers withholding compensation payments that is due to wind up by year-end.

Demand from customers is high. In this environment, even the supply chain disruptions have positive aspects for lessors, since they further support high lease rates. Many COVID-19 rescue deals are still in place, but other than that, lease rates have been up substantially even for Boeing 737 Next Generation or Airbus A320ceo aircraft as airlines have grown increasingly desperate to find capacity. "We fly whatever can fly," says Malcolm Macbeth, senior vice president of global air fleet management at DHL Express. Almost any airline would concur.

It does not hurt that the U.S. Federal Reserve has announced the first interest rate cut in a long time, as financing costs will come down again. The money is there, by and large, but how should lessors spend it?

They have been shying away from direct manufacturer orders for the past few years. Lead times for narrowbodies have become too long for them, particularly with price escalation clauses in place that guarantee aircraft will become more expensive over time, while the market situation at the time of delivery is hard to predict. Most lessors are not considering widebodies, as the operator base is too small.

Among this year's commitments: SMBC Capital added to an earlier Airbus A320neo order, Nordic Aviation Capital swapped some A220s for A321neos, Macquarie AirFinance bought 20 Boeing 737 MAXs, and Aviation Capital Group added 35 of the aircraft to its portfolio. Both Boeing and Airbus list several undisclosed customers for this year, some of which could be lessors. If they are not, 22% of this year's Boeing orders will have come from lessors.

On the Airbus side, the share would be down to 5%. "What has changed since last year is that the manufacturers are sold out even further into the future, and so if people were hesitant because of the wait time 18 months ago, that is even more pronounced now," Avolon CEO Andy Cronin tells Aviation Week. "We are really into the 2030s now before we could get to large-scale deliveries. I suspect it will be a quiet year on the lessor side."

That overall lessor share in the backlog is not a bad thing for those that remain part of it, including Avolon, which bought 120 aircraft from Airbus in 2023. But not only have these companies ordered fewer total aircraft, the number of lessors active in direct orders has also declined. A lot of what AerCap CEO Aengus Kelly once described as "tourist capital" has left the industry, handing over much of the market to a few more experienced and rational players.

Boeing and Airbus have contributed to this trend by focusing their recent deals on a smaller number of lessors. Those moves and the supply-demand imbalance have supported lease rates, as campaigns are no longer so easily disrupted by smaller lessors that want to gain market share at the expense of margin.

"If you have a large number of lessors on the same program, then you are effectively competing against each other in the placement market, and we have no problem competing with established, long-term lessors," Cronin says. "When you have startup lessors that are placing their first orderbook, that can distort the market—certainly if you have four or five of them operating in the same time window."

Portfolio acquisitions have been another avenue for growth. Avolon's acquisition of Castlelake Aviation, with a portfolio of 118 aircraft worth $5 billion, is expected to close in early 2025. While there may be company-specific reasons that Avolon jumped at this opportunity and others did not—having an interest in deploying available capital at this time—the transaction also points to an underlying trend.

"We are all bulking up because there are benefits of scale," DAE Group and DAE Capital CEO Firoz Tarapore says. "The power of a scaled platform is incredible," Carlyle Aviation Partners President Robert Korn concurs.

While the deals will be governed by case-by-case scenarios, "the transactions will continue," Tarapore predicts. DAE Capital itself made a big move into the 737 MAX market last year by buying an 83-strong portfolio of undelivered aircraft from China Aircraft Leasing Corp.

"These transactions always depend

on a number of factors," Cronin says. "Castlelake wanted to sell their portfolio. It is a portfolio accumulated during COVID, relatively well bought. It is 50% on lease to Delta [Air Lines], IndiGo, Qatar [Airways], Air France—so [these are] blue-chip credit counterparts."

"The trading market is about as active as we have ever seen," Tarapore says. In some way, lessors themselves are adding pressure to do more deals just by adjusting portfolios and selling assets, even in small numbers, which creates a constant stream for anyone relevant in the business. Yet to maintain current fleet sizes, a lot more aircraft have to come in. And as manufacturers struggle to ramp up production, lessors need to find other sources of growth. "If you are not buying, you can't be selling," Korn says.

What makes the situation complex is that while it is a great time to sell, it is not such a great time to buy. Everything—aircraft, spares, engines—is expensive and often not in a condition conducive to transitioning from one operator to another.

In spite of the slow pace of direct orders, lessors ultimately will continue to control a much larger share of the commercial fleet. That currently stands at more than half of in-service aircraft, as the leasing companies finance many deliveries through sale-leaseback transactions, which are also the easiest way for new players with available capital to enter the market.

As for lease rates, supply and demand will dictate future trends. Having risen sharply over the last two years, lease rates have now "pla-

Crisis Management

> SECURITY EXPERTS WARN OF INCREASING THREATS TO CIVIL AIRCRAFT IN THE MIDDLE EAST

> AIRLINES ADAPT FLIGHTPATHS, THEN RETURN TO USUAL ROUTES

Jens Flottau Frankfurt

The first day of this month was a complicated one for airlines, to say the least. Iran fired well over 180 ballistic missiles targeted at Israel, and 16 airlines operating in the region were forced to divert 81 flights, according to Flightradar24 data. While waiting for the situation to improve, many flights were delayed until the next day or ultimately canceled.

The escalating conflict in the Middle East is quickly becoming another major burden for airlines on top of the long-established closure of Russian airspace for carriers based in countries complying with Western sanctions. It is particularly relevant because it also affects the most important detour for flights between Europe and Asia. With no signs of deescalation, the Middle East conflict is likely to be a major factor for long-haul services for the foreseeable future.

With the closure of Russian airspace, European and Asia-Pacific airlines have rerouted their flights to the south, routinely crossing Iran on the way. Some had avoided the country all along, instead flying through Central Asia. Lufthansa has used Iranian airspace and, until recently, has flown to Tehran—one of its most profitable routes. Air France has used both northern and southern routing in recent weeks; British Airways stayed in the north. The southern route went through Iraqi airspace. Longer flight times could well be the norm for many operators.

Notices to Air Missions (NOTAM) were issued only by affected countries after the Iranian missiles had been fired, meaning missiles were crossing airspace with dense civil traffic, according to aviation security advisory Osprey Flight Solutions. The countries affected included Iran, Iraq, Jordan, Saudi Arabia and Syria—as well as Israel, the ultimate target.

"The airspace closures were late or did not happen at all," Osprey Chief Intelligence Officer Matthew Borie says. Osprey has upped its risk assessment for civil flights operating in Iran, Iraq, Israel and Syria to "extreme" while keeping it at "high" for Jordan. Iranian missiles were shot down in Iraq, Israel, Jordan and Syria, according to Osprey.

Borie warns that aviation could be "careening toward" a catastrophic event—an intended or unintended shootdown of a civil aircraft. He asserts that warnings by various national or regional authorities such as the U.S. FAA or European Union Aviation Safety Agency (EASA) as well as some European governments lack consistency. It would not be the first such event. Among the worst: In 2014, Russian-backed forces in Eastern Ukraine shot down a Boeing 777 being operated as Malaysia Airlines Flight 17, and 298 people on board died. In January 2020, a Ukraine International Airlines Boeing 737-800 was hit by an Iranian missile shortly after takeoff from Tehran, leading to the loss of 176 lives.

A Middle East Airlines Airbus A320 took off from Beirut amid Israeli attacks on the city in early October.

International legal obligations to protect civil aviation during military conflicts "will be unfulfillable should the line between military and civil aviation blur, even in the slightest," International Air Transport Association Director General Willie Walsh warned in an Oct. 4 statement. "That

teaued," as Tarapore observes. But if Baker has it his way, that will be a temporary issue. "Metal will be scarce for the foreseeable future," he asserts. "You have to pay for what is available. People need to be prepared to pay a premium for reliable current-technology aircraft."

Moreover, lessors helped many airlines survive the pandemic by agreeing to restructured deals, power-by-the-hour contracts and other relief. "That should sustain them for some time," Baker contended. Down the road, "airlines have to price in lease rates, and if they are disciplined they should be fine," he says. "[Aircraft] are revenue-generating assets."

They generate revenue if they fly, that is. Operational issues and delivery delays have affected airlines and lessors alike for some years now. But the level of frustration has reached new heights. "It is anybody's guess when the issues will be sorted, Tarapore says. Referring to Airbus, he adds, "It is a little bit surprising that it has not been ironed out yet." And just to be clear about what lessors expect, he notes: "It will be much harder to understand if it is not sorted out next year."

"Nothing has gotten better over the last 12 months," Cronin says. At this point, he expects it will take 4-5 years to get aircraft production mostly back on track. In the short term, things are worsening due to the International Association of Machinists and Aerospace Workers' strike at Boeing. Cronin's biggest concern is that the strike has "significant potential to disrupt the supply chain" further.

AFP/GETTY IMAGES

would bring deeply troubling consequences for innocent populations trying to survive through conflict, and especially for those in need of humanitarian aid."

Walsh further pointed out: "The Chicago Convention explicitly obliges states to protect civil aircraft and passengers in flight, refrain from the use of force against civil aircraft, and by corollary coordinate and communicate any activities potentially hazardous to civil aviation. These are essential to keep flying safe."

The Iranian missile attacks mark only one of the most serious occurrences in a long series of troubling events. Since then, there have been explosions near Lebanon's Beirut-Rafic Hariri International Airport in neighborhoods suspected of hosting Hezbollah arms depots. Most airlines now avoid flying to or across Lebanon, although Middle East Airlines (MEA) continues to serve its home base at Beirut-Rafic Hariri.

Flights in and out of Israel's Tel Aviv Ben Gurion International Airport also are suspended by most carriers because of the risk of flying through Israeli airspace alongside frequent Hezbollah and possible Iranian attacks. Iran temporarily closed its airspace, presumably expecting Israeli retaliation. When nothing happened, it quickly reopened, and airlines crossed the country as usual.

Flightradar 24 says Qatar Airways was the worst affected by the Oct 1 missile attack, with 29 flights diverted, followed by Emirates with 26. Temporary airspace closures were in place for Iran, Iraq, Jordan and Lebanon. Lufthansa decided to turn around two flights to India that had departed from Frankfurt. Many aircraft landed in places such as Vienna and Istanbul to wait for an opportunity to proceed safely to their destinations.

In the immediate aftermath, airlines chose to reroute flights from the Gulf region to the west, crossing Saudi Arabia and Egypt instead of Iran and Iraq. By Oct. 2, in spite of the extreme risk, the picture had changed. Some airlines such as Air Abu Dhabi, Air Arabia, Emirates, Emirates SkyCargo, FlyDubai and Wizz Air Abu Dhabi had begun to fly through Iranian airspace after it was reopened. Iraqi Airways, Kuwait-based Jazeera Airways, Royal Jordanian and Syrian Air were using Iraqi airspace. MEA continued to operate into Beirut, and El Al flew into Tel Aviv as usual. Lufthansa quickly restarted services to Erbil, Iraq.

The same day, EASA issued a Conflict Zone Information Bulletin and recommended "not to operate in the airspace of Iran at all flight levels." EASA noted: "In view of the Iranian attack against Israel on Oct. 1 and the announced Israeli retaliation, the Iranian airspace represents high risks to be considered by air operators in their risk assessments."

Australian Market Plays Key Role in Asian Airline Fleet Plans

> MULTIPLE CARRIERS SEE STRONG POTENTIAL TO ADD MORE FLIGHTS

> VISAS, AIR SERVICE RIGHTS ARE CHALLENGES TO GROWTH

Adrian Schofield Brisbane, Australia

Asia-Pacific airlines have ramped up their services to Australia to leverage a boom in international travel demand, and many are targeting further expansion in this market as they look to grow their widebody fleets.

VIETJET

Several overseas-based carriers have already boosted their Australian capacity beyond pre-pandemic levels. This has strengthened the country's role as one of the most important markets for Asian airlines, helping them offset slower recovery in other countries such as China.

Philippine Airlines (PAL), Thai Airways, Vietjet and Air India are among those that are bullish about Australia. Senior executives from the carriers told Aviation Week about their aspirations for this market during the CAPA Airline Leader Summit Australia Pacific held here Sept. 12-13. They also discussed some constraints that will have to be addressed for this growth to occur.

Thai Airways has more Australian capacity than in 2019 thanks to increases this year, said Otto Gergye, advisor to the CEO and director of revenue and network. Thai Airways operates 35 flights per week into Australia on routes to Sydney, Melbourne and Perth.

Gergye said Thai Airways is seeing very strong demand in Australia, not just for travel to Thailand but also connecting to the airline's routes to South Asia and Western Europe. This is helping Thai Airways rebuild and strengthen its Bangkok hub while substantially improving its traffic flows to Europe and elsewhere.

Australian demand is particularly high in premium cabins. This means the country "definitely punches above its weight" in terms of passenger revenue, Gergye said. It ranks closely behind Europe and North Asia as measured by revenue generated, even though those markets have about 90 and 100 flights per week, respectively.

There is significant growth potential for Thai Airways in the Australian market. Brisbane "features prominently on our radar," Gergye said, although "it is a question of getting enough aircraft" to launch new routes. Thai ordered 45 Boeing 787s in February, but the first deliveries of these aircraft are not due until 2027.

PAL has "quite a big footprint" in Australia, said Alex Featherstone, the carrier's vice president of revenue management and commercial planning. PAL operates 22 flights a week to Australia, covering Sydney, Melbourne, Brisbane and Perth. This is up from 16 flights to three destinations before the pandemic, meaning there has been a 37% increase in frequencies.

Australia represents the fifth-largest visitor source market for the Philippines, so it is an important inbound flow, Featherstone said. While there is some connecting traffic via Manila to countries such as Taiwan, Japan and South Korea, the carrier's main focus is demand between Australia and the Philippines. This is driven by tourism to the Philippines and is also helped by a large Filipino population in Australia, which spurs traffic in both directions.

Vietjet operates Airbus A330-300s on its Australian flights and has ordered 20 A330-900s.

PAL is planning to boost frequencies on its Brisbane and Perth routes, and "the fundamentals are there for continued strong growth" in the longer term, Featherstone said. Outbound demand from the Philippines will be supported by the country's robust GDP and population growth, with an expanding middle class, and PAL intends to increase its services to match demand.

Vietjet is a relative newcomer to Australia, launching its first flights there in April 2023 and growing rapidly since then. The carrier now operates 50 flights a week to Australia, serving Sydney, Melbourne, Brisbane, Perth and Adelaide from Ho Chi Minh City. It also added routes in June to Sydney and Melbourne from Hanoi.

The low-cost carrier's push into Australia stemmed partly from the slow recovery of the China market, Vietjet board member Chu Viet Cuong said. Like many Asian airlines, Vietjet realized after the pandemic that it was overreliant on China. The carrier "need[ed] to open and explore new markets," and Australia was one of its priorities, Chu said.

To reach Australia and other longer-haul markets, Vietjet leased seven Airbus A330s to complement its large fleet of narrowbodies. This was the

carrier's first foray into widebody operations, and in July it ordered 20 A330neos to grow this part of its fleet.

Vietjet can tap into a large Vietnamese community in Australia. Demand from Australia to Vietnam is augmented by travel beyond Vietjet's hubs to elsewhere in Asia, with connecting opportunities set to improve through the carrier's plans to open its first routes to Europe when its A330neos begin arriving, Chu said.

Chu noted that there is a "huge opportunity . . . for Vietjet to explore" in the Australian market. The new widebody deliveries will allow the carrier to have daily flights from the five Australian cities to both Ho Chi Minh City and Hanoi, and potentially flights to other Vietnamese cities such as Da Nang and Nha Trang, he said.

Air India has doubled its frequencies to Australia over the last two years, although that was from a low baseline, CEO Campbell Wilson said. The airline flies a combined 17 flights per week from Delhi to Sydney and Melbourne and from Mumbai to Melbourne.

Wilson said there is great potential for Air India to expand in Australia, with additional frequencies and new routes. "As soon as we get more aircraft we'd like to put more into Australia, absolutely," he said. The carrier has 64 widebody aircraft on order as part of a massive fleet upgrade program (*AW&ST* Sept. 30-Oct. 13, p. 44).

As with Vietjet and PAL, Air India can benefit from its country's large diaspora. The Australian government estimates there are more than 700,000 Indian-born residents in Australia, and the total is projected to surpass one million by 2035. In terms of tourism, Australia is ranked in the top three places Indians want to visit, Wilson said.

One of the Australian airports generating interest from overseas airlines is the yet-to-be completed Western Sydney International Airport (WSI). The facility is due to open in late 2026, and Singapore Airlines has already committed to launching flights there.

The Thai Airways, PAL and Vietjet executives said their carriers are also interested in WSI. "I think WSI would be a welcome addition once it's open, and if we decide to fly there, it has the potential to do quite well and complement our services" at the main Sydney Kingsford Smith Airport (SYD), Gergye said. This is partly because WSI will be more convenient for a large percentage of the population of the Greater Sydney region.

The fact that WSI will have no flight curfew is a major benefit, Gergye said. Airlines will be allowed to operate flights past 11 p.m. local time, unlike at SYD. This allows more flexible scheduling at WSI and "makes it easier from an operational perspective," he said.

WSI's lack of curfew also makes it appealing for Vietjet, Chu said. The carrier is considering adding flights there, although it has questions regarding transportation links between the airport and the central city, he said.

Likewise, there is insufficient capacity to accommodate Vietnamese carriers' growth plans at major Australian airports under existing agreements, Chu said. Vietjet is optimistic the Australian government will support expanding bilateral rights, since the two countries signed a comprehensive strategic partnership this year. One of the many goals of this agreement is enabling more travel.

The cost, time and complexity of obtaining visas is another issue these airlines cite as constraining demand for travel to Australia. "It is very difficult to apply for a visa to Australia,

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Thai Airways has used Airbus A350s to increase its Australian services this year.

PAL's Featherstone agreed that WSI "is a much-needed development" for Sydney and Australia. "We're keen to further explore what potential it might have as it gets closer to operation," he said.

While there are significant opportunities in the Australian market, there are also challenges to growth, the executives said. For example, limitations on frequencies at Australia's major airports under bilateral air services agreements are a headache for many carriers.

The growth of PAL and Cebu Pacific in the Australian market means that Philippine carriers are close to exhausting the capacity available under the bilateral agreement between the two countries, Featherstone said. "So we're hopeful that in the next round of air services talks this can be addressed and we can unlock some further capacity to grow in line with expected market [demand]," he said.

for study, tourism or work," Chu said. "That negatively impacts our customer numbers coming here from Vietnam."

Featherstone said there have been some positive developments regarding visas in recent years, but it remains an important issue. "Anything that can help Filipinos get visas to visit Australia on a more timely and cost-effective basis would be welcome," he said.

Aircraft availability can also be a challenge. For example, supply chain problems forced PAL to ground the A330s that were configured to fly its Australian routes. This led it to arrange short-term wet-lease deals for two A330s to cover the Australian services, which have since transitioned into damp leases.

"Instead of coming off those routes, we wanted to make sure we maintained service" despite the aircraft groundings, Featherstone said. "We did [the wet leases] because of the importance of the Australian market to us."

Embraer Develops Training Plan To Support Automatic Takeoff Capability

> AUTOMATIC SYSTEM MIMICS MANUAL TAKEOFF PROCEDURES

> SMALL BUT KEY CHANGES MANDATE NEED FOR PILOT TRAINING

Graham Warwick Washington

Embraer is developing a pilot training program for the industry's first automatic takeoff system, which is to be introduced first on the E2 regional jet family. As the auto-takeoff system mimics manual takeoff procedures, the manufacturer expects the training required to be simple.

"We think, because it is a novel system, we should have some training," says Luis Carlos Affonso, Embraer senior vice president of engineering and technological development. "We have seen in the industry that sometimes you try to save on training, and this may then have adverse consequences.

"We believe that training just to explain how the system works, so that the pilot has full awareness of how it works, will prepare them to operate it," he says. "We believe it is good practice to have this training. But it will be very simple, because the changes in terms of the operation are minimal."

The Brazilian manufacturer introduced the Embraer Enhanced Takeoff System (E2TS) at the Farnborough International Airshow in July. The E2TS is a function of the E2 family's fourth-generation full-authority fly-by-wire system, which provides a high level of integrity and availability with its triplex-redundant flight control computers and quadruplex air-data sensors, says Patrice London Guedes, E2TS technical leader. A retrofittable software upgrade, the E2TS is planned to be available in the fourth quarter of 2025.

The E2TS is designed to reduce takeoff distance by providing precise and consistent control of pitch angle, which increases the payload/range performance of longer aircraft taking off from short runways. The system also will increase safety, London says, reducing pilot workload in crosswinds and engine failures. From runway-limited London City Airport, the system will add 350 nm of range, Embraer calculates.

Takeoff distance is measured from brake release to an altitude of 35 ft., called the screen height. Long aircraft like the E195-E2 have a pitch limit to avoid tail strikes, and this sets the takeoff distance. With the E2TS, when the aircraft is a few feet in the air, the system automatically begins a continuous pitch increase to a higher angle, reaching screen height sooner.

When operating from a short runway, this reduction in takeoff distance can translate into more range for the same payload, more payload for the same route or a thrust reduction. The E2TS is being certified as a fail-passive system. "This means the system disengages with a single failure, and the pilot easily assumes control and safely continues the takeoff," London says.

The E2TS is designed to mimic the manual takeoff procedure, with two key differences that require dedicated pilot training to be mandatory. After lining up on the runway, the pilot must first engage the system by calling up the E2TS page on the multifunction control display unit and pressing a button. An E2TS indication appears on the primary flight display.

The pilot also engages the autopilot and autothrottle on the ground. This is a change from the current procedures, which prohibit autopilot engagement before liftoff. This is not a certification rule but is a means of compliance, London says, and Embraer is discussing an alternate method of compliance with regulators to permit autopilot engagement on the ground.

The other key change comes during the takeoff roll. "The only thing you have to focus on is not to rotate the aircraft and allow the aircraft to rotate itself, because if you rotate it, the system will disengage," says Affonso, who is type-rated in the E2 and has flown the E2TS.

At 200 ft. altitude, the E2TS hands over to the autopilot. "It is not that E2TS will give the aircraft back to the pilot; it is that the autopilot mode will move from E2TS to flightpath, which is the vertical mode of the autopilot. At 400 ft., the lateral mode engages . . . and you can take your hands off the yoke," he says.

Precise and consistent automatic control of pitch angle will reduce takeoff distance and improve safety.

"The standard operating procedures are the same, the callouts, everything," Affonso notes. "If E2TS fails, the callout is one the pilot is used to—'autopilot, autopilot'—so they don't need to learn anything new. Whenever a pilot hears 'autopilot, autopilot,' they know they have control.

"It's amazing that the human-machine interface is the same. That's why we believe the training will be very easy," he continues. "Pilots need to know and be comfortable with how the system operates, but it will be second nature for them."

Although designed to improve performance, the E2TS also will improve safety, London says. "In lateral directional control, the system is much more precise than the pilot, even in high crosswind conditions or with an engine failure," he says. If an engine fails on takeoff, the E2TS will apply rudder to compensate. "It will not only rotate; it will take care of bank angle and also compensate for yaw," he says.

Airbus Targets Increased Speed and Lower Fuel Consumption for Racer

> NEW TOOLS CAN PREDICT HIGH-SPEED ROTORCRAFT BEHAVIOR

> FLIGHT TESTS PROVED FUEL-BURN SAVINGS OF ALMOST 30%

Tony Osborne London

Airbus Helicopters has set a new speed target of 240 kt. for the next round of flight tests of its Racer compound high-speed rotorcraft.

Following its first flight in April, the Racer broke its 220-kt. target speed when it reached 227 kt. in June after just seven flights (*AW&ST* June 3-16, p. 50). The aircraft is in maintenance after its first 8 hr. of flight testing.

When flights resume toward year-end or in early 2025, the addition of a low-drag rotor hub fairing and landing gear doors should enable the aircraft to achieve the new target speed and deliver even lower fuel consumption, Racer Chief Engineer Brice Makinadjian told the Royal Aeronautical Society here on Oct. 2.

A new low-drag rotor head fairing and landing gear doors aim to add even more fuel savings for the Racer.

"The best is to come with the Racer," Makinadjian said. Engineers used 2024 to "fine-tune"the aircraft, he said, adding that "2025 will be dedicated to mission demonstration, eco-mode function, noise reduction and flight displays."

Analysis of the first flights found lower fuel consumption for the 7-8-metric-ton rotorcraft than estimated—with data suggesting almost 30% lower fuel burn than similar-weight aircraft. Makinadjian credited lower drag, comparable to the 2.8-metric-ton Airbus H125, for the efficiency gains.

The Racer's drag coefficient is lower than the preceding Airbus design, the X^3 demonstrator, and its rotor hub will reduce main rotor drag 25%, he said.

With the lower fuel consumption, Airbus expects the aircraft to exceed current range targets of 400 nm.

The Safran Aneto-1X-powered aircraft matures and refines the compound dynamic system proven in the X^3 demonstrator, which first flew in 2010 and secured a 255-kt. speed record three years later.

The Racer—short for Rapid and Cost-Effective Rotorcraft—combines the main rotor with two box-wing-mounted variable-pitch pusher propellers that provide asymmetric antitorque and symmetrical forward thrust enabling the aircraft's increased speed.

As part of the drag reduction effort, Airbus engineers adopted a slick, narrow streamlined fuselage and fairings for the engines and dynamic systems. The Racer's box wing offloads some of the lift from the main rotor in forward flight but also reduces the impact of download, stiffening the fuselage, and enables the supercritical shafts that connect the pusher propellers with the main gearbox to be bearingless, simplifying the system and reducing the maintenance burden.

The Racer is one of two rotorcraft demonstrators funded by the EU's Clean Sky 2 aerospace research and technology initiative; the other is Leonardo Helicopters' yet-to-fly Next-Generation Civil Tiltrotor Technology Demonstrator (*AW&ST* Feb. 26-March 10, p. 42).

With the Racer, Airbus aims to prove that its compound technology can boost helicopter speed, range and endurance without substantial increases in the cost of operation.

The aircraft uses the same controls as a conventional helicopter, apart from an additional switch on the collective that the pilot thumbs forward to accelerate and clicks back to decelerate.

Makinadjian also said the demonstrator was built to specifications that would meet the European Union Aviation Safety Agency's CS-29 Large Rotorcraft certification standards, along with special amendments.

"We consider this aircraft a rotorcraft," Makinadjian said, noting that 51% of lift is on the main rotor and 49% on the winds when flying at 220 kt.

An additional 15% fuel-burn reduction is expected when the company installs its eco-mode battery system in 2025. The system, developed in conjunction with Safran Helicopter Engines, will enable the rotorcraft to shut down one of its engines in cruise and maintain a cruise speed of 180 kt.

JEROME DEULIN/AIRBUS HELICOPTERS

When required, the 100-kW battery system will spool up the shutdown engine to full power—within 5-7 sec. Batteries for the eco-mode system will be housed in the aircraft's cabin.

Airbus also plans flights to demonstrate the value of high-speed helicopter operations, including potential intercity hops between London and Paris or search-and-rescue flights.

Perhaps most crucial is that Airbus has developed a series of simulation tools to predict blade loading through computational fluid dynamics and flexible blade model scoping.

"We now have tools that are able to predict the behavior of the high-speed formulas," Makinadjian said. "If tomorrow we want to make a serial product . . . we are able to do so."

New Skills Signal the BEA's Bid for More Autonomy

- THE FRENCH INVESTIGATION BUREAU STRIVES TO MAINTAIN PUBLIC TRUST
- IMPROVED LABORATORY EQUIPMENT IS REDUCING DEPENDENCE ON MANUFACTURERS

Thierry Dubois Le Bourget

Keeping the public's trust is a long-term endeavor. Over the years, France's Bureau of Enquiry and Analysis for Civil Aviation Safety, the counterpart of the U.S. NTSB in aviation accident investigations, has shown it can be relied on for its doggedness.

After the 2017 Air France Flight 066 (AF066) accident, when an Airbus A380 lost a large chunk of an engine in flight over Greenland, Bureau of Enquiry and Analysis (BEA) investigators took 20 months to find a crucial component under a thick layer of ice. The search effort paid off. Their findings went against expectations, discovering potential weakness in a metal alloy.

To maintain its level of expertise and anticipate future needs, the BEA is investing in new equipment and personnel training. Such improvements may help accelerate investigations, putting their duration more in line with public expectations in the era of news channels and social media.

Pierre-Yves Huerre became the BEA's executive director on Jan. 1. Ten months on, his ongoing effort aims to increase the BEA's autonomy and to continue to prove its independence from external pressure.

"We want to keep the public's trust in what an investigation bureau publishes," Huerre says. "That means we must be able to issue a report relatively fast. The report must explain what happened and draw lessons."

Families of accident victims expect to understand the chain of events and what rules will be implemented to prevent such accidents from recurring, Huerre emphasizes. "Everything is fast nowadays, and some people jump to conclusions, so taking time for an investigation is a challenge," he says. "We will be given that time if the public feels confident about the quality of the report."

In turn, Huerre points out, that quality depends on the BEA's cooperation with various players, such as other investigation bureaus, civil aviation authorities and operators. "Independence does not mean working alone," he notes. "Moreover, we have to show we are not the pencil pushers of any group of lobbyists or politicians. That is not about showing we write what we want because we are superb and independent, but because what is written is serious and has a strong basis."

The agency has been striving to improve its laboratory equipment. After all, engineers must determine what happened to an aircraft through its wreckage. "The BEA must have the ability to make a piece of twisted metal talk and dig up data from a damaged memory card to build safety lessons," Huerre says.

To analyze larger aircraft parts more quickly and precisely, the BEA acquired an X-ray computed tomography (CT) scanner in 2023. Tomography is an imaging technique that creates virtual cross-sections of an object using X-rays, providing access to information contained inside an object without altering it. BEA engineers use tomography at the beginning of a probe to help determine the integrity of a component and how to draw information from it. They can assess the condition of the memory module in an electronic device, for instance.

BEA PHOTOS

To maintain its level of expertise and anticipate future needs, the BEA is investing in new equipment and personnel training.

The BEA's new CT scanner can accommodate large, heavy parts up to 60 cm (24 in.) in height and 80 kg (176 lb.) in weight. "For a long time, we wanted a CT scanner," says Frederic Hervelin, head of the agency's structure, equipment and engines department. "Fan blades did not fit into our radioscope. We have often relied on engine manufacturers for such analyses, but the idea is to guarantee our independence and the objectivity of the results. We want that autonomy in our core activity." For fuel analysis, agency engineers still rely on suppliers.

The BEA once had a radioscope that could provide 2D imagery. Even after being upgraded to 3D, its performance was well below that of the new CT scanner, as its use was limited to very small and low-density samples.

The CT scanner relies on two tubes as X-ray generators: a high-energy 230-kV tube for large, dense parts and a high-resolution 160-kV tube more suited to electronics. While the high-energy tube has a 4-micron resolution, the high-resolution tube is 10 times better, with 400-nanometer resolution. Data can be obtained with the scanner in just 5-10 min., helping to expedite the investigation process, Huerre notes.

The BEA plans to acquire a field emission gun-scanning electron microscope. "It has the final say in fractography, [the science of material failures]," Hervelin says. With that tool, an engineer can see whether a crack has formed dimples, which indicate a sudden failure due to overload, or microstriations, which result from fatigue.

The BEA has improved its analysis of passengers' personal devices, as it demonstrated in sourcing imagery of engine damage from a passenger's tablet for its investigation of the AF066 accident.

Over recent years, the BEA has improved its skills and equipment for analyzing passengers' personal devices. Videos and photos from a smartphone or tablet can supply valuable data on the aircraft's attitude or condition, or a chain of events, Huerre says. In the AF066 accident, images of the damaged engine—just after it broke up and before it lost more debris—were recovered from a passenger's tablet, for example.

Since 2022, the BEA also has developed a new software program for decoding binary data extracted from avionics systems. Unlike flight recorders that use a relatively standardized data format, those systems require the capacity to process a variety of file formats. This improves BEA engineers' understanding of data organization, Huerre explains. "When they see a value, they want to know whether it is a measure of speed or another parameter," he says.

The system has helped other investigation offices as well. "When we develop a capability, we are happy to help our counterparts," Huerre says. "This has us coping with cases we do not know."

In addition, an aircraft's Enhanced-Ground Proximity Warning System is a new source of data for the BEA. It helps engineers see how an alarm was understood and processed, Huerre notes. The BEA has therefore developed a bench for downloading that system data.

Despite all the information gleaned from passenger devices and cockpit hardware, purpose-built flight recorders for voices and flight parameters remain must-haves, Huerre emphasizes. "They are certified for shock, fire and immersion," he says. "The rest augments our analysis."

Pierre-Yves Huerre, BEA executive director

The BEA also wants to understand a technology fully before its engineers have to deal with it. Recently, that has applied to electric motors and generators. "We need a good knowledge of the problems aging and thermal runaway can cause, as well as the overall propulsion system," Huerre says.

To develop that knowledge, one BEA employees is taking relevant master's degree courses while another is maintaining their piloting skills through an agreement with an unnamed carrier under which they perform copilot duties on an Airbus A320 one week per month. "We are very keen on that initiative. We see an interest in understanding the life of a crew," Huerre says. "They are humans who do not mechanically implement procedures." Moreover, having an active commercial pilot in-house strengthens the BEA's credibility with operators.

By the same token, the carrier has an interest in having external eyes on its operations, Huerre notes. The BEA is seeking to include a second employee in the agreement with the carrier.

Every year, within the framework of the European Network of Civil Aviation Safety Investigation Authorities, investigation bureaus in the region audit one of their counterparts. It is the BEA's turn to be audited next year. The approach, unlike a governmental audit, is another guarantee of independence.

PRODUCTIVE PATHWAYS

- > MANY U.S. AIRLINES HAVE PAUSED PILOT HIRING
- > THE FAA MIGHT EXPAND QUALIFICATION PATHWAY
- > THE AGENCY'S BASELINE FIRST-OFFICER FLIGHT-HOUR REQUIREMENT WILL REMAIN

Sean Broderick Washington

FIRST IN A SERIES

The world's largest commercial airline market has plenty of pilots—for now, at least.

Data compiled by Future & Active Pilot Advisors shows that hiring at the largest U.S. passenger and cargo carriers is on pace to fall at least 50% this year. After adding a combined total of more than 25,000 pilots in 2022-23, U.S. majors might not hire even 5,000 in 2024. Only five of the 13 carriers that the advisory tracks added pilots in August. Three others—Alaska Airlines, FedEx and Spirit Airlines—have not hired any in the entire year.

The reasons are familiar to industry-watchers. Delivery and reliability delays on current-generation equipment have left most carriers with fewer available aircraft than expected. Mix in an increasingly challenging demand environment, and many airline fleet planners are suddenly considering options for offloading surplus older aircraft instead of scrambling to find more.

But the trends will not last. Eventually, Airbus and Boeing will return to steady, predictable delivery rates. Reliability issues that have plagued a few fleets, notably Pratt & Whitney PW-1000G geared turbofan-powered narrowbodies and Rolls-Royce Trent 1000-powered Boeing 787s, will ease.

"Just as hiring paused during the COVID-19 pandemic onset but roared back with the return of demand, any amelioration in the pilot shortage we see today will rapidly reverse when larger aircraft deliveries resume," Regional Airline Association (RAA) President Faye Malarkey Black told the U.S. House of Representatives aviation subcommittee in written testimony for a workforce development hearing in July.

Most big airlines did not suffer from the pilot shortage—at least not when measured in raw numbers. Making sure trainees were checked out and cleared to fly was a regular problem for carriers that lost experienced training captains through voluntary early retirements or buyout packages put in place to cut costs. But bringing trainees onboard was not an issue—bigger airlines simply tapped the regional sector to keep their recruiting classes full.

For regionals, the knock-on effect was twofold: Not only did mainline carriers snap up regional pilots quickly, but the people moving up tended to be experienced captains. The ripple effect means regionals will feel the recruitment pain even as mainline hiring stabilizes.

"Regional pilot shortages . . . are likely to persist through next year due to the time required for training and recruitment," the FAA said in its most recent 20-year forecast, released in April.

Most industry stakeholders conclude that recent pilot-hiring challenges stem from a shortage driven in part by more stringent and costly requirements, led by the 2013 first officer qualification (FOQ) rule (*AW&ST* April 25-May 8, 2016, p. 47). A few industry groups—notably pilot unions—argue that the only shortage is among companies willing to pay market wages that reflect the upfront training investment aspiring pilots must make.

Regardless of why some airlines are struggling to find enough pilots, the need for a steady flow of qualified, well-trained candidates across the board is not going away.

Mandated by language prompted by the 2009 Colgan Air Flight 3407 accident and folded into the 2010 FAA reauthorization law, the 2013 FOQ rule's most significant change was mandating that a first officer hold an airline transport pilot (ATP) certificate. Previously, a first officer needed a commercial pilot certificate, which requires a minimum of 250 flight hours and an instrument rating.

The 2010 law also adopted the long-time FAA requirement of 1,500 hr. of flight time to obtain an ATP. Under the law, the FAA can develop alternative pathways for earning a "restricted" ATP (R-ATP) that allow relevant classroom work to count toward some of the 1,500-hr. ATP minimum. The main condition: Such pathways must "enhance safety" more than simply accumulating flight hours would.

The 2013 rule includes R-ATPs for military pilots and students trained at

GARY HERSHORN/GETTY IMAGES

A pilot-hiring slowdown is not expected to last, pressuring industry to maintain a full candidate pool.

flight schools and other institutions that meet certain qualifications. Under the provisions, pilots qualify for an R-ATP with 750-1,250 flight hours, depending on experience. They can then serve as first officers with certain restrictions until they accumulate the 1,500 hr. required for ATP qualification.

Some stakeholders, notably the airlines hit hardest by recent pilot-staffing challenges, see possibilities for additional R-ATP pathways.

The Pipeline, Pathways & Partnerships Workgroup—linked to the Air Carrier Training Aviation Rulemaking Committee tasked with considering whether the FAA should create another regulatory path for prospective pilots—examined the pilot-training landscape as part of its work. The group was noncommittal on whether new regulatory paths are needed (*AW&ST* Sept. 2-15, p. 23).

Among the group's conclusions: Aspiring commercial pilots have plenty of options, but the lack of standardization among them is problematic. Affordability is also a major roadblock—a view shared by stakeholders on both sides of the pilot-supply debate. Developing accreditation for Part 141 schools could ease both problems by helping establish a consistent set of standards and convincing lenders to offer more favorable financial options for prospective students, putting the institutions on par with four-year colleges.

A provision in the most recent FAA reauthorization law, enacted in May, offers hope to proponents of additional R-ATP pathways. The law gives the FAA six months—or until mid-November—to "establish the requirements" for an enhanced qualification program (EQP) that air carriers could offer.

The language is clear that an EQP does not automatically mean earning an R-ATP with fewer flight hours in exchange for FAA-approved classroom training. It also makes plain that the 2010 law's provision giving FAA the authority to apply credit for flight hours is on the table.

A six-month timeline is meteoric in FAA terms. But in the case of the EQP, the agency has completed working group studies as part of turning the 2010 law into the FOQ regulations to guide it. Among the recommendations submitted to the FAA by the Education, Training and Experience Alternatives for an ATP Workgroup (ATP WG): The agency should develop a Part 121-specific R-ATP program that can be combined with existing R-ATPs.

The ATP WG largely agreed on what the EQP should cover and how students should progress through it. Not surprisingly, members disagreed on how to convert coursework into flight-hour credits.

Representatives from Airlines for America, CAE, Delta Air Lines, FlightSafety International, the National Air Carrier Association and the RAA favored a program that provided credit for all but 500 hr. of flight training. Labeled the "variable-credit" method, it would permit classroom training to offset as many as 750 hr. of flight training required by the current R-ATPs to reach the statutory 1,500-hr. ATP requirement.

The Air Line Pilots Association, International (ALPA), and the Airline Dispatchers Federation favored what the ATP WG called the "uniform-credit" method that would give all qualified candidates 250 hr. of credit.

The variable method "proposes that everyone completing an EQP qualify for an R-ATP with not fewer than 500 hr. of aeronautical experience regardless of the existing [R-ATP] pathway they came from prior to entering the EQP," ALPA said in comments included in the working group report.

Under this approach, the variable EQP method "actually gives more credit . . . to the pilot with a [two-year] associate's degree" than one with a four-year degree, implying the shorter-duration program has more value, ALPA added.

Variable-method proponents said their approach takes into account the relevance of training to an airline pilot's working environment.

"EQP academic coursework provides focused training on topics directly related to safely and competently operating aircraft for Part 121 air carrier operations," their joint comments said. "Conversely, the academic course offerings include subjects not required for the safe and competent operation of aircraft in Part 121 operations.

"The argument that student pilots from three different knowledge levels will all gain the same benefit from material that is new to some but review to others is flawed," the variable-method proponents added. "It is in conflict with the longstanding instructional design principle of considering student entry levels when designing curricula."

Republic Airways referenced some of the ATP WG's work in an effort to create an EQP based largely on replicating military training. But U.S. officials ultimately rejected the airline's petition for exemption (*AW&ST* Sept. 26-Oct. 9, 2022, p. 38).

The FAA is offering little insight into how the EQP standards will look, although the agency suggests it is on track to meet the mid-November deadline to issue them.

"The FAA is required to establish an Enhanced Qualification Program within six months of the passage of the FAA Reauthorization Act, which would be November 2024," the agency tells Aviation Week in a statement. "The program requires air carriers to provide enhanced training for pilots who want to obtain restricted airline transport certificates, by the air carrier directly or certified training institutions. It includes testing, training and a pilot-assessment program for prospective pilots. It also allows the FAA to issue rulemaking, if necessary, on this topic."

That rulemaking, the agency adds, will not alter the FOQ's baseline requirements. "The program is in place of changing the 1,500-hr. threshold rule and does not replace the 1,500-hr. rule," it said.

The FAA is developing an additional pathway for newly trained pilots from flight programs and other sources to qualify for air carrier work.

SEAN BRODERICK/AW&ST

The RAA, among those firmly in favor of expanding R-ATP pathways, is confident that an EQP would help the pilot-supply issue without compromising safety.

"Among their many safety-enhancing attributes, EQP pathways will incorporate scenario-based training so that pilots master challenging and potentially dangerous situations in the aircraft they will be flying," Malarkey Black told lawmakers. "Numerous peer-reviewed academic studies have demonstrated that these structured training pathways produce highly qualified pilots with excellent performance in airline initial training."

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AVIATION WEEK NETWORK

Expansion Beckons for Italy's Fighter Pilot School

- SARDINIAN FACILITY HAS CAPACITY FOR 80 STUDENTS ANNUALLY
- DOWNLOADING OF TRAINING TO THE M-346 IS SHORTENING THE ROUTE TO THE FRONT LINE

Tony Osborne Decimomannu Air Base, Sardinia

Every year, hundreds of thousands of tourists are drawn to the Italian island of Sardinia to enjoy the weather, the laid-back atmosphere and sun-kissed beaches. Now the Mediterranean island is also attracting a glowing reputation among international air forces for the training of combat pilots.

TONY OSBORNE/AW&ST PHOTOS

In the past three years, around 140 pilots from nearly a dozen global air forces have graduated from the International Flight Training School (IFTS), a joint military and industry collaboration among the Italian Air Force, Leonardo and CAE.

Located at Decimomannu air base, the school takes students through a nine-month Phase IV Advanced/Lead-in Fighter Training course, readying fighter pilots for their frontline fourth- and fifth-generation combat aircraft using a combination of live and synthetic training.

The Italian Air Force leads the program, manages the project, decides the syllabus and ensures training quality and flight school standards, while the industrial partners—through a joint venture, Leonardo-CAE Advanced Jet Training—built the facilities and maintain the aircraft, simulator and training systems. The training is provided by instructors from both military and industry.

The biggest customer is the Italian Air Force, followed closely by Qatar. Alongside them, pilots from Austria, Canada, Japan, Saudi Arabia and the UK have graduated from the school over the past year.

The Netherlands, Singapore and Sweden also use the IFTS, and they soon will be joined by students from Hungary, which became a signatory to the IFTS on Sept. 19.

The school, which has an annual capacity of 80 students, is attracting so much interest that foundations are being laid for additional student housing, and plans are in place to expand the current fleet of Leonardo M-346 twin-engine advanced jet trainers to cope with the expected influx.

The IFTS uses 22 aircraft—the air force owns 18, and Leonardo owns four. Another six aircraft owned by Qatar are also based with the IFTS and solely train Qatari aircrew.

The need for expansion comes from increases in global defense spending and countries reequipping or expanding their fighter fleets. Retiring trainer fleets have left Western training capacity taut, particularly after the closure of NATO Flying Training in Canada. Availability of the Northrop T-38 fleet of the Euro-NATO Joint Jet Pilot Training Program is being affected by the age of the aircraft, while in the UK, engine problems have troubled BAE Systems Hawk T2 operations, prompting the Royal Air Force to look for training capacity elsewhere. The IFTS aims to cash in on this growing demand for new pilots.

Customer nations also are attracted by the technology. In addition to M-346 live flying, students can use an extensive ground-based training system, including full-mission simulators, flight-training devices as well as computer- and simulation-based training—some of which students can use to hone their skills in their own time.

Instruction at the IFTS is provided by a mix of civilian instructors from industry—dressed in blue—and military personnel from the Italian Air Force.

The IFTS also is making use of live, virtual and constructive training, which blends the synthetic world with live flying.

Pilots in real M-346s can fly alongside their wingman, who is flying in the simulator, while technicians on the ground can generate and fly threats by mouse and keyboard. "If we are training a [beyond-visual-range] aerial engagement, we can fly two jets and two simulators versus four red air threats," Italian Air Force Lt. Col. Marcello D'Ippolito told Aviation Week during a visit in September. He is the commander of the Italian Air Force 212th Flying Sqdn., the military unit that operates the IFTS. The threats show up on the M-346's simulated radar, data link and in the aircraft's targeting pod.

"With only two aircraft in flight, we can train four students, and you are saving the need to fly another six aircraft," he said, adding that this results in more realistic training at a lower cost.

Perhaps the most crucial is the ability to download training from the front-line type onto the M-346, allowing the student pilots to learn skills on a less expensive aircraft.

The Italian Air Force's training syllabus is built around this principle, with students learning to undertake air-to-air engagements and simulate the employment of GPS and laser-guided air-to-ground munitions. There are even

courses on performing the Quick Reaction Alert mission, including procedures on how to intercept aircraft correctly. Nations that send their personnel must follow this core syllabus set by the air force, but there are additional modular courses, including night vision goggles, aerial refueling and air-to-ground missions on a range in Sardinia in conjunction with Joint Forward Air Controllers, almost all of which are taken up by customers.

"We can download a lot because the aircraft is the only trainer that allows us to do a lot of these tasks," D'Ippolito explained.

"This way, we are learning these skills on a cheaper aircraft," he said. "Learning these complex skills will cost much more on the Eurofighter, F/A-18, F-16 or F-35. . . . This is why so many nations are looking at our system."

The approach allows the student pilots to be better equipped when they reach their operational conversion unit (OCU)—parlance for the training unit flying the front-line type—and their journey to becoming combat-ready is shorter as a result.

The IFTS operates 22 M-346s: Eighteen are owned by the Italian Air Force, four are owned by Leonardo, while six Qatari aircraft (one of which is pictured) are co-based. All are maintained by the Leonardo-CAE joint venture.

"This course goes into a little bit less depth, much more breadth," one of the UK Royal Air Force students sent for training at the IFTS told Aviation Week. He asked that his name be withheld for security reasons.

By comparison, the Hawk T2 courses in the UK put a greater focus on air combat maneuvering, but the addition of courses in air-to-air refueling and operations on live ranges "help to derisk the transition to the OCU," the trainee said.

Personnel who trained in Italy have found the conversion from the M-346 to Eurofighter Typhoon easier because they have already flown a twin-engine aircraft with fly-by-wire controls.

The IFTS' origins trace back to 2017, when Leonardo and the Italian Air Force began discussions on how to strengthen Italian Air Force training and open it up to international customers. The parties signed a letter of intent at the Farnborough International Airshow in 2018, and IFTS courses began at the Italian Air Force's mainland training base at Lecce three years later, a temporary measure until the 130,000-m^2 (1.4 million-ft.^{2}) campus at Decimomannu was completed in early 2022 and training started in Sardinia later that year.

The new facilities have been developed so that the students can focus on their training, with all their needs taken care of, D'Ippolito explained. There are apartments for the trainees, a gymnasium, swimming pool and a cafeteria, while the ground-based training system building contains all the flight training devices, classrooms and briefing rooms used by students and instructors. New hangars and sun shelters have been constructed for maintenance and flight line operations.

The IFTS has brought a new lease on life to Decimomannu after a post-Cold War lull in activity. The airfield had been a hub for NATO training, as several countries have a nearly permanent presence for air combat training. Today, IFTS activities dominate proceedings, with the school's M-346s flying 30-40 sorties a day, thanks to the year-round good flying weather and thousands of square kilometers of airspace available to the west and east of the island. This airspace is separated by an air corridor for commercial traffic into the nearby island capital of Cagliari, although operations often have to be sequenced in the summer to cope with the rush of holiday flights arriving on the island.

Both the air force and Leonardo jointly market the IFTS to international air forces, and the school also has secured accreditation as one of the NATO Flight Training Europe (NFTE) campuses alongside the Czech Republic's Flight Training Center at Pardubice, potentially leading to more nations joining the IFTS. The NATO Flight Training Europe effort is part of an alliance bid to reduce European allies' reliance on U.S. training facilities, but how this will work at the IFTS has yet to be fully defined, Leonardo officials say.

The air force's role in leading the IFTS is well appreciated by international customers, says Carmine Russo, Leonardo's head of IFTS marketing.

"When you send young guys thousands of kilometers away from home to a civilian [training] entity, it can become difficult to monitor their military attitude . . . . So the military control of IFTS is definitely appreciated from our partner air forces," Russo says.

Maintenance Technician Shortage Drives New Training and Recruiting

- NORTH AMERICAN SHORTFALL IS EXPECTED TO BE 20% BY 2028
- LACK OF INSTRUCTORS AND EXAMINERS IS EXACERBATING TRAINING PIPELINE CHALLENGES

Lindsay Bjerregaard Chicago

A booming market is forecast to boost maintenance, repair and overhaul business over the next two decades, but the industry might struggle to meet demand if the pipeline of new maintenance technicians cannot keep pace. In response, stakeholders across the aftermarket are ramping up efforts to increase the supply of technicians and accelerate training.

EMBRAER

The Aviation Week Network's 2025 Commercial Aviation Fleet & MRO Forecast predicts demand for $1.4 trillion in maintenance, repair and overhaul (MRO) services during the next decade, increasing the global need for aviation maintenance technicians (AMT). Airbus' 2024-43 Global Services Forecast projects a need for 690,000 new AMTs over the next 20 years while Boeing's 2024-43 Pilot and Technician Outlook forecasts 716,00. Both OEMs anticipate a particularly strong need for AMTs in the Asia-Pacific region, Europe and North America.

In its outlook, Boeing noted that insufficient training capacity to overcome the personnel shortage and the lag time required to bring new staff up to speed will be major challenges in meeting this demand. These training issues have been highlighted for two consecutive years by the Aviation Technician Education Council (ATEC), which releases an annual Pipeline Report that tracks how the North America region is meeting AMT demand.

Released in late September, the 2024 ATEC-Oliver Wyman Pipeline Report estimates a 9% shortfall of new technicians in North America this year based on commercial aviation's projected demand. The report forecasts that by 2028 this shortage will reach nearly 20%, or about 25,000 certificated mechanics.

"When we spoke to operators and MROs, [they said] it takes 3-5 years for a new technician to be as productive as an experienced one," Livia Hayes, director at Oliver Wyman Vector, said during the report's release luncheon on Sept. 19. "If you add in that juniority impact, you get another 4% shortage on top of that. So this gap is expected to persist throughout the decade, first worsening before it gets a little bit better."

Although AMT school enrollment is rising in North America—last year it was up 6%, and new mechanic certificates increased 32%—ATEC believes enrollment must grow 15% every year to keep up with demand and close the shortage gap. Two major bottlenecks are the dearth of AMT school instructors and designated maintenance examiners (DME), who are licensed to perform the FAA's required testing for graduates to receive their airframe and powerplant licenses. ATEC estimates that North America needs 30% more DMEs just to account for the current flow of AMT school graduates.

In March, Rob Cush, legislative affairs director for the Aircraft Mechanics Fraternal Association, told Aviation Week that the U.S. had about 700 DMEs before the COVID-19 pandemic, but this number shrank to 67 and is now estimated by ATEC to be about 250. Twenty percent of AMT schools that ATEC surveyed reported that this shortage is affecting their ability to certify graduates.

Growing customer demand for new maintenance lines led Embraer to launch a new training program this year in Brazil.

"It's crazy," Cush said. "You're asking kids to wait months upon months and to travel to neighboring states because there's no DME in their location." He added that the situation is exacerbated because DMEs are prohibited from crossing state lines to test students.

INDUSTRY EFFORTS

ATEC is working with the FAA on draft guidance to create a program in which Part 147 schools and certified industry partners could manage and conduct airframe and powerplant testing. ATEC has also asked the agency to remove geographic limitations to help alleviate these bottlenecks. To

address the instructor shortage, the organization this year launched ATEC Academy, which provides training that helps aviation industry professionals transition to the teaching environment at AMT schools.

Across the Atlantic, European aviation training provider Resource Group is increasing the continent's AMT learning and testing opportunities. The company is expanding its remote offerings so students located anywhere can learn at their own pace and prepare to test for Part 66 aircraft maintenance licenses through the European Union Aviation Safety Agency and UK Civil Aviation Authority.

GMR AERO TECHNIC

Several MRO companies have launched training programs aimed at recruiting and preparing local workers. In January, Embraer opened its Guiding and Inspiring Future Technicians (GIFT) training program in Sorocaba, Brazil. GIFT provides students with classroom training at local colleges and hands-on training at the airframer's facilities. Embraer says the program was driven by high demand from customers requesting more maintenance lines, which requires additional labor.

In India, where large new aircraft orders are spurring efforts to expand the country's MRO capabilities, OEMs are investing in local training efforts. Boeing recently partnered with MRO provider AI Engineering Services Ltd. to provide training materials, aids and instructor guidance to boost the company's technician training programs. Airbus teamed with Indian MRO provider GMR Aero Technic to open a new aircraft maintenance training school in Hyderabad in January.

Africa, too, is building up its MRO and training capacity. The Cameroon Civil Aviation Authority (CCAA) in 2022 launched its first university-level aviation training program, a nine-month course on aircraft maintenance and recycling. French MRO provider Vallair signed a memorandum of understanding with the CCAA in July on collaborative training programs and bilateral student exchanges to increase Cameroon's MRO workforce. Last year, Jordanian MRO provider Joramco opened a maintenance training school in Ghana in partnership with Aerojet Aviation. As part of its initiative to strengthen MRO capabilities in Africa, Airbus is working to create a licensing curriculum that is trusted across the continent to enable aviation professionals trained in one African country to work in another.

In the U.S. last May, Mitsubishi Heavy Industries' MRO subsidiary MHIRJ launched a career upskilling program based at its facility in Bridgeport, West Virginia. The program, MHIRJ Academy, seeks to recruit and train the hundreds of additional technicians the company needs for the work in its pipeline. The tuition-free, eight-week program pays participants while they undergo training in aviation sheet metal. If students pass the course requirements, MHIRJ offers them a job.

MHIRJ Chief Operating Officer Ismail Mokabel tells Aviation Week that the academy's local recruiting model has been crucial to achieving high retention and engagement, since participants are looking to build a new career locally instead of opting for temporary jobs. As of MHIRJ Academy's first graduation ceremony in June, the program had nearly 400 applicants, more than 300 of whom heard about the academy from current employees.

Airbus partnered with Indian MRO provider GMR Aero Technic to open a new aviation maintenance training school in January.

U.S. regional carrier PSA Airlines also revamped its in-house training program to appeal to younger generations and speed up productivity of its new hires. PSA uses what it calls a progressive training model, whereby new hires spend at least one month on the shop floor to become familiar with aircraft components and concepts before they start general familiarization training in the classroom. After that, the training prioritizes subjects based on where PSA sees the most technical issues, such as pneumatic bleed leaks and door pressurization problems.

"I'm only investing in that student as much as they need to be proficient at that given point," says James Ellis, PSA's assistant director of maintenance training. "I'm not giving them more information than they need to know."

The airline has also rolled out digital training materials, such as a video platform and a virtual 360-deg. tool, that allow trainees to navigate around an aircraft to study components. Ellis says the progressive training model and new digital tools have reduced post-training employment attrition by more than 20% year-over-year.

Reliable Robotics Pushes Forward on Autonomous Caravans

> THE COMPANY IS TARGETING DUAL-USE CARAVANS FOR DEFENSE, CARGO AND LOGISTICS

> CARAVAN VIEWED AS LAUNCH PLATFORM FOR SCALABLE AUTONOMY

Ben Goldstein Mountain View, California

Widespread adoption of uncrewed aerial systems has transformed military aviation, but progress on commercialization has been frustratingly slow.

Regulations to permit commercial drone services have been held up in multiple jurisdictions by concerns ranging from airspace integration to the privacy and safety of people on the ground. But as regulatory frameworks and technologies evolve, so do the platforms that host them.

Several U.S. startups are working to automate existing utility aircraft like the Cessna Caravan as a stepping-stone to introducing autonomy to large portions of the existing global commercial and defense fleet.

One such company is Reliable Robotics, a startup based in the San Francisco Bay Area, which is developing a continuous autoflight and navigation system as a retrofit for existing fixed-wing aircraft. It chose the Cessna 208B Caravan for its first application.

RELIABLE ROBOTICS

Reliable designed the autopilot and navigation system for its autonomous Caravan with off-the-shelf components whenever possible, including commercially available sensors, radar altimeters, inertial weather vanes and GPS.

Covering all stages of flight from taxiing to takeoff, cruise and landing, Reliable's autopilot system allows the Caravan to fly without a pilot onboard. A human operator programs the flight plan and remotely supervises the aircraft from a ground control station.

Reliable describes its technology as a means to reduce common fatal aircraft accident causes including controlled flight into terrain and loss of control by a human pilot. Its autopilot is aircraft-agnostic, scalable and dual-use, with target applications for both defense and civil aviation.

On the defense side, Reliable has been collaborating since 2021 with the U.S. Air Force through the AFWerx Autonomy Prime program and the Air Force Research Laboratory, as part of an effort to explore applying its autopilot to military cargo and refueling platforms ranging from small utility aircraft to large multi-engine tankers.

The modified Caravans present an appealing solution to the U.S. Defense Department because the Air Force lacks a Caravan-size platform that can handle smaller payloads efficiently, Reliable Robotics co-founder and CEO Robert Rose explained.

"The Air Force is using the [Lockheed Martin] C-130 or [Boeing] C-17 for missions that could be flown with a small utility aircraft—even though it's totally wasteful to transport a single component on a platform that costs the taxpayer $20,000 per hour to operate," Rose told Aviation Week during a tour of the company's headquarters here.

"For the cost of a single C-130, they could get five or 10 automated Caravans," he added. "Instead of having a single C-130 or C-17 flying these serial hops between airfields—picking up one component and dropping another off and on and on—you could have multiple Caravans fan out and just do

MATTHEW C. CLOUSE/U.S. AIR FORCE

U.S. Air Force personnel performed simulated resupply and logistics missions with autonomous Caravans from Reliable Robotics and XWing in August.

JOSEPH JONES/U.S. AIR FORCE

A remote pilot supervised the autonomous Caravan from a ground control station during the U.S. Air Force's Agile Flag 23-4 exercise.

everything in parallel. So what takes 8 or 10 hr. for a single C-130 can be done by midmorning with a fleet of autonomous Caravans for the same cost."

But the Caravan is only the first step for Reliable's defense ambitions. The company completed a gap analysis study last fall on behalf of the Air Force that concluded its autopilot system can be scaled to larger multi-engine platforms like the Boeing KC-135.

"We concluded that we can basically transfer the whole system over and just add in more parts," Rose explained. "But it's essentially the same system with the same I/O computers, same actuators—just more of them."

In the commercial realm, Reliable sees huge opportunity to use uncrewed Caravans for cargo and logistics. The startup has partnered with FedEx, which projects enormous potential in using uncrewed fixed-wing aircraft for middle-mile package delivery.

Toward that effort, Reliable in 2020 acquired New Mexico-based AirDialog, which operates a small fleet of Caravans as cargo feeder aircraft for FedEx, later rebranding it as Reliable Airlines. As the world's largest Caravan operator, FedEx depends on the workhorse utility aircraft to distribute parcels from hub airports to smaller communities, enabling overnight deliveries across most of the U.S.

"It's their fleet of hundreds of Caravans that enables FedEx to meet their customer expectations," Rose said. "The problem for cargo operators is that it's getting harder now to find pilots to fly those missions, and it's getting costlier to pay and train these pilots. It's not sustainable. It's kind of existential for companies like FedEx or UPS; same-day, overnight package delivery might just not be a thing in the future if those trends continue."

The solution, according to Rose, is autonomy. "How do you get a factor of 10 or a factor of 100 more aircraft in the sky?" he mused. "How do you expand the window of operations so we can get reliable same-day package deliveries to small and rural communities? How do you lower the cost of aviation and do all that while making aviation safer? These are the questions we're passionate about solving."

As part of its go-to-market strategy, Reliable designed its autopilot and navigation system with off-the-shelf components whenever possible, including commercially available sensors, radar altimeters, inertial weather vanes and GPS. Other components, such as flight computers, actuators and detect-and-avoid radars, were developed in-house.

"We're building our own radar out of necessity," Rose said. "We were unable to convince any of the established players to build a radar that meets the standards accepted by the FAA for detect-and-avoid. The existing options were either cheap weather radars or military tracking radars that are too expensive and overbuilt. So we're building our own—it hasn't flown yet, but we look forward to installing it soon.

"It's the same with our flight computers," he added. "Nobody makes a flight computer that has enough computing power, is fast enough and has enough RAM storage capacity and interfaces to be able to manage all the digital interfaces on the aircraft—so we had to build our own."

The FAA formally accepted Reliable's certification plan in 2023 and agreed on all requirements for its navigation and autopilot systems this year. The company recently received its draft G-1 certification basis from the FAA and has exchanged comments with the agency. "[We] are making great progress that will converge on a solution," Rose posted on LinkedIn on Sept. 25.

BEGINNINGS

Rose, 47, came of age during the tech boom of the late 1990s and early 2000s. He started his career as a software engineer at Hewlett Packard before transitioning to the video game industry, where he developed PlayStation games for Sony. Looking for a new challenge, he joined SpaceX in 2009. There, he developed flight software as project lead for the Falcon 9 and later worked on the Dragon 1 and 2.

In early 2014, he left SpaceX to join an AI startup backed by Elon Musk, but soon after he was recruited by his former boss to become senior director of autopilot at Tesla, where he oversaw the introduction of the company's first self-driving cars. Next, he went to Google X, developing automated warehouse equipment as his interest in autonomy continued to grow. It was while catching a flight one afternoon at San Martin Airport in the Bay Area that he first had the idea that ultimately birthed Reliable Robotics.

"It just hit me: Why the hell isn't this automated?" Rose said. "It seems ridiculous that we require people to fly

planes when we clearly have the capability to safely automate it at scale. We can send an autonomous spacecraft to space; we have drones flying around all day in all sorts of environments—and yet the benefits of autonomous aviation can be so much greater. Space has done wonderful things, but aviation is interwoven into the fabric of our lives in ways that people don't appreciate. It just seemed so dumb—like, why aren't we doing this already?"

After linking up with fellow SpaceX alumni Juerg Frefel and John Couluris, the three co-launched Reliable Robotics in the summer of 2017. A few months later, they decided to purchase a Cessna 172 as an initial test aircraft. The FAA granted experimental authorization in January 2018, allowing the company to begin flying with a safety pilot onboard with an operational radius of 260 nm from San Martin Airport.

RELIABLE ROBOTICS

Reliable's modified Caravan first flew with no onboard pilot in November 2023.

Reliable made its first flight in February 2018, and by October it had installed the necessary hardware and software to perform fully automated gate-to-gate test flights. In parallel, the startup received approvals to fly without a pilot in December 2018. Three months of hardware installation and six months of testing and analysis followed before the first uncrewed flight in September 2019.

"We completed all of the analysis," Rose recalled. "We were emotionally ready, and so we went and did it. To be honest, it was very boring—which is exactly what we wanted, because our system worked as it was designed."

Around the same time, Reliable Robotics acquired its first Cessna 208B Caravan from FedEx. Another company before it had used the aircraft as an R&D testbed. After installation of actuators and other hardware, the aircraft went through further testing and analysis before its first flight in February 2021. The modified Caravan completed its first fully autonomous flight—a 12-min. sortie over Hollister Municipal Airport in Central California—in November 2023.

At a tour of Reliable's hangar and flight-test facility in San Martin, Rose displayed the company's second autonomous Caravan, expected to make its first flight during the fourth quarter of 2024. "Everything that we're installing on this airframe is supposed to be the stuff that gets certified," he said. "We'll test the aircraft on the ground, and then we can probably be flying by the end of the year."

While most of the hardware on the aircraft is close to conforming, Rose said the company will probably need a third airframe for use in its for-credit certification test flight campaign.

COMPETITIVE LANDSCAPE

Reliable is one of three U.S. startups developing autonomous systems for the Caravan, although all are taking slightly different approaches. Boston-based Merlin Labs has augmented its Merlin Pilot system with machine learning and artificial intelligence (AI), whereas Reliable's system runs on deterministic, algorithm-based laws.

Another key difference is that Merlin's autopilot is mainly aimed at reducing multi-engine crews to one pilot from two, rather than removing the pilots altogether like in Reliable's remotely-piloted system.

And Bay Area-based XWing, which Joby acquired in June, has designed a remotely piloted system that is largely deterministic but augmented by computer vision and deep learning in certain scenarios. Like Reliable, its system is designed to fly with no safety pilot onboard.

The different approaches represent fundamentally opposing views on what levels of autonomy regulators will realistically approve. Merlin founder and CEO Matt George says there is "no realistic venture-backable timeline" in which uncrewed Caravans and other fixed-wing civil aircraft are permitted to operate in the National Airspace System. While acknowledging that leaving a safety pilot in the Caravan will not unlock true scale, George describes the Caravan as "more of a flexible and relatively cheap general testbed" to use in developing and certifying its aircraft-agnostic and scalable Merlin Pilot system, which will later be applied to larger defense platforms.

Unsurprisingly, Rose does not share George's assessment about the feasibility of certifying a remotely piloted system for the Caravan. "Some of our competitors want to take baby steps that slowly reduce pilot workload. But in this case, we think you have to make a calculated leap," he says.

Rather than going for uncrewed operations, Rose sees the bigger certification risk as the incorporation of machine learning and AI—both of which Merlin and XWing are doing to varying degrees. "We don't see any pathway to certifying AI in aviation anytime soon," he says. "It seems like our competitors are making an already hard problem much harder than it needs to be."

To be sure, there is probably room for more than one company to develop autopilot flight systems for commercial aircraft, but it could end up being a small playing field.

"There's a number of advantages and economies of scale you get by having an outsize footprint," Rose says. "In the future, I think there's going to be one, two or possibly three companies providing these sorts of systems for the entire Western world."

ZEROAVIA

The potential for zero-emission propulsion to bring new value to Caravans has lessors such as Monte interested.

POSTER CHILD FOR TECH

> AVAILABILITY AND POPULARITY ARE KEY TO FLYING TESTBED CHOICES

> CARAVAN'S MARKET SUCCESS MAKES A PREFERRED ENTRY POINT FOR TECH

> REGIONAL 19-SEATERS ARE AN EARLY TARGET FOR GREENER PROPULSION

Graham Warwick Washington

The poster child for new aviation technologies, such as electrified propulsion and autonomy, is not some exotic NASA X-plane but an everyday workhorse: the Cessna Caravan. Because of its size, availability and popularity, the utilitarian Caravan is the go-to platform for flight testing and market entry for many a startup in aviation.

Battery-electric, hybrid-electric or hydrogen-electric—you name it, and a Caravan somewhere is flying with it, or close to. The same goes for autonomous flight control, and more than one Caravan is flying around with no human hand touching the controls.

The Caravan is the A-lister when it comes to being a testbed for advanced propulsion and control technologies, but it is not the only one. Others include such unlikely candidates as a 1940s-vintage Beaver floatplane and a 1970s-era Dash 7 four-turboprop regional airliner—coincidentally both past products of the De Havilland Canada brand.

The choice of testbed for a new aviation technology often comes down to cost and availability: something easy to find, cheap to buy and often no longer in production. But in many cases, the decision is influenced by business strategy.

Precisely because it is popular and still produced, the Caravan is the chosen market-entry platform for Ampaire's hybrid-electric powertrain, ZeroAvia's hydrogen-electric propulsion system and several other electric aircraft hopefuls. The Caravan's Textron Aviation stablemate, the Beechcraft King Air, is another early target, along with De Havilland Canada's still-produced DHC-6 Twin Otter.

What these aircraft have in common is their powerplant: the ubiquitous Pratt & Whitney Canada PT6A turboprop. By sizing their initial product offering to replace the PT6A in popular applications such as the Caravan, King Air and Twin Otter, the propulsion startups hope to tap into a ready market to replace the turboprops when they come up for expensive overhauls, offsetting the cost of switching powerplants.

PROPULSION PIONEER

Ampaire has been flying its 570-kW AMP-H570 hybrid-electric powertrain in a Caravan since November 2022 and is now aiming for FAA supplemental type certification (STC) of the improved Gen 2 system on the aircraft within two years. A version of the AMP-H570 packaged to fit in the King Air's nacelle has just passed its critical design review with funding support from the U.S. Air Force's AFWerx innovation unit.

ZeroAvia first flew its 600-kW ZA600 hydrogen-electric engine in a Dornier 228 testbed, replacing one of the 19-seater's two turboprops, but the company is working with the UK Civil Aviation Authority to certify the system in the Caravan first, followed by the Twin Otter, aiming for service entry in 2026. The startup plans to repeat the process with its 2-megawatt ZA2000, flying first in a De Havilland Canada Dash 8-400 testbed.

Others planning to use the Caravan as their route into the electrified aircraft market include Spanish-Austra-

lian startup Dovetail Electric Aviation and U.S. regional Surf Air Mobility. Dovetail plans to follow with hydrogen-electric versions of the Caravan and King Air, while Textron is providing engineering services to Surf Air for electric and hybrid versions of the Caravan under a nonexclusive agreement.

The Caravan also is the chosen path to market for several startups developing autonomous flight systems for piloted aircraft, among them Merlin, Reliable Robotics and Xwing, now part of Joby Aviation. These companies are particularly attracted by the Caravan's ubiquity in the regional cargo feeder market.

Most new entrants to the propulsion industry are aiming at the regional market because of the perceived potential to revitalize the sector by offering substantially lower operating costs, in part through the use of electricity or hydrogen as an energy source. This brings leasing companies such as Monte into play, as they look to restore value to aircraft being retired from major U.S. and European markets because of wholesale changes in the regional airline industry.

Targets range from the nine-passenger Britten-Norman Islander, for which Cranfield Aerospace Solutions is developing a 240-kW hydrogen-electric powertrain, to 70-80-seat regional turboprops and jets, such as the ATR 72 and Bombardier CRJ, for which ZeroAvia aims to have conversions available by 2027 and 2029, respectively. Australia's Stralis Aircraft plans to convert the 19-seat Beechcraft 1900D to hydrogen fuel-cell power, while Deutsche Aircraft and H2Fly plan to fly a hydrogen-electric version of the 40-seat Dornier 328.

JEAN-MARIE URLACHER/VOLTAERO

VoltAero has used the Cessna Skymaster as a flying testbed for a hybrid powerplant and electric propulsion system.

ROTARY-WING RIVAL

If there is a rotary-wing rival to the Caravan's popularity as an aviation technology testbed and market opener, it is the Robinson Helicopter family of light rotorcraft, with the R22, R44 and larger turbine-powered R66 being used as platforms for autonomy, enhanced piloting systems and electrified propulsion. This raises the intriguing possibility that a customer could one day buy an R66 with hydrogen-electric powertrain, fly-by-wire controls and touch-screen displays.

Rotor Technologies has begun selling the R550X, an uncrewed aircraft based on the R44 and developed in collaboration with Robinson. The company is selling two versions: the 1,000-lb.-payload Airtruck for cargo and 110-gal.-payload Sprayhawk for aerial application. Skyryse is taking orders for its Skyryse One, a new-build R66 equipped with its SkyOS automated flight control system.

Tier 1 Engineering flew an R44 modified to battery-electric propulsion in 2018, and Robinson is now working with Quebec-based Unither Bioelectronics to fly an R44 converted to hydrogen fuel-cell propulsion and to develop an R66-based production version for zero-emission organ transport. Robinson, meanwhile, has its own internal electrification and advanced autopilot research efforts (*AW&ST* Sept. 16-29, p. 56).

Another testbed worthy of mention

CRANFIELD AEROSPACE

Cranfield Aersopace Systems plans to modify the Britten-Norman Islander to hydrogen-electric propulsion.

is the EcoPulse, a TBM 940 modified by Daher, Airbus and Safran to demonstrate distributed hybrid-electric propulsion. The aircraft has been in flight testing since November; that could lead to a hybrid-electric version of the popular single-turboprop TBM entering production around 2027.

Dovetail Electric Aviation has chosen the Beechcraft King Air as its hydrogen-electric propulsion application.

A final honorable mention should go to Cessna's unconventional 337 Skymaster. The aircraft's push-pull centerline-thrust engine arrangement has made it a popular choice, allowing one piston engine to be replaced with an electric motor while avoiding the thrust asymmetry complications of a

Rotor Technologies' R550X is an uncrewed aircraft based on the Robinson R44.

conventional twin if either powerplant fails. Ampaire, France's VoltAero and the National Research Council Canada have all used the Skymaster to test hybrid-electric propulsion, making it an icon of alternative propulsion.

DOVETAIL

ROTOR TECHNOLOGIES

Startup Ampaire is certifying its hybrid-electric powertrain first on the Cessna Caravan.
AMPAIRE

Istari Extends the Digital Thread To Enable Engineering at Software Speed

NASA

- FLYER ONE DIGITAL TWIN BUILDS ON X-56A MODELS AND FLIGHT DATA
- MODEL ONE PLATFORM CONNECTS ENGINEERING TO AIRWORTHINESS

Lockheed Martin Skunk Works built the X-56A to demonstrate active flutter suppression of a flexible wing.

Graham Warwick Washington

Innovators intent on disrupting aerospace are fond of citing Formula One auto racing as an example of doing things fast with technologies that are at least close cousins to those used in aircraft composite structures, electric drives and especially digital engineering.

Inspired by Formula One teams' routine use of digital twins to evolve and field race cars rapidly, startup Istari Digital is working under a $19 million contract with the U.S. Air Force AFWerx innovation unit to flight-certify a digital twin before the aircraft is physically built. Under the Flyer One program, a modification of Lockheed Martin Skunk Works' X-56A is on track to become the first digitally certified aircraft. The program goal is to enable aircraft development to move at the pace of software engineering.

"Physical engineering and software engineering don't look like each other today," Istari founder and CEO Will Roper says. "The reason is that physical engineering has all these compliances that approving bodies enforce for safety certification in the real world.

"There has never been a way to turn them into code that did not get away from making copies of the sources of data," Roper says. "By fixing that, we can start turning compliance into code. Then there is no reason that all engineering can't be like software engineering."

Istari's goal is to digitally connect the manufacturer's engineering and customer's certification processes so engineers and approvers can automatically and continuously check that designs comply with airworthiness requirements as systems are developed.

"No one went to MIT because they want to check a bunch of boxes, but you have to do it if you want to build an airplane," Roper says. "Now it's going to happen automatically, and Flyer One is the first time we're proving we can take the compliance checks for flight certification, turn them into code and check them automatically."

First flown in 2013, the X-56A is an experimental uncrewed aircraft developed to demonstrate active flutter suppression for slender, flexible wings. Flyer One features significant modifications to the landing gear and other systems while also addressing obsolescence issues. Critically, Skunk Works collected substantial data during the original program, providing a solid foundation for simulation of the updated aircraft's flight performance.

In June, Istari won a second, $15 million AFWerx contract to develop Model One, a digital thread platform that will link models and simulations across the Air Force and enable secure, real-time digital collaboration across difficult-to-integrate data types, from intellectual property to classified data. Model One is underpinning the development of Flyer One.

Istari's intent is to connect the manufacturer's authoritative models and simulations as well as their underlying artifacts directly to the Air Force's airworthiness process. Digitally certifying a modified aircraft rather than a clean-sheet design was deemed more practical and widely applicable.

"We're turning the process into a digital model, so we're already blazing a trail from an infrastructure perspective," Roper says. "We wanted to make the airplane use case meaningful but not so extreme that we're trying to embed two miracles in one program."

The objective is to leverage the X-56 data to obtain military flight release for the modified Flyer One by certifying its digital twin.

"If we succeed in getting a flight release, it's not going to bring in an era where new airplanes, blazing new physics boundaries, are going to be certified overnight," he says. "That may never happen. That certainly isn't the case in Formula One racing.

"But it might bring in an era where

more and more of the testing artifacts can be done digitally if they're extrapolations from the past, and that will speed up the process, save money and provide more feedback during the early design phase," Roper says. "That is the Formula One model."

Digital certification will require the Air Force to accept the results of virtual testing. "We are simply bringing a focus that digital testing is testing if you can account for all the errors associated with the models," Roper says. "Just because you test in the real world doesn't mean the result is correct. We get errors all the time," he notes, citing variations in the environment, sensors and prototypes.

"Good engineering is about keeping track of these errors, so we're simply saying models and sims have different error sources, but we can keep up with them with the same process," he says. "And as long as the total error leads to acceptable risk, then you don't need to do the physical testing."

What Istari plans to deliver is a digital twin that is threaded into the Air Force's airworthiness process. "There are a lot of components of the airworthiness process that we're turning into automated unit tests against which you can run a digital artifact," Roper says. "So rather than paper, it's now a software test."

Formula One auto racing teams use digital twins to test, evolve and certify their cars rapidly.

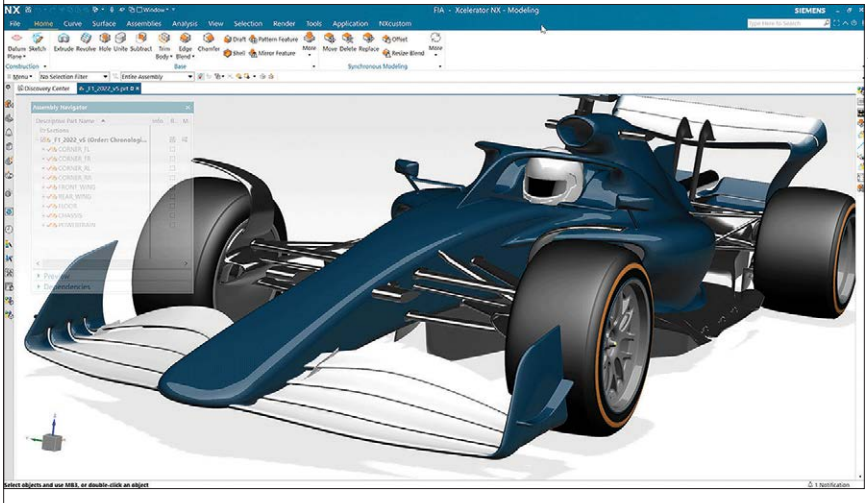
The Model One platform allows disparate sources of data to be integrated for airworthiness certification without being aggregated on one network. "In the past, the only way to build a digital twin was to aggregate the sources of truth, and then everything went to the highest level of classification," he says.

"That's not an impediment for a Formula One racing team—they have only one product to deliver and it's a race car," he says. "But an air force has thousands of products to deliver and many levels of classification, so aggregating data comes with a big penalty."

What are the sources of truth for airworthiness? "One source of truth is Lockheed Martin," Roper says. "They have the authoritative models of the structures and the aerodynamics. The other authoritative model is the airworthiness process owned by the Air Force. We have technology that allows those two things to be integrated together in real time and also integrated with code so we can do things like run automated tests and turn things that in the past were documents into software that you can test against automatically."

The inspiration for Model One is the software world's DevOps process to improve communication and collaboration among development and operations teams, thus increasing the speed and quality of software deployment. DevOps automates the continuous integration of code changes from multiple contributors and the continuous delivery of code changes to production.

"We're taking the continuous integration, continuous delivery process from software and adding one more step, which is continuous compliance," Roper says. "The compliance in this case is flight certification, but we could do this for any compliance. And as equal a breakthrough as the digital flight certification is that we are creating for the first time an example of compliance as code."



SIEMENS/RED BULL RACING

One reason compliances such as airworthiness certification have not been turned into software is that there are many different sources of truth involved in developing a complex system of systems, with multiple companies collaborating to build an aircraft. In these cases, people are used as the integration layer. This prevents the application of automation, analytics and artificial intelligence to the process.

"Let's say the Air Force created a digital model of airworthiness and gave it to Lockheed," Roper says. "If Lockheed were to say, 'Our system passed this model,' the Air Force can't accept that just on good faith. They have to have an auditable way of proving compliance.

"The only way of auditing has been to create multiple copies of the authoritative sources of truth and give them to another entity so they can do their own fact checking," he continues. "What we have created is a way where, rather than a copy, you can give them access to your source of truth, where it lives, so that everyone is operating on the authoritative real-time data at the same time.

"This allows a Lockheed Martin airplane to be checked against an Air Force airworthiness process, where both parties can agree it was the authoritative data that was run through the process," he explains, noting the fact-checking is done via software instead of by people.

If successful, Istari does not plan to stop with airworthiness certification. "There are many forms of compliance and all are documents," Roper says. "What Istari envisions is turning them one by one into code so that an engineer won't have to submit their file to a government official and wait six months for a reply.

"Physical systems engineering today is compiling and is done serially, like the systems engineering V," he says, referring to the sequential decomposition and recomposition process used today. "I'm seeing the first pivot to full-stack engineering, where those compiling steps no longer happen serially. They are happening automatically and continually, and that means the drudgery of engineering should end."

Contrails Present Challenge and Opportunity for Business Aviation

- ALTITUDE IS KEY TO MITIGATING PERSISTENT CONTRAILS
- EUROPEAN AIR TRAFFIC CONTROL CONSTRAINTS CREATE DIFFICULTY BUT ALSO AN OPENING

Graham Warwick Washington

IN AN AUGUST PRESS release announcing the results of a study into the effects of aircraft operational differences on the persistence of contrails, Imperial College London boldly declared, "Private jets [are] the worst offenders." That is not good news for a business aviation industry already struggling with public perceptions of its sustainability.

But all is not lost. In May, a study of contrails by aviation sustainability solutions provider 4AIR found that small altitude adjustments to business aviation flights could substantially reduce their contrail impact on the environment without CO_2 trade-offs.

Contrails form through the mixing of warm, moist engine exhaust with the surrounding colder air. In ice-supersaturated regions of the atmosphere, ice crystals in the contrail can grow, and from there the contrail can persist, spread and merge with other contrails to produce aircraft-induced cirrus clouds.

During the day, the cirrus reflects sunlight and has a cooling effect on the Earth's climate. But at night, such clouds trap the Earth's heat and have a warming effect. The prevailing theory is that contrails have an overall warming effect and a climate impact greater than that of aviation's CO_2 emissions.

But the scale of this warming is highly uncertain. Across aviation, multiple studies and tests are underway to understand contrails, quantify their climate effect and mitigate their impact. Most of this work is focused on commercial aircraft but applies equally to business jets.

The Imperial College study set out to quantify the factors controlling contrails by matching air traffic data to satellite imagery to isolate the role of aircraft type in contrail properties and evolution. Based on 64,000 cases, the study observed that more efficient aircraft form longer-lived contrails more frequently. This is primarily driven by an increase in flight altitude, the researchers said. In addition, the study found that business jets produced longer-lived contrails, despite their smaller engines' lower fuel flow, as they fly at higher altitudes.

Imperial College used imagery from the NASA-NOAA GOES-16 weather satellite to identify contrails over the Western North Atlantic using a convolution neural network. These were matched with aircraft position reports from the FAA's traffic flow management system and to aircraft-engine combinations using flight numbers. The resulting dataset included older airliners flying at about flight level 370 (FL370)—37,000-ft. pressure altitude—as well as modern airliners flying at around FL400 and business jets above FL410.

The researchers concluded that more efficient aircraft generate contrails with longer satellite-detectable lifetimes because they fly higher, where the ambient air temperature is colder. They also noted that the aircraft in the region studied usually fly in the troposphere rather than in the drier stratosphere, as is common farther north, likely increasing the frequency of persistent contrails.

Where Imperial College chose to focus is important, as results for the subtropical Atlantic region studied are not necessarily true for where most business jets fly, 4AIR President Kennedy Ricci says. Another factor is the altitude capability of most business jets—up to 51,000 ft. "If you fly even higher, you do not make contrails at all," he states. "That is lost in the [Imperial College] study."

The contrail study performed by 4AIR used publicly available automatic dependent surveillance-broadcast (ADS-B) data from almost 16,900 business jet flights involving 34 aircraft of seven different Bombardier, Embraer and Gulfstream types, 11 based in Europe and 23 in the U.S. The aircraft were not limited to flying in those regions, and the data included many global trips.

4AIR's study did not match the flights to contrails observed in satellite imagery, as Imperial College's did. Instead, researchers used a contrail prediction model based on historical weather data. "While the model is a leading model for predicting contrails, it does not include any observational data to confirm its results, and models inherently will be imperfect and may be inaccurate," the study cautions.

Fleetwide, 4AIR found the aircraft spent about 1.1% of flight time in contrail-forming regions, varying based on aircraft location. Those based in Europe spent more time in regions where contrails form, an average of about 2.1% of flight time, versus 0.7% for U.S.-based aircraft.

The 4AIR report states that the relative difference in time flying in contrail-prone regions is likely related to cruise altitude. "Contrail-forming regions typically emerge between FL330-430, so aircraft that had more flights that reached cruise altitudes above that range correlated with lower flight time spent in contrail-forming regions," the study says. "We didn't see anything above 43,000 ft.," Ricci adds.

Contrails with the greatest warming impact formed between FL350 and

FRANK WAGNER/GETTY IMAGES

Persistent contrails can spread, merge and form aircraft-induced cirrus, which can have a climate-warming effect.

FL400. EU-based aircraft flew at cruise levels in these altitudes on 18.7% of flights compared with 4.4% for U.S.-based aircraft. "We have two parallel fleets in the U.S. and EU with the same types," Ricci says. "The EU fleet more often flies low enough to create contrails, even on similar mission profiles. Most of that comes down to air traffic control [ATC] and operating rules, which means there is a bigger opportunity to mitigate."

EU-based aircraft most frequently had cruise altitudes at FL380-420—43.1% of flights versus 8.1% for U.S.-based aircraft. The study found that 49.3% of the U.S.-based aircraft flights were flown above FL420, compared with 9.6% for EU-based aircraft. Because of that, U.S.-based aircraft spent less time in contrail-forming regions, even comparing similar types.

"The biggest climate impact comes from contrail persistence, or when we have a hot spot with lots of contrails that combine," Ricci says. Contrails that persist and grow are much more impactful than those that quickly form and disappear. Longer-lasting contrails have more time to absorb heat leaving the Earth or to reflect sunlight back into space.

4AIR estimated that the contrails formed by flights in its dataset lasted about 2.5 hr. EU-based aircraft formed contrails with an estimated duration of 3 hr. compared with 2.2 hr. for those based in the U.S.—one factor in why the EU flights had a higher contrail impact per flight hour, the study says.

"We've started expanding the flights we are looking at and doing more forecasting to find out what are the real opportunities to mitigate contrails," Kennedy says. "We found a lot are ATC-related, so we need to understand what is practical. How much a flight can climb or descend [to avoid forming contrails] is limited by the ability of ATC to handle the change. We need a more realistic assessment."

One of the services 4AIR will provide for operators is compliance with the new monitoring, reporting and verification system for non-CO_2 effects—such as persistent contrails and nitrogen-oxide emissions—that will be operational beginning in 2025 under the EU Emissions Trading System.

Under this scheme, which covers only intra-EU air travel, operators will provide ADS-B data on their flights for the EU to run in its contrail prediction model. 4AIR uses the same model. "Once we start to measure, we can start to update the modeling," Ricci says. "Over the next three years, we can build an understanding of what we can do [to avoid forming persistent contrails]."

The 4AIR study sought to identify "big hits"—flights with extremely high contrail impacts in proportion to the distance flown, often far exceeding their CO_2 effects. Although only 17.9% of flights in the overall dataset created contrails, the lion's share of the overall contrail footprint calculated by the model came from flights meeting this "big hit" criterion, the study says.

A mere 17 flights (0.1%) accounted for more than 26% of the entire fleet's contrail footprint over a year. About 50 (0.3%) of the almost 16,900 flights in the dataset accounted for 51% of the total contrail impact, and about 123 flights (0.73%) accounted for 75%.

"Had mitigation efforts been able to successfully avoid or minimize contrail exposure on just 50 flights over the course of the year, it would have avoided 51% of the entire sample's contrail impact," the study says.

"We do not need to mitigate every flight," Ricci says. "This is low-hanging fruit. We do not need to sacrifice fuel just to know where the hot spots are. And we need to incorporate that at the operator level." He notes that ForeFlight is developing a way for operators to visualize areas of possible contrail formation through its flight planning tool.

While the scale of the problem for business aviation is far smaller than it is for commercial aviation, contrails are highly visible, draw public attention and could add to the industry's image issues with sustainability. "All aviation needs to focus on this," Ricci says. "But for business aviation, we found so many opportunities to mitigate contrails.

"These are aircraft with ceilings above 45,000 ft.," he continues. "The airline operating ceiling is right in the contrail formation zone. Business aviation has a greater opportunity to mitigate the problem. And we do not need to mitigate every flight. We can identify hot zones and times of day when other aircraft are in the area and also creating contrails, and mitigate just those flights."

TECH TAKE

By **Graham Warwick**

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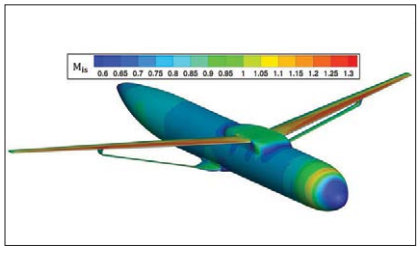
Wake-Energy Project Aims at Fuel Savings

Having demonstrated fuel savings crossing the Atlantic by flying two A350s in formation, one surfing the vortices of the other, Airbus is leading a European project to develop technologies and procedures that would allow airlines to use the wake energy retrieval technique in routine operations.

AIRBUS



Airbus' fello'fly project demonstrated more than 5% fuel savings from wake energy retrieval.

Funded by Europe's SESAR-3 air traffic management research program, the three-year Geese project (Gain Environmental Efficiency by Saving Energy) is a follow-on to Airbus' fello'fly project, which culminated in November 2021 with the first long-haul demonstration of wake energy retrieval (WER).

The demonstration involved two A350s flying as a pair from Toulouse to Montreal, separated by about 2.2 km (1.2 nm). This allowed the trailing aircraft to benefit from lift generated by updraft from the preceding aircraft's vortices. Subsequent analysis showed that airlines could save 5-10% fuel per trip.

To maintain steady level flight within the updraft from the wake vortex shed by the leader aircraft, the follower must pitch nose-down so it is descending relative to the upward moving air. The lift vector, normally vertical, is then tilted slightly forward. This counters some of the drag, requiring less thrust to maintain horizontal flight—thus reducing fuel consumption.

The €10 million ($11 million) Geese project aims to enable WER operations for both transatlantic routes and transcontinental flights across Europe. The project will define the necessary operational tasks for pilots and technology to manage WER operations automatically, including flight management systems (FMS) and cockpit functions that capture and track the wake vortex.

The project will explore a "pairing assistance" system for dispatchers at airline operations control (AOC) centers that will enable operators to work together to change their flight plans to enable suitable aircraft to pair, taking into account routing to the rendezvous point and other factors.

Geese will run a series of simulations to validate pairing procedures, with Air France, French Bee, Delta Air Lines and Virgin Atlantic taking part. Flight trials are planned to start in the second half of 2025. Paired aircraft will be positioned at different altitudes in accordance with normal vertical separation minima, as the objective is to validate the processes not redemonstrate the flight physics of WER, Airbus says.

The project has three work packages. The first is enabling Europe to North Atlantic WER operations by developing the initial concept of operations and its safety assessment, analyzing the impact on legacy systems, and conducting simulations and flight trials. The second is extending WER operations to European domestic airspace. The third involves wake science and investigating the potential non-CO_2 benefits of formation flights.

In actual airline operations, it is envisaged that a new WER flight plan would be released only by the AOC and uplinked to the pilots after consultation with air traffic control, during which controllers would confirm whether or not they could accept the changes.

Once uploaded to the aircraft FMS, the WER flight plan would be selectable as a secondary option with the original no-WER flight plan remaining in the FMS as the primary. "Only once a new flight plan is approved would the pilot be authorized to activate the secondary flight plan in the FMS," Airbus says.

The aircraft's fuel load would remain exactly as per the original flight plan. "The fuel loaded would not be impacted, as it will be based on the no-WER scenario," says Laura Montironi, a vehicle systems architect at Airbus. "In fact, what we propose is that the respective airlines will not know if they will effectively constitute a pair. They will just declare their intention that their flight could be part of WER."

While the WER trials are planned to be type-agnostic, some aircraft-level requirements are preferred—including the ability to automatically position the follower aircraft behind the leader and track its vortex. Airbus says the A350 will likely be its platform of choice because of its range and avionics capability, but extending the trial to include the A330 and Boeing aircraft is under discussion.

Solar Stratospheric Sunglider Adapted for Military Missions

AeroVironment has flown an upgraded Sunglider solar-powered stratospheric uncrewed aircraft system (UAS) with improvements planned for a Horus A version intended for government applications such as surveillance, communications relay, backing up GPS and even space domain awareness.

AEROVIRONMENT

Upgrades tested in stratospheric flight will apply to government Horus A and commercial Sunglider aircraft.

The Horus A features improvements in design, avionics, redundancy and autonomy that will flow back into continued development of the 256-ft.-span flying-wing Sunglider high-altitude platform station (HAPS) being developed with Japan's SoftBank for commercial applications.

Additional autonomy increases mission flexibility and multiple redundancy enhances mission assurance, AeroVironment says. The Horus A is capable of carrying a 150-lb. payload with 1.5 kW of available power. On the stratospheric test flight, the aircraft simultaneously operated a synthetic aperture radar and a tactical-grade mesh network radio.

"During this recent Horus A flight,

we demonstrated the ability to carry multiple payloads for the U.S. Defense Department and transmit real-time data, advancing the viability of HAPS for government applications," says Jeff Rodrian, senior vice president and general manager of AeroVironment's MacCready Works.

The Horus A received airworthiness approval from the U.S. Army and a special airworthiness certificate from the FAA that allowed flight testing to be conducted in national airspace, AeroVironment says. The stratospheric test flight was conducted in New Mexico.

During the test flight, the aircraft demonstrated the ability to maneuver in adverse and turbulent weather and land safely, the company says. Those conditions have proved problematic for many solar-powered stratospheric UAS.

Potential military roles identified by AeroVironment for the Horus A include: resilient communications and network extension; assured positioning, navigation and timing; space domain awareness; long-duration intelligence, surveillance and reconnaissance; and deep sensing.

HAPS for Maritime Domain Awareness

Japan has launched a project to develop technology enabling high-altitude uncrewed aircraft to conduct long-duration stratospheric flights at higher latitudes to perform maritime domain awareness missions over Japan and Europe, even in winter when fewer daylight hours pose a challenge.

Funded by Japan's New Energy and Industrial Technology Development Organization (NEDO), the project aims to be the first to establish the capability to use a high-altitude platform station (HAPS) for remote sensing—and not just as an airborne base station for wireless mobile communications.

Under the first theme of the project, NEDO has awarded a four-year, ¥6 billion ($41.5 million) contract to a team of Space Compass, ShinMaywa Industry and Mitsubishi Research Institute to conduct research and development on maritime domain awareness technology to be installed on a HAPS.

Electro-optical/infrared sensors and synthetic aperture radar that previously could only be carried by large uncrewed aircraft will be reduced in

A stratospheric HAPS would carry sensors and radar to monitor the maritime domain.

weight and energy consumption to fit on a HAPS. The project includes a flight demonstration and development of a system to plan and manage the HAPS missions and another to analyze the data from the platform's sensors.

Under the second theme of the project, NEDO has awarded Softbank a one-year, ¥200 million ($1.3 million) contract to conduct a feasibility study into power technologies that would enable long-duration flights year-round over Japan for the maritime domain awareness mission.

Softbank will identify development goals for high-energy-density battery packs for energy storage and ultralightweight, high-efficiency solar cells for power generation on the HAPS. Research will focus on lithium-metal batteries, which have a higher energy density than lithium-ion, and battery-pack assembly technology that reduces weight and volume

Reducing the weight and increasing the efficiency of power generation will require thinner and lighter solar panel materials and solar cells with ultrahigh conversion efficiency and low cost, Softbank says. The cells will need to be fine-tuned for the stratospheric environment where the solar spectrum differs from that on the ground and temperatures are extremely low.

Lift eVTOL Will Carry Modular Medical Payload

Startup Lift Aircraft has been awarded a U.S. Army contract to develop and demonstrate a modular medical payload that enables its Hexa electric vertical-takeoff-and-landing vehicle to deliver blood and evacuate a casualty.

Austin, Texas-based Lift has partnered with autonomous flight systems developer Near Earth Autonomy for the Small Business Innovation Research (SBIR) contract, awarded by the Army Applications Laboratory (AAL). The companies say the modular payload will be easily adaptable to different transportation means.

Lift is producing the Hexa, a single-person multicopter electric vertical-takeoff-and-landing (eVTOL) aircraft, and has developed and tested an uncrewed cargo version under an SBIR contract from the U.S. Air Force's AFWerx innovation unit.

At the culmination of the Army contract, Lift will demonstrate the modular medical payload being transported by air and ground vehicles, including the Hexa Cargo. The payload will be climate-controlled to maintain blood temperature and incorporate monitors to track a casualty's vital signs.


LIFT AIRCRAFT

Lift's Hexa Cargo uncrewed eVTOL will resupply medicines or evacuate casualties in a modular payload.

"The current practice of relying on crewed vehicles to provide blood resupply and casualty evacuation [casevac] in contested areas has significant challenges," says Maj. Rickey Royal, project manager for the AAL solutions innovation group. "The Army has identified a significant need for a modular, multimission payload capable of climate control and telemedicine that can deploy via an autonomous aerial and/or ground platform."

The Lift contract is the latest in a long-running quest by the Army to develop autonomous systems that can deliver medical supplies and recover casualties in battle zones, although carrying injured soldiers in uncrewed vehicles remains controversial. Near Earth was involved in an early-2010s program with Piasecki Aircraft to demonstrate an uncrewed casevac helicopter using the Boeing Unmanned Little Bird and in an early-2020s project with L3Harris Technologies to deliver blood by eVTOL drone.

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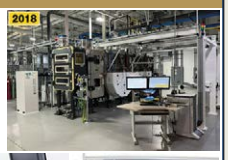

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VIEWPOINT

Aligning Higher Education and Industry

By **Sharon B. DeVivo**

If you had $500 million, how would you solve [fill in the problem]? This was a question posed to panelists at a recent conference of aviation industry professionals. Not surprisingly, the answers varied depending on the issue.

When it comes to building the workforce pipeline, $500 million would disappear quickly if it were simply directed to the industries that already have identified shortages. But what about the industries that are emerging, such as air taxis and vertiports, and all the brainpower we need to achieve net-zero in carbon emissions by 2050? Maybe there is a way to solve this issue without needing to hit the lottery.

The good news is that we are an industry that has untapped potential from underrepresented groups, including women and those from underresourced communities. The tough news is many folks have no idea what it means to work in aviation and aerospace, let alone the emerging fields within these industries, and we must work to create awareness, interest and demand. At the same time, higher education and technical institutions need to align their teaching with emerging skill sets. Once we have achieved that, we must make sure we are creating a sense of belonging for individuals who bring a host of skills and talents.

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"HIGHER EDUCATION AND INDUSTRY CAN BUILD PARTNERSHIPS THAT CONTRIBUTE TO THE EXPANSION AND SUCCESS OF OUR SECTOR."

Advanced air mobility, sustainable aviation fuel, uncrewed aerial vehicles and more are on the cusp of revolutionizing transportation, promising to transform how we move people and goods. To align with higher education for a skilled workforce, foster innovation and address regulatory and societal challenges, institutions like Vaughn College are developing specialized programs and curricula—not all of which require a four-year degree.

Certificate programs, such as the one Vaughn has in programmable logic control (a skill used in making robots or automation work), provide students a way to jump right into a career or apply their learning toward an engineering degree later in their professional career. Airports are an environment in which programmable logic control is used (think baggage systems), and technicians and engineering expertise make those systems hum. The same approach can be used with other technical fields, such as air traffic management, cybersecurity and regulatory compliance. Providing jobs that have differing entry points has the added benefit of supporting efforts to diversify the workforce by lowering barriers.

This idea can also work in reverse as technology advances and the needs of industry change. Maybe you already have an engineer who needs specialized skills that were not part of the initial degree program—partnering with an institution can help that employee gain new skills and bestow the next wave of graduates with those skills as well.

Interdisciplinary programs that combine technical skills with an understanding of business, law and regulation can also provide a holistic understanding and help solve complex challenges.

Higher education institutions can help teach the public about the innovation and sustainability efforts happening across aviation and aerospace, too. When Joby Aviation parked its 56-ft.-long simulator trailer on our campus in New York City for almost two weeks this year, we welcomed a variety of government leaders, youth-serving organizations and industry partners to learn more about advanced air mobility and what it could mean for everyone's quality of life.

Maybe you don't have a simulator on wheels, but aviation is a thrilling, high-touch opportunity, and everyone can get excited about a virtual reality headset that allows you to climb inside the flight deck or repair a part of an engine, tour the airside of an airport or visit a manufacturing floor. By fostering an informed and engaged public, higher education and industry can build trust and understanding.

Higher education can collaborate with industry partners to create inclusive work environments as well. Partnering with minority-serving institutions, such as tribal colleges, Hispanic-serving institutions (like Vaughn) and historically Black colleges, higher education institutions can ensure that the industry benefits from a wide range of perspectives and talents.

The ongoing advancements in aviation and aerospace continue to hold immense potential to transform transportation and improve quality of life—as this industry has done since its founding. Working together, we can bridge the skills gap, foster innovation, promote inclusion and build partnerships that contribute to the expansion and success of our sector. Collaboration is the key to growth for us all.

Sharon B. DeVivo is president of Vaughn College of Aeronautics and Technology in Flushing, New York.

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