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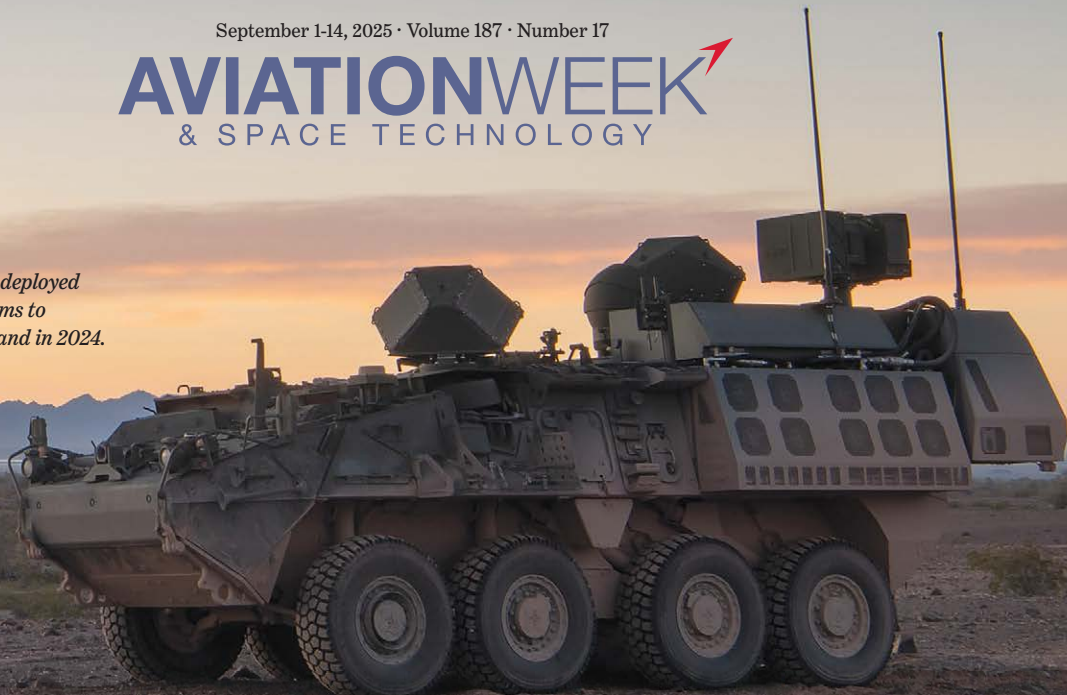
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The U.S. Army deployed four laser systems to Central Command in 2024.



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ON THE COVER

Shanghai-based AutoFlight, the first company to certify a winged electric vertical-takeoff-and-landing vehicle, the V2000CG Carryall uncrewed cargo aircraft, ranks third in a new Advanced Air Mobility Reality Index developed specifically to assess the progress of China's fast-moving industry. Our report by Executive Editor for Technology Graham Warwick begins on page 56. AutoFlight photo.

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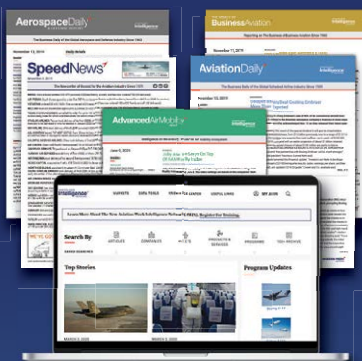
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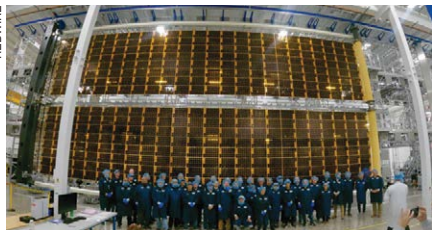
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A LIGHTHOUSE FOR SCIENCE

The present budget proposal by the White House faces NASA with what is probably its worst crisis ever ("*\$10 Billion Gives NASA a Reprieve—But No Clarity*," July 14-27, p. 20). Surely an aged organization such as NASA has its bureaucratic problems, as also highlighted recently by not-to-be-director Jared Isaacman. But cutting down drastically on the budget is hardly the solution.

A visionary such as Isaacman could well have been the person to lead NASA into the future; now we shall never see what he might have achieved. Not only will NASA need to abandon several future prime projects. It will also need to terminate ongoing missions that are constantly yielding impressive results at very little cost.

It is a legacy of NASA that some of the most successful missions became so exactly because they were funded far beyond their originally planned duration. Voyager, Hubble, the Mars rovers Spirit and Opportunity are such examples. These missions have been NASA's most popular enterprises. They have inspired and are inspiring the younger generation to enter science and technology for the benefit of society, just as Apollo did in the 1960s. And they have spurred all-important international cooperation in space.

NASA survived both the Apollo 1 fire and the loss of the Challenger space shuttle, not least due to its inherent internal qualities combined with outside help. Let us hope that NASA, with help from its many supporters, will manage to survive as a lighthouse for science and technology for the U.S. and all cooperating nations.

Jens Hoeg, Herlev, Denmark

THE ESSENCE OF SUCCESS

A historical perspective might have led Stephen Perry ("*Defense Disruptors*," Aug. 11-31, p. 10) to write that "the U.S. defense industry is fast becoming more collaborative." We Europeans

have been at it for some 60 years. Not always successfully—the Anglo-French Variable Geometry fighter program collapsed in 1967, accompanied by some acrimony. The Eurofighter of the 1980s spawned two competing aircraft. And lessons have still to be learned about better marshaling the Continent's resources into the latest generation of combat aircraft.

But European collaboration produced the Panavia Tornado, which is to my mind one of the best light bombers of the 1970s and '80s, and a sound military transport, albeit some 20 years in the making!

There are, of course the Lockheed Martin F-35 international program and the earlier McDonnell Douglas-BAe AV-8B Harrier as evidence of some effective joint work already on the American side.

But Perry should not underestimate the downside of collaborative tensions and perhaps spectacular fallings-out. The essence of success is good faith and trust, and of course, for most Europeans, there was and is no realistic alternative. The latter has been the most powerful adhesive holding partnerships together.

Keith Hayward, Royal Aeronautical Society Fellow, London



HUMAN INGENUITY

After reading Graham Warwick's Leading Edge column "Designer's View: Evolving the F-35" (Aug. 11-31, p. 14), I realized that many points, especially "tribal and experiential knowledge" discussed in Garrett Reim's Quantum Leap column "Hidden Knowledge" (Aug. 11-31, p. 13), had been applied in the potential F-35 upgrade. Artificial

intelligence is a useful tool, but it will never capture the knowledge of experienced aviation professionals or replace human ingenuity.

Mike Terre, Milton, Delaware

'ALMOST' INCIDENTS

I find it incredulous that the FAA discovered "only" 874 incidents in the area around Ronald Reagan Washington National Airport ("*Perilous Procedures*," Aug. 11-31 p. 22). How many does it take to trigger a change in the traffic pattern? If there were only two incidents, regardless of their classification, I could see that a reasonable person would say that no change in the procedures/routes was necessary. But 874? That's a lot of reporting, and in my view, every one of those was a potential midair collision.

How many other airports have large numbers of "almost" (midair collision) incidents in the database? I hope someone is looking at that and not focused primarily on only this collision, tragic as it was.

Fred Furtak, Baldwinsville, New York

ON AVIATIONWEEK.COM, IN

RESPONSE to "Opinion: Aerospace Needs A New Deal For Suppliers" (July 14-27, p. 10), JOHN L. comments: As a retired CPA and director of SEC reporting for a multibillion-dollar publicly traded company, I find the emphasis on "cash flow" instead of earnings bordered on the fraudulent. How to boost cash flow? Simple: They delayed paying their vendors! Company profits didn't change, but suppliers got so squeezed some went bankrupt or left the industry. Others reduced quality. Any industry emphasizing cash flow at the expense of reporting profits should be avoided as a customer and investor.

CORRECTION

"An Epic Accounting" (July 28-Aug. 10, p. 12) should have stated that Epic Aircraft aims to complete one aircraft per week.

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.



Adriaan Den Heijer has been promoted to chief commercial officer from executive vice president of cargo at *Air France-KLM*, succeeding Angus Clarke.

Den Heijer has been with KLM since 1995 and has worked across the group in ground services, marketing and pricing and revenue management.

Vertical Aviation International has appointed **François Lassale** president and CEO. He has more than 35 years of experience in the industry, most recently as group managing director and CEO of SGi, HeliNiugini and Allway Merit. Before that, he held senior positions at HeliOffshore, including CEO and chief operating officer.

Nikhil Ravishankar has been named CEO at *Air New Zealand*, effective Oct. 20.

He will succeed Greg Foran, who announced his resignation in March. Ravishankar has been chief digital officer, a position he previously held at telecommunications company Vector.

Comtech has appointed three executives in its Satellite and Space Communications segment: **Steve Black** as chief operating officer, **Mark Dale** as chief technology officer and **Brent Norman** as chief financial officer. Black was vice president and general manager of General Dynamics' Advanced Manufacturing Group and before that worked at L3Harris Technologies. Dale was a senior technical fellow and vice president of U.S. business development and previous to that was chief scientist of satellite communications at Kratos Defense & Security Solutions. Norman was executive director of finance at General Dynamics and before that held finance positions at L3Harris.

Ottmar Pfänder has been named chief program officer and appointed to the executive board at *MTU Aero Engines*, effective Jan. 1, 2026. He will succeed Michael Schreyögg, who is leaving the company. Pfänder was senior vice president of commercial programs and previously led corporate strategy.

Haggen Aviation has promoted **Chris Haight** to CEO and equity

partner from vice president of operations. Before joining the company, he was a general manager at Straight Flight, another Part 145 aircraft repair station.

UK defense tech company *Qinetiq* has tapped **Scott McGleish** as chief growth officer. He was president and general manager at Weibel Scientific North America, and held senior positions at Raytheon



Technologies and Booz Allen Hamilton.

Kerry Holder has joined *Air Charter Service* as chief financial officer.

She brings more

than 30 years of experience in financial management, most recently as group finance director of Oxford International Education Group.

Alaska Airlines has hired **Steven C. Udvar-Házy** as head of fleet strategy and planning. He was senior vice president and chief of aircraft operations at Aviation Capital Group, where he worked for about 13 years.

Jessica Rust has been promoted to executive vice president of sales from director of charter sales at private aircraft management and charter company *Silver Air*. Her past employers include Jet Aviation and Universal Jet.

Eric DiStasi has been appointed vice president of strategy and general manager of advanced missile programs at *L3Harris Technologies*. He was vice president of strategy, business development and communications at subsidiary Aerojet Rocketdyne and before that worked at Lockheed Martin and United Technologies.

Avianca has hired **Jaime Manso** as senior vice president of loyalty and LifeMiles. He was nonfinancial ecosystem managing director at LATAM Pass. Before moving into the airline industry, he worked at SMU S.A. and BNP Paribas.



Ispace-Japan has hired **Hideari Kamiya** as executive vice president of business development. He was head of the space business at Mitsubishi Corp., where he worked for 28 years.

Vilma Vaitiekūnaitė

has joined air charter company *Chapman Freeborn* as vice

president of passenger for Saudi Arabia. She was CEO of air charter brokerage Skylence and before that was chief communications officer of its parent company, Avia Solutions Group.

Motion, control and power products provider *Allient* has hired **Greg Kraus** as director of strategic operations for Allient Defense Solutions. He brings years of experience from Moog, where he was most recently director of operations for military global sustainment.



Douglas Brooks

has succeeded Rakesh Gangwal as independent chair of the board of directors at *Southwest Airlines*.

Gangwal remains on the board, of which he became chair in November after joining in July 2024. Brooks is the former chairman, president and CEO of Brinker International, a casual dining restaurant company.

William Edwards has joined *ENSCO* as director of counter-uncrewed aircraft operations. He brings experience from the private and public sectors, most recently as president of the federal and public safety directorate at Building Intelligence. In addition, he was director of intelligence for the U.S. Army Special Operations Command North.

HawkEye 360 has added **David Wajsgras** to its board of directors. He was CEO of Intelsat, where he supported its acquisition by SES. Before that, he was president of intelligence, information and services at Raytheon, where he worked for more than 14 years. 📧



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.:

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Santiago, Chile



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FIRST TAKE

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U.S. AIR FORCE



DEFENSE

General Atomics Aeronautics Systems Inc. flew the YFQ-42A for the first time on Aug. 27, kicking off tests of the U.S. Air Force's Collaborative Combat Aircraft.

Thailand has formally become the second export customer for Saab's Gripen E/F combat aircraft after signing a \$556 million contract for four aircraft.

India has placed a \$7.5 billion follow-on order for 97 Hindustan Aeronautics Ltd. Tejas Mk. 1A light combat aircraft, adding to 83 previously purchased.

India has chosen Safran to help develop and produce a next-generation turbofan engine for the planned Advanced Medium Combat Aircraft.

China has flown two high-speed rotorcraft demonstrators, a tiltrotor and a rigid coaxial-rotor compound helicopter (page 24).

SNC has joined the competition to replace the U.S. Navy's Boeing T-45 Goshawk trainer, offering an update of its clean-sheet Freedom design (page 26).

Raytheon's Stinger shoulder-launched surface-to-air missile is set to be produced in Europe through a deal with Germany's Diehl Defense.

The Israel Defense Ministry plans to buy two additional Boeing KC-46 refueling aircraft, bringing its fleet to six, if the deal is approved by the government.

New Zealand has selected five Sikorsky MH-60Rs to replace its Kaman SH-2G(I) naval helicopters and two Airbus A321-XLRs to replace its Boeing 757 transports.

SPACE

A SpaceX Starship-Super Heavy rocket lifted off on Aug. 26 from Starbase, Texas, for its 10th flight, its first full-duration test since Flight 6 in November 2024 (page 54).

SpaceX launched a U.S. Space Force Boeing X-37B orbital test vehicle Aug. 21 on the eighth mission of the reusable mini-spaceplane.

Russia launched the Bion-M No. 2 biological research spacecraft into polar orbit Aug. 20 to test radiation effects on living species, the country's 10th space launch of the year.

China completed the first static test on Aug. 15 of the YF-100K engine for its Long March 10 rocket, which is designed for future crewed lunar missions.

The European Space Agency has awarded two launches to startup Isar Aerospace and three to Avio for Vega C missions under its Flight Ticket Initiative to test space technologies.

The U.S. Air Force Research Laboratory has awarded contracts to Anduril and Blue Origin to study its Rocket Cargo concept to transport equipment globally using commercial launch vehicles.

NASA has issued a request for information on a nuclear fission power plant for launch as early as 2030 to operate on the lunar surface.

The Italian Space Agency signed an agreement with SpaceX to fly science payloads on a Starship mission to Mars, with the first uncrewed launch targeted for the fall of 2026.

COMMERCIAL AVIATION

Korean Air has agreed to purchase 103 aircraft from Boeing: 50 737-10s, 25 787-10s, 20 777-9s and its first order for eight 777-8F freighters.

Turkish Airlines says its €300 million (\$350 million) bid for Air Europa has been accepted, and the deal should be completed in 6-12 months.

The U.S. Transportation Department is seeking bids to provide essential air service in Alaska after Ravn Alaska ceased operations, ending 77 years of service.

Bridges Air Cargo in Malta has become the launch customer for the Embraer 190 P2F converted freighter, with an order for four freighters from lessor Regional One.

VIEW FROM KYIV

Ukraine Eyes U.S. Drone Market

Kyiv has pitched a \$50 billion proposal to the White House to supply the U.S. with 50 million drones over a five-year period, Ukrainian President Volodymyr Zelenskyy told reporters Aug. 20.

The offer involves domestic production in Ukraine and co-production with U.S. companies, Zelenskyy said in remarks reported by Interfax-Ukraine.

But the proposal appears to be on hold as the White House, the Kremlin and Kyiv consider holding peace talks in the coming weeks. "Probably, after the war, it will work," Zelenskyy said.

U.S. President Donald Trump has promised to buy Ukrainian drones after its war with Russia ends, when the country can afford to put such weapon systems on the export market.

"We have an agreement with the U.S. president that when we open exports, they will buy Ukrainian drones," Zelenskyy said. "This is important for us."

The Ukrainian government set a goal last year for its domestic industry to produce 4 million uncrewed aircraft of all types in 2025, more than double the total produced in 2024.



Lufthansa has restored its Lockheed L-1649A Starliner in the colors worn when the aircraft entered service in 1957 with the German flag carrier as the "Super Star." The restored aircraft has been delivered to the Lufthansa Conference and Visitor Center in Frankfurt, which will open in the spring of 2026, marking the 100th anniversary of the airline's founding. The piston-powered Super Star was flown primarily on nonstop service to New York from Hamburg on flights that lasted up to 17 hr.

LUFTHANSA

A U.S. appeals court has reinstated a jury award of \$81 million in damages against Boeing for stealing trade secrets from failed electric aircraft startup Zunum Aero.

Beta Technologies has delivered its first Alia CX300 electric conventional-take-off-and-landing aircraft to Bristow Norway for cargo demonstration flights.

An Australian court has ruled Qantas must pay fines of A\$90 million (\$59 million) for illegally outsourcing the jobs of 1,800 ground workers during the COVID-19 pandemic.

Gulfstream Aerospace delivered the first G800 ultra-long-range business jet to a customer on Aug. 27 from its completion facility in Appleton, Wisconsin.

Loft Dynamics has raised a \$24 million Series B round to fund the development and rollout of virtual reality-based Airbus A320 and Boeing 737 simulators.

The FAA has certified Garmin's Autoland and Autothrottle emergency landing system on select Beechcraft King Air 350 twin turboprops. 🛩️

65 YEARS AGO IN AVIATION WEEK

The first production model of the Lockheed JetStar, the grandfather of all business jets, was featured on our cover on Sept. 5, 1960, flying near the company's plant in Marietta, Georgia. Commissioned by the U.S. Air Force as the VC-140B, a utility jet to transport the president and other high-ranking government officials, the JetStar was repurposed by Lockheed and became the world's first private jet when it entered service in 1961. Powered by four rear-mounted Pratt & Whitney JT12 turbojet engines, the aircraft was famously featured in the 1964 James Bond movie "Goldfinger." JetStar production ran through 1979, but Lockheed would never build another business jet.



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OBITUARY

Pierre Jeannot, former director general of the International Air Transport Association (IATA), has died at age 92. Born in Montpellier, France, Jeannot began his career with Trans-Canada Air Lines (later Air Canada) where, as maintenance division chief, he contributed to development of the "black box" flight data recorder. As president and CEO from 1984 to 1990, he led the privatization of state-owned Air Canada. Under his leadership of IATA from 1993 to 2002, industry agreed to and achieved a target to cut the accident rate in half over 10 years. Jeannot died in Montreal on June 22.



IATA

UP FRONT

RICHARD ABOLAFIA

**GOVERNMENT-DIRECTED JETLINER**

sales are back. Qatar and the United Arab Emirates signed large orders during President Donald Trump's Middle East trip in

May (see photo), and Poland's LOT Airlines selected Airbus A220s over Embraer 195s in June in a very politicized selection process (*AW&ST* June 30-July 13, p. 22).

The use of high politics as a sales tool stands to transform the airliner market landscape, but it is nothing new. In the 1970s and 1980s, Europe used political pressure to promote Airbus' emergence, and the U.S. responded in kind.

Government-to-government and government-to-airline commercial aircraft sales gradually diminished with global free trade agreements in the 1980s and 1990s. The Clinton administration's aggressive 1993 Saudi Arabia sales campaign, in retrospect, was the end of an era.

In fact, one of these free trade agreements banned government-directed airliner sales campaigns outright. The World Trade Organization Agreement on Trade in Civil Aircraft (ATCA) clearly states that "purchasers of civil aircraft should be free to select suppliers on the basis of commercial and technological factors." It also stipulates that "signatories shall not require airlines, aircraft manufacturers or other entities engaged in the purchase of civil aircraft, nor exert unreasonable pressure on them, to procure civil aircraft from any particular source, which would create discrimination against suppliers from any Signatory." ATCA bans aircraft trade tariffs between signatories, too, so other features of this treaty are under attack as well.

The only major market where governments have played a key role in airliner sales in recent decades has been China. Even there, government purchase announcements often serve as a final approval stage of airline-determined purchases. (China is not an ATCA signatory, but it does have observer status.)

If the Qatar, Etihad and LOT agreements are harbingers of further market politicization, government involvement in airliner sales will shape the industry in three ways—none of them good.

First, politicized sales lead to bad economic consequences. Airlines do best when they can select the right equipment at the best price. Just as military effectiveness can be impaired when weapon choices are limited to less capable manufacturers, politicians can saddle airlines with aircraft that are less efficient for their particular networks.

Hence, airlines have liked ATCA and disliked the idea of being strong-armed into buying specific aircraft. ATCA has allowed U.S. airlines to buy Airbus aircraft and European carriers—even Air France—to become some of Boeing's largest customers. Even in China, airlines work to select their own aircraft despite government interference. The saying goes, "The emperor is far, and the mountains are high."

Political interference in airline purchase decisions also would induce manufacturer complacency. Why try as hard to innovate with new technologies and products when government salesmanship helps protect markets?

Second, politicizing aircraft sales puts manufacturers at risk of being blindsided by geopolitical developments. As a former Boeing executive once told me, "We're the designated hostage in any trade standoff."

Today, the U.S. is in the middle of any number of trade standoffs. China, the world's largest export airliner market, has overwhelmingly favored Europe and Airbus since the first Trump administration, and there are few signs of this changing.

India, hit by some of the highest import tariffs proposed by Trump, also is likely to retaliate by continuing to favor Airbus.

Securing a few additional orders from countries in the Middle East would be some consolation, but the Gulf superconnector airlines tend to buy in roughly equal numbers from Airbus and Boeing, and Trump-related sales are unlikely to signal a shift.

Continuing to lose out in China and India would be very damaging for Boeing's market share. In the long run, these political winds could shift, putting Europe at a disadvantage, but for now, Boeing and its suppliers are at greater risk.

Finally, politicizing jetliner sales might produce a big unintended consequence. One new jetliner prime, Comac, has a growing lineup of unproven products, almost zero market share and a minimal global product support and sales presence and potentially very strong national political and economic backing.

If the U.S. and Europe openly abrogate ATCA, normalize the use of politics as a key selling tool again and work to weaken airline purchasing autonomy, China ultimately could be the biggest beneficiary. Indeed, those developments might be Comac's best hope. 

Contributing columnist Richard Aboulafia is managing director at AeroDynamic Advisory.

Risky Revival

Politicized airliner deals could have unintended consequences



BRENDAN SMIALOWSKI/AFP/GETTY IMAGES

GOING CONCERNS

MATTHEW FULCO



BY INVESTING \$400 MILLION IN Nevada-based MP Materials, the Trump administration signaled its determination to break China's grip on global critical mineral supply chains while embracing aspects of Chinese industrial policy once decried by U.S. free-market fundamentalists.

MP Materials owns and operates the only active U.S. domestic rare earth production facility, located in Mountain Pass, California. The partnership makes the Pentagon its largest shareholder, with a 15% stake, and guarantees that 100% of the offtake of the company's second rare earth magnet production facility, 10X, will be purchased by defense and commercial customers over the next 10 years. The agreement also guarantees \$140 million minimum in annual pretax earnings. The Pentagon will receive the first \$30 million above that threshold and split any further profits equally with MP Materials.

Investors have reacted enthusiastically to this government intervention. MP's stock has more than doubled in value since the deal was announced July 10. Analysts say the tie-up marks an inflection point for the U.S. approach to critical minerals, which are increasingly seen as strategic assets requiring state support. "The Pentagon has effectively moved from being a passive buyer of components to an equity investor and anchor customer of the upstream, midstream and downstream materials on which its own defense systems rely," Tom Moerenhout, who leads the Critical Materials Initiative at Columbia University's Center on Global Energy Policy, stated in a July analysis. Moerenhout expects that "picking winners may work in rare earths," given the metals' unique position, being important for national security but "small enough in market size to justify direct government intervention without excessive cost."

Limited visibility and traceability in the China-dominated rare earth supply chain make estimating market size difficult. Publicly available data suggests the total rare earth market is worth around \$4 billion.

The MP-Pentagon partnership "marks a critical step toward building the resilient, mine-to-magnet supply chain the U.S. needs—and in the long term, toward taking away one of China's most powerful bargaining chips," Mahnaz Khan, vice president of policy for critical supply chains at the Silverado Policy Accelerator, tells Aviation Week.

The previous owner of the Mountain Pass mine, Molycorp, filed for bankruptcy in 2015 in part because it could not compete with cheap rare earths from China, where illegal mining contributed to a flooding of the market that made its business nonviable.

Given China's history of driving competitors out of business with low prices, the partnership's price floor commitment is crucial. Over a 10-year period, the Pentagon will pay the difference between the market price for MP Materials' neodymium-praseodymium (a rare earth compound used in permanent magnets) products sold or stockpiled and a \$110/kg price floor. The agreement will reduce "vulnerability to nonmarket forces," the company stated.

To be sure, the deal has raised eyebrows from Wall Street to Washington. Outside investors in MP may worry the Pentagon's stake will become a golden share or proverbial foot in the door for an eventual government takeover. Some analysts say that by picking a rare earths winner, the Pentagon could harm market competition. "This approach could inadvertently squeeze out other U.S. magnet-makers who lack similar guarantees or government backing," Henry Sanderson, an associate fellow at the UK's Royal United Services Institute for Defense and Security Studies, stated in an August analysis.

Setting a price floor could be costly for the Pentagon. Neodymium-praseodymium was about \$77/kg as of Aug. 25, according to metals information provider SMM. At the same time, Mountain Pass' strengths lie more in light rare earths like neodymium and praseodymium than the medium and heavy ones—samarium, terbium and dysprosium—integral for magnets in key defense systems. Samarium is of particular concern to the Pentagon, given its importance for the Lockheed Martin F-35 and missile guidance systems. China has a near monopoly on production and processing of the metal. The U.S. does not have enough samarium to meet sustained defense production demand in an emergency.

MP plans to start separating dysprosium, terbium and samarium by 2028, drawing on the heavy rare earth concentrate it is producing and stockpiling. Achieving that capability would significantly reduce U.S. dependency on Chinese heavy rare earths.

However, separation is technically complex. It employs specialized solvent extraction processes and infrastructure that China has mastered over the past 30 years. MP "will need to prove that they can ramp up to full commercialization," Moerenhout said. 🌐

State Capitalism

The Pentagon aims to beat China at its own rare earths game



MP MATERIALS



INSIDE BUSINESS AVIATION

WILLIAM GARVEY

THE FAA REPORTS THAT THE U.S.

has 5,000 public-use airports—no other country comes close. About 3,300 of those airports are eligible for federal funding, ranging from massive Hartsfield-Jackson Atlanta International to Colorado's Boulder Municipal, whose two paved and turf strips are frequented by light aircraft with and without engines.

Like Boulder Municipal (BDU), most airports are general aviation (GA) facilities that serve business, charter and cargo aircraft; flight training; medical airlift; law enforcement and disaster relief; tourism and more. That extraordinary range represents some billion dollars in economic activity, which is why the FAA rightly labels the network "a national asset."

It is therefore disturbingly ironic that the asset is being steadily diminished. In the 1970s, there were 7,000 such facilities, which is to say we have lost nearly a third since then. Long Island's Deer Park Airport in New York, where I learned to fly, is among the sadly departed, swallowed by ever-expanding suburbia. The hunger has not abated. Just ask those who are backing California's Santa Monica and Reid-Hillview, Cleveland's Burke Lakefront, Connecticut's Hartford-Brainard and so many other targeted GA airports.

The reasons for the appetite include complaints about aircraft noise, fumes and now lead, along with concerns about safety and tax dollars expended. But in almost all cases, complementing such motivators is a craving for airport land—tantalizingly flat, open, close-in acreage—and the housing, hotels, shops, offices and eateries they could accommodate and the local tax revenue they would generate.

As many anti-airporters have learned, those imaginings can be flawed. After all, more housing means more schools and teachers, more demands on government services and infrastructure, more road traffic and maintenance, and more complaints about all the foregoing, along with the end of airport benefits. Beyond that, the FAA can demand repayment of grants it provided, some of which require that an airport operate in perpetuity. Moreover, under its current reauthorization, the agency can forbid the closing of a "grant-obligated" airport unless a replacement is built or the shutdown furthers broader aviation interests.

Thus, when residents and their officials come to understand the consequences of eliminating an airport, the course then chosen can be quite different from what they initially expected. This has been demon-

strated time and again, most recently in the aforementioned Front Range city of Boulder.

BDU was a dirt strip when founded a century ago. Over the decades, it was expanded to 179 acres, the runway paved, service buildings erected, ramp laid down and a parallel turf strip created. Federal funds facilitated a variety of those improvements with the guarantee that the airport would not close. Today it is home to some 130 airplanes, 40 gliders and a pair of helicopters. It also accounts for 260 jobs and contributes \$57 million to the area's economy annually.

Self-sufficient, the airport seemed well accepted by residents until a few years ago, when some individuals began complaining about aircraft noise and leaded av-

gas and suggested that the runways and hangars give way to affordable housing. They circulated a ballot proposal promoting the housing idea—downplaying the airport's consequent closure—and got the required 3,500 signatures.

Seeing that unfolding, BDU's supporters acted, with Jan Burton, a former Boulder City Council member and Cirrus SR22T owner-pilot, in the fore. They briefed city leaders and created a website detailing how the airport

benefited the community while noting that its closure would likely result in daunting penalties. They invited questions and comments, authored positive articles for the local paper, held a well-attended rally and established a ballot measure committee to fund community outreach. They also enlisted the support of the Aircraft Owners and Pilots Association, whose Airport Support Network exists for just such a purpose.

Burton says the response from the general population was overwhelmingly in favor of BDU's continuation, which she found reassuring and "heartwarming."

However, in July 2024, the city government had become so concerned with the impending fiscal penalties for shuttering BDU that it filed a lawsuit against the FAA seeking a release from its grant obligations. Thereupon, the anti-airporters withdrew their ballot proposals for closure and housing. The FAA is seeking to have the city's lawsuit tossed. Meanwhile, BDU's takeoffs and landings continue into the airport's second century.

"I guess you could say we won the battle," Burton says. "But we don't feel like this is over."

Sadly, many know that feeling, and with good reason. ☹

William Garvey was editor-in-chief of Business & Commercial Aviation from 2000 to 2020.

The Battle for Boulder

First Round: Airplanes 1, Housing 0



GOOGLE EARTH

THE LAUNCHPAD

IRENE KLOTZ



ENCOURAGED BY THE GROWING

technical prowess of the U.S. commercial space industry, NASA is considering buying a small-satellite servicing mission to reboost its Swift telescope in low Earth orbit.

Now known as the Neil Gehrels Swift Observatory—a nod to its original principal scientist—the telescope was launched on Nov. 20, 2004, to study gamma ray bursts (GRB) and other high-energy cosmic phenomena.

GRBs stem from the most powerful explosions in the universe—the deaths of massive stars, the formation of black holes, the crashes and mergers of systems that contain orbiting neutron stars or black holes.

From its perch in low Earth orbit (LEO), Swift operates three telescopes simultaneously to observe GRBs and their afterglows in gamma ray, X-ray, ultraviolet and visible light. The observatory can detect and localize a GRB to within a 10th of a degree and then relay the position to the ground within 20 sec. for follow-up studies by other telescopes.

Swift then swiftly pivots back to where it first detected the burst to observe the explosion's afterglow in X-ray and ultraviolet. Swift finds about 100 GRBs per year, a track record that has prompted NASA to extend its original two-year mission repeatedly.

Swift started off in a stable orbit ranging from 585 mi. to 604 mi. above Earth and inclined 20.6 deg. relative to the equator. But—like all spacecraft in LEO—Swift's altitude is descending due to friction with atmospheric molecules shot into space by heightened solar activity.

Swift, which is not outfitted with a propulsion system to boost its orbit, currently circles 278-283 mi. above Earth. Without intervention, NASA predicts it will enter the atmosphere in late 2026.

Swift's salvation depends on a proposed small-satellite servicing mission, which would need to take place around June. If successful, a Swift reboost mission would not only extend the life of a productive, operational space telescope but also demonstrate an emerging, multiuse, commercially developed technology for the space domain—several technologies, actually.

One proposal under study pairs a novel electroadhesion-based pad, developed by Cambrian Works of Reston, Virginia, with flight-tested technologies for rendezvous, proximity operations and docking (RPOD) that have been developed and demonstrated by Astroscale U.S., based in Denver.

Cambrian's electric Thin Attachment Pad (eTAP) is

suited for in-space servicing missions that do not require pre-preparation of the attachment surface, Kalia Crowder, Cambrian's director of strategic development and principal systems engineer, said at the SmallSat Conference in Salt Lake City on Aug. 13.

Reboosting Swift “would validate eTAP both for operational servicing and provide a pathfinder for potential future operational mobility servicing missions,” Crowder added.

Cambrian Works is developing a spacecraft known as Spidee to support missions to detumble and provide space mobility for de-

funct satellites or rocket bodies, among other missions. Astroscale, founded in Tokyo to develop technologies for orbital debris removal, twice demonstrated rendezvous and proximity operations during 2021 and 2024 flight tests.

Astroscale's upcoming contracts include two refuelings of a spacecraft in geostationary orbit for the U.S. Space Force; launch is slated for the summer of 2026, about the same time as a Swift

Saving Swift

NASA mulls smallsat reboost mission for Swift telescope



NASA'S GODDARD SPACE FLIGHT CENTER CONCEPTUAL IMAGE LAB

reboost mission would occur, if approved.

“A successful Swift orbit boost would not only extend the mission of one of NASA's most productive science assets but also serve as a demonstration of U.S.-developed, commercially led capabilities that can be applied to future government and commercial spacecraft,” Astroscale U.S. President Ron Lopez said in a statement.

NASA awarded \$150,000 study contracts for Swift reboost mission concepts on Aug. 12 to Cambrian and to Katalyst Space Technologies of Flagstaff, Arizona. Katalyst proposes using its robotic servicing spacecraft to phase, rendezvous, capture and raise the observatory's orbit so science operations could continue. Katalyst is also eyeing the Swift mission to showcase tactically responsive space and sustained space maneuver capabilities of interest to the Defense Department, among others.

Both awards are through NASA's Small Business Innovation Research (SBIR) Program, managed by the Space Technology Mission Directorate. NASA is also working with Tukwila, Washington-based Starfish Space under an existing SBIR program to assess its Small Spacecraft Propulsion and Inspection Capability technology to reboost Swift.

NASA said it expects to complete evaluation of the concept studies and make decisions about Swift's future this fall. 🌌



Advantage Airbus

- > AIRBUS A320-FAMILY DELIVERIES WILL SOON SURPASS BOEING'S 737
- > A320 FAMILY TO TAKE THE TOP SPOT IN AIRCRAFT DELIVERIES
- > THE REAL A321NEO REVOLUTION HAS YET TO COME

Jens Flottau Frankfurt

The Airbus A320 is about to take over from the Boeing 737 as the most successful commercial aircraft program as measured in deliveries. Airbus is hitting that milestone 37 years after the aircraft started flying revenue services with Air France in 1988. First delivery of an A320 also came 21 years after Boeing had introduced the 737-100 with Lufthansa.

Airbus A320 and Boeing 737 Deliveries by Year

Airbus A320	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	58		
Boeing 737	3	108	112	36	30	22	23	55	51	41	25	40	77	92	108	95	82	67	115	141	161	165	146	
	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	

According to statistics the two companies published at the end of July, Airbus has delivered 12,151 A320/A320neo-family aircraft, and Boeing has handed over 12,171 to its customers—just 20 more. But at the current rates—Airbus’ customers took 54 A320neo-family aircraft in July while Boeing’s accepted 37 of the 737 MAX—it will likely be sometime in early September that a historic swap at the top of the list of most successful aircraft will occur.

Airbus launched the A320 to offer customers a broad range of products similar to Boeing’s. Before this first narrowbody, Airbus’ portfolio consisted of only the A300/310 family, the twin-engine widebody aircraft for which the company was founded. The A320 was later followed by the A340, which entered service in 1993, and the A330 (1994), A380 (2007) and A350 (2015).

While Airbus had already won significant market share from Boeing (and earlier from McDonnell Douglas) with the

first-generation A320, the story behind its surpassing of Boeing in the narrowbody market is that of the astonishing success of the A320neo. Because the A320 is easier to upgrade, with more modern and bigger engines than those on the 737, Airbus launched the “new engine option” version in 2010, after deciding against developing an all-new aircraft.

Of course, the A320neo was soon no longer an option, but the standard. Lufthansa introduced it into scheduled service in January 2016, after Qatar Airways backed off from the role of launch operator almost at the last minute.

Somewhat ironically, the development and later success of the A320neo was prompted by the launch of the Bombardier C Series in 2008, for which Airbus sought a competitive response.

Airbus has sold 11,179 A320neo-family aircraft since program launch and so far delivered 4,051, a little over a third of them. The success of the A320neo program is mainly



The A321neo has driven the success of the A320neo family.

driven by the A321neo, which has sold 7,067 units so far. That compares with 4,055 for the A320neo and just 1,784 for the A321ceo. By contrast, the A320ceo still outsells the A320neo by 701 units, showing how much the market has shifted to larger aircraft.

The real A321neo revolution has yet to come, subject to Airbus' ability to deliver the aircraft. At 1,787 in service, only around 25% of them have been delivered. By contrast, the A319neo so far is even less successful than the infamous A318—57 versus 80 orders, respectively.

The 11,179 firm A320neo-family orders compare with 8,591 for the 737 MAX, which was launched a year after the A320neo program and has since been hit by several crises, including a global grounding following the 2018 and 2019 crashes, a production stop and the ongoing production cap imposed on Boeing by the FAA.

Unlike on the Airbus side, sales of the 737 MAX family have been driven by the medium-size version, the 737-8. Together with the high-density 737-8-200, the variant has a backlog of 3,080 aircraft, in addition to the 1,651 that have been delivered, followed by the 737-10 with a backlog of 1,273. Two hundred and 72 737 MAX 9s have been delivered and 187 are in the backlog; the -7 has a backlog of 316. The 737-7 and -10 have yet to be certified.

Leadership Change

Deliveries by Model

Airbus	
A318	80
A319	1,484
A320	4,752
A321	1,784
ACJ	138
A319neo	32
A320neo	2,232
A321neo	1,787
Boeing	
737-100/200	1,144
737-300/400/500	1,988
737-600/700	1,233
737-800/800A	5,174
737-900/900ER	557
737-7	0
737-8	1,651
737-9	272
737-10	0
BBJ	152

Backlog by Model

Airbus	
A319neo	25
A320neo	1,823
A321neo	5,280
ACJ	8
Boeing	
737-7	316
737-8	3,080
737-9	187
737-10	1,273

Total Backlog

A320neo family	7,136
737 MAX family	4,856

Check 6 Listen in as analyst Richard Aboulafia joins our editors to talk about the politicization of aircraft orders: [AviationWeek.com/Check6](#)

Total Deliveries

Airbus	12,151
Boeing	12,171

Sources: Airbus and Boeing data as of July 31, 2025

58	119	111	71	64	56	71	128	167	223	241	257	236	233	233	289	339	367	386	402	401	421	455	493	490
174	215	218	152	121	89	76	135	282	320	286	296	222	174	201	213	302	329	291	371	376	372	415	440	485
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014

The 737-8 has therefore been more successful in the market than the A320neo, and interestingly, Boeing has a backlog of six times more 737-7s than the number of A319neos that Airbus has marketed.

Based on the current production plans of both manufacturers, the gap between the A320neo family and the 737 will only grow wider for the foreseeable future. Airbus is adamant that it will move monthly rates up to 75 by 2027. Boeing's output of new-build aircraft is capped at 38 per month but is likely to rise significantly in the coming years, should the FAA lift its restrictions. A doubling in production that would be needed to stop further market share loss appears to be out of Boeing's reach for the time being.

The 737-10 has yet to be certified and is far behind the A321neo in orders.

491	545	558	626	642	446	483	516	571	602	309
495	491	529	580	127	43	263	387	396	265	273
2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025

Source: Aviation Week Network Fleet Discovery



Airbus' New Integrated Radio and Audio System Creates Pilot Headaches

➤ CREWS FACED RADIO, TRANSPONDER, COLLISION AVOIDANCE AND LANDING AID FAILURES

➤ AIRBUS AND THALES DEVELOP SOFTWARE PATCH

Thierry Dubois Lyon

The crew of a Transavia-operated Airbus A321neo flying to Amsterdam on April 29 found that adjustments to their first radio management panel were not synchronized with the second, although the first took into account those made to the second. Then an air traffic

separation with a Norwegian-operated Boeing 737 MAX. They closed in at a minimum distance of 3.9 nm horizontally and 1,400 ft. vertically. As the Airbus transponder was in standby mode, neither the aircraft's traffic collision avoidance system (TCAS) nor the controller's short-term conflict alert could sound alarms. Thanks to primary radars, however, which rely on the reception of echoes rather than transponder transmissions, controllers eventually cleared the flight to its destination.

That was just the latest incident investigated by the French Bureau of Enquiry and Analysis for Civil Aviation Safety (BEA) involving the digital radio and audio integrated management system (Draims) that has been used by new Airbus aircraft since 2022. The system has caused at least 10 incidents—including serious ones such as the Transavia-Norwegian close call—in two years, the BEA said in an interim report published in July.

Airbus and Thales designed the new system with a streamlined architecture to be robust and reduce crew workload. Compared with the previous-generation system, which relied on separate units and analog links, the Draims offers crews a more straightforward interface. The system's radio and audio management panel (RMP) includes controls for the transponder and the TCAS.

A control panel on the Draims includes the transponder and traffic collision avoidance system.

But that higher-level integration presents the risk of extensive failures that can affect voice

communications, aural alerts, the use of approach and landing aids, and even the transponder—and therefore the ability of air traffic control to follow and identify the aircraft. Such a failure can wipe out the safety barriers devised to prevent midair collisions.

Numerous Airbus aircraft across three types are affected. The airframer delivered 1,062 new A320neo-family aircraft with faulty Draims between February 2022 and an unspecified date early this year. As of July 1, it had delivered 30 A330neos since March 2024 and 25 A350s since November 2024.

Draims failures have caused a broad range of issues on the A320neo family. For example, on Sept. 20, 2024, the crew of an Aer Lingus-operated A320neo lost radio contact while flying to Bordeaux. The pilots could not hear each other through their headsets. After a series of difficulties, radio contact was reestablished on emergency frequency 121.5 MHz, but the transponder would not work for the rest of the flight.

The Aer Lingus A320neo then lost separation with a British Airways flight, coming down to 3.2 nm horizontally and 175 ft. vertically. After struggling to select a frequency for the instrument landing system, the crew eventually landed the aircraft.

In another instance on Jan. 13, the pilots of a different Transavia-operated A321neo en route to Amsterdam had serious transponder and radio communications issues. The crew could not process messages from the electronic centralized aircraft monitor used for troubleshooting, because they kept disappearing and reappearing on the screen. On the ground, a maintenance team could not identify any failure.

Using simulator and system bench tests, BEA investiga-



controller informed the crew that he had lost radar contact with one of their transponders and asked them to switch to the other. The crew could not help—they had problems with both transponders.

While the crew and air traffic controller worked to find an airport to land sooner rather than later, the A321neo lost

tors found the root cause. One component in the Draims' audio management unit (AMU) is not robust enough to withstand disruption by Ethernet micro-cuts. "The AMU may switch to degraded mode, leading to erratic processing of the Ethernet data flow between the RMPs and the AMU," the report stated. "The AMU may then send erroneous messages that could compromise the correct functioning of the interfaced systems, with possible repercussions on all functions dependent on the Draims."

For the A320neo family, Airbus and Thales have developed a software patch, which the European Union Aviation Safety Agency (EASA) certified in December. The patch monitors the component that causes the failure. When a failure is detected, the modified program restarts the component. The AMU then performs additional checks to prevent corrupted messages from being sent to interfaced systems, the BEA explained.

Airbus is installing the patch on new aircraft and retrofitting those in service. Based on an Airbus service bulletin and an EASA airworthiness directive, the retrofit began in April and is required to be completed by Dec. 4, 2026. As of July 1, about 950 in-service A320neos had yet to receive the modification.

EASA is working on the certification of a patch for the A330. On the A350, the consequences of a failure are more

benign because the Draims cannot force the transponder into standby. Nevertheless, a similar software upgrade will be implemented in the system's next version on the A350.

Until the retrofit is complete, Airbus has devised temporary procedures for the A320neo and A330neo, both of which EASA mandated in February. An interim procedure was not considered necessary on the A350.

The procedures contain instructions to regain communication and transponder capabilities. On the A320neo, this begins with a manual restart of the AMU using the two circuit breakers. If the problem persists, the crews are to switch off RMPs 1 and 2 and use the third RMP, which enables setting of the transponder and TCAS. Instead of an RMP 3,

the Draims' configuration may include a third audio control panel (ACP). The ACP 3 automatically switches the transponder to 7600, the code for radio failure. In both instances, voice communications remain possible, albeit not necessarily on the desired frequency.

Safety recommendations may come with the final report—so far, the BEA has issued "safety messages." The agency's report urged flight crews to be prepared for the possibility of a total loss of radio communications and radar contact before leaving a published flightpath or air traffic control route. 📡

"The patch monitors the component that causes the failure."

When a failure is detected, the modified program restarts the component."

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RECOVERY ROAD



- > PRATT POSITIONS FOR GTF RESET AS UPGRADED CERTIFICATION LOOMS
- > THE ADVANTAGE NEARS EASA CERTIFICATION
- > HOT-SECTION UPGRADE IS IN FLIGHT TESTING

PRATT & WHITNEY PHOTOS

Guy Norris Colorado Springs

With multiple engine upgrades underway and a major design refresh poised for full-scale production, Pratt & Whitney is approaching a key inflection point in its decades-long single-aisle comeback campaign with the PW1000G geared turbofan.

At the heart of the geared turbofan (GTF) initiative is the GTF Advantage (GTFA), a comprehensive core improvement package that targets greater performance while addressing nagging durability issues, particularly on the initial PW1100G variant powering the Airbus A320neo. Springing off this upgrade, Pratt has also developed a high-pressure, hot-section retrofit package, dubbed the HS+, to give existing PW1100G operators approximately 95% of the durability benefits of the Advantage.

Flight tests of the HS+ package are underway on Pratt's Boeing 747SP flying testbed.

The upgrades come out of hard-won experience gained from battling issues on the GTF in the nine years since it entered service with Lufthansa in early 2016. Although the reliability and durability of the smaller GTF family members have been less affected, lessons learned are also being applied to the PW1500G, which entered service on Airbus' A220 in July 2016, and the PW1900G, which debuted in commercial service on Embraer's 190-E2 in 2018 and 195-E2 in 2019.

Pratt received FAA type certification for the Advantage in February, earlier than expected. The company is "in the next steps" with the European Union Aviation Safety Agency (EASA), says Rick Deurloo, Pratt's president of commercial engines, "and then we'll follow that up with EASA CS-25 aircraft level certification," he notes.

"All that right now is on schedule," Deurloo says. "We anticipate both will happen in the next coming months, and we remain on track to ship our first production engines to Airbus by the end of this year, and then they're going to go into service starting the first half of next year."

Changes incorporated in the Advantage include increased airflow in the core to reduce operating temperatures and an improved hot section to double time on wing. "The technology that we're bringing into this really is around enhancements throughout the gas path," Deurloo says. "It's fundamentally more durable."

Enhancements to the high-pressure turbine (HPT) include an advanced airfoil design with more durable coatings. The HPT and combustor also feature optimized cooling hole size,

shape and location to reduce oxidation, all made using improved water jet drilling techniques in place of the original laser drilling process. The overall combination is designed to produce a 4% thrust improvement at sea level and up to 8% at higher elevations while reducing fuel burn by a further 1% compared with the current engine.

The improved combustor panel design was introduced early on as part of the Block D.1 production standard alongside upgrades to airfoil coatings, hot-section cooling and air seals. “Now we’re already seeing early indications [of improved durability] because we put it into service first in a harsh operating environment with IndiGo,” Deurloo says, referring to India’s largest carrier, which was significantly disrupted by issues with its GTF-powered A320neos. “So we’re seeing what those panels look like in the combustor, which will be in the Advantage.”

“We now have life-limited parts going into service at full length, unlike when we first launched the GTF—that’s big,” Deurloo says. “We learned our lesson. The Advantage had more than double the amount of development testing than we did on the base engine, so we feel good about it.”

Development and certification has included flight testing on the company’s Boeing 747SP flying testbed as well as additional durability evaluations, such as sand and dust ingestion trials. Pratt also conducted military-style accelerated mission testing, which stressed the configuration through simulated, repeated operating cycles in rapid succession.

Upgrades also include an improved No. 3 compartment. This incorporates a ball bearing assembly that supports the front of the high-pressure compressor and carbon face seals seated axially against a rotating ring, which prevent oil leaks. Issues with the lift-off seals—so called because extra air is used to physically lift the seal off the ring during engine operation—led to a redesign. “That same configuration is going into the Advantage as well,” Deurloo says.

“Going into COVID, we had two significant issues,” he explains. “The low-pressure turbine (LPT) third stage was very fragile, and we were getting a lot of issues hanging back there. The other big issue was the accessory gearbox. But you don’t hear boo about them now. We put in a new,

redesigned third-stage [LPT] and a new, beefed-up accessory gearbox.

“In 2019, these issues were a huge headache for us, and during COVID, we completely retrofitted the fleet,” he notes. “These are examples of where we took a lot of learnings from the base and brought it into the Advantage, and what we’re learning on the Advantage incrementally, we are trying to bring as much as we can back into the base.”

Airbus expects to begin delivering GTF-powered A320neos in the first half of 2026. Pratt aims to switch

ing on right now is bringing this engine to that standard for the 24K, and by that, I mean for both the A220 and the Embraer E2.” Upgraded components and sections will include a redesigned combustor, new turbine hardware and improved No. 4 compartment. The No. 4 section houses the roller bearing support assembly aft of the HPT and forward of the LPT rotor.

“There’s a lot going on in that program,” he explains. “This engine in the 2027 time frame will have a lot more goodness brought to it in the hot



GTF compliance tests began on an A320neo at Airbus’ Toulouse site in March.

entirely to the new production standard over “somewhere between 18 and 24 months, at which point 100% [of] production build will be Advantage engines,” Deurloo says. “It is a low production rate on the front end, as the industrial machine ramps up with it. Is there an opportunity to take that low production rate and try and move it to the left a little bit? If things are going well, yes, but we’re trying to plan accordingly and not overcommit.”

In the background, the smaller PW1500G/1900G family is quietly undergoing similar enhancements. Although not yet the subject of a focused package of upgrades, the 24K—or 24,000-lb.-thrust—engines in this class are in line for a series of continuous improvements, Deurloo says. “People ask me all the time: ‘Is there going to be an Advantage-type [program] for the 24K?’ What we are work-

section. It’s all going through test right now. We’re talking to our operators, and they know that configuration is coming. But it’s all retrofittable. Let me emphasize: What we are delivering today is a significantly better configuration than what we were delivering years back. And this will only take it a step further, and it’s all retrofittable back into today’s 24K motor.”

Simultaneously, Airbus and Pratt are conducting EASA and FAA certification tests on a set of reduced climb thrust ratings designed to improve PW1100G durability.

“It reduces the hot section temperatures during the climb and effectively extends time on wing,” Deurloo says. “This is something that depends on the operator, and whether they’re in a benign or harsh environment, and whether the engine is at 27,000-lb.-thrust or a 33,000-lb.-thrust rating.

But it gives anywhere between a 5-20% improvement in time on wing on a freshly overhauled engine or freshly delivered engine.”

The upgrade, which will be available as a basic electronic engine control software update, will provide an incremental durability improvement on top of the Advantage or HS+ package. “We are currently in the middle of certification on that software update as

cludes the improved combustor, an optimized HPT first-stage blade with improved coatings and a revised No. 3 bearing compartment. “It brings pretty close to twice the durability, so it’s a big one,” he says.

Although Pratt has not decided which MRO facility will be first to install the HS+ package, Deurloo says it will be one of the “mature shops,” such as the company’s sites in West

Al Ain in the United Arab Emirates the following year.

“We’re also growing our capacity with existing partners,” Deurloo says, citing an expansion plan underway at MTU Aero Engines that will allow it to accept almost 600 shop visits annually across all GTF models. “So as MTU is spooling up and investing, Delta TechOps is also taking a 30% increase in annual GTF overall capacity, just for the PW1500G,” he says. Delta TechOps agreed this year to expand GTF overhaul capacity at its Atlanta facility over the next decade.

With help from increased investments in artificial intelligence and robotics—including a new automated high-pressure compressor rotor assembly system at the ESA facility that has a 100% pass yield rate—Deurloo is optimistic that Pratt is overcoming the aftermarket bottleneck hindering its broader recovery from the contaminated powder metal (PM) parts crisis revealed in 2023.

That issue, which centered on the discovery of flawed PM parts made in 2015-21, resulted in hundreds of additional engine shop visits—primarily for PW1100Gs—with an average turnaround time of 300 days. That caused a spike in aircraft-on-ground (AOG) events that peaked in early 2024 at around 650, mostly affecting A320neos.

This year, the number of AOG events settled in at about 300-350, where they are expected to remain until 2026. Off-wing times are slowly coming down to 250 days or less thanks to an increase in spare part output, improvements in initial disassembly and post-work reassembly processes and some newly developed repairs, Pratt says. “We peaked in the first half of the year, and we’re now working the trajectory down,” Deurloo says. “We hope you’ll see that improvement by the end of this year and continuing into next year.”

Deurloo echoes guidance from Pratt parent RTX’s second-quarter earnings call that it remains on track for improvement of at least 30% in MRO output for the full year, noting that more is being done to reduce AOG events. “We’re pleased with the 30% year-over-year output across the GTF,” he says. “It is probably premature, but when I look at the full year, I think there’s an opportunity, maybe, to do even greater than 30% this current year.”

The Advantage package provides up to 4% higher thrust at sea level and up to 8% in hot and high conditions.



PRATT & WHITNEY

well, and it’s in EASA’s hands,” Deurloo says. “It’s going through the FAA already. So we’re hopeful that in the coming months as well, it will get into final software certification approval.”

While EASA and FAA approvals will enable immediate reciprocal incorporation in some countries, for others—such as India—it will require additional regulatory scrutiny. “But it allows us this year to start putting it in,” Deurloo says. “We’ll start by going to the final assembly lines. We’ll then go to the rest at the [maintenance, repair and overhaul (MRO) companies] and make sure every fresh engine gets it before it leaves. And then we’ll start going out into the fleet. We’ve got a detailed customer by customer plan on how to incorporate that.”

Meanwhile, Pratt’s 747SP is trialing the HS+ upgrade package. “We’re in the middle of flight-testing it right now,” Deurloo says. “The next step will be FAA FAR Part 33 engine certification, which we anticipate in the coming months, and then we’re targeting next year to get final certification done. We’ll begin by putting it in the MRO network during shop visits next year.”

Incorporating 35 part numbers from the GTFA, the HS+ package in-

Palm Beach, Florida; Eagle Services Asia (ESA) in Singapore; the Columbus Engine Center in Midland, Georgia; or MTU Maintenance in Hannover, Germany.

“We have started working through them on what it means from a workscope perspective on that engine when it comes in,” he says. “But right now, we’re laser-focused on just getting that certification done and getting the industrial ramp to produce the hardware done.” Initial installations at the MRO sites are due to begin in the first quarter of 2026.

Part of the ramp-up includes additional MRO facilities to support the GTF fleet, with four new sites opening in 2026-28 to add to the 17 already in operation. These include the \$150 million expansion of an existing International Aero Engines V2500 facility with Air New Zealand in Christchurch, New Zealand, which will begin its first GTF overhaul in the fourth quarter of 2026. Kawasaki Heavy Industries in Japan will also induct GTFs that year. Additional MRO capacity is expected to come online when PW1500G/PW1900G overhauls begin at ITP Aero’s Madrid facility in 2027 and when a GTF overhaul shop opens at Sanad’s facility in



MANUAL REBOOT

- BOEING MODERNIZING, SIMPLIFYING PRODUCTION PROCESS INSTRUCTIONS
- CHANGES EMPHASIZE GIVING WORKERS BETTER INFORMATION, TRAINING
- STEPS ARE PART OF FAA-MANDATED TURNAROUND PLAN

Sean Broderick Renton, Washington

Changes introduced in the last year have helped Boeing stabilize and steadily improve output from its commercial aircraft production operations. Many are well-publicized, such as the half-dozen metrics the company and the FAA use to monitor final assembly line health, new move-ready criteria posted at each production line station and steps to ensure suppliers deliver conforming parts that do not need costly, disruptive rework.

Boeing says it is relying heavily on employee input to improve the content and usability of company instruction manuals.

But the initiatives with arguably the greatest potential to bring long-term, substantive transformation to how efficiently Boeing Commercial Airplanes (BCA) operates are just now gaining momentum. Some 15 months after earning FAA approval for a sweeping improvement plan, the airframer says it is making measurable progress on a multiyear process to revamp the instructions that guide front-line employees on how to assemble and test its products.

The instruction review and improvement effort is one of a series of steps laid out in the company's May 2024 Safety and Quality Plan (AW&ST July 1-14, p. 54). Boeing developed the road map in response to its own findings as well as those from an FAA-backed expert panel tasked with reviewing its processes in the aftermath of January 2024's Alaska Airlines in-flight door plug loss on a 737 MAX.

Boeing is methodically working through the plan. Changes include new training and shop-floor mentoring, added inspections internally and within its supply chain, and enhanced final assembly line processes to help limit out-of-sequence work. The move-ready criteria, which do not allow fuselages to advance if certain jobs are incomplete or deemed unacceptable to accomplish later, minimize disruptive out-of-sequence catch-up work.

Steady increases in 737 and 787 monthly production with no new major quality-related problems suggest the changes are bearing fruit, and CEO Kelly Ortberg says he is committed to emphasizing safety and stability over speed (AW&ST Aug. 11-31, p. 26).

Still to come are more fundamental changes to how Boeing's facilities operate. The post-Alaska reviews determined core instructions that the company's front-line employees rely on every day became too cumbersome from decades of often uncoordinated updates. Issues ranged from having multiple ways to accomplish the same task to appending instructions steadily over time instead of rewriting them to maintain simplicity.

Accessing necessary information can be overly complex for front-line workers. Assembly instructions might

reference torque values or other specifications found in a separate software program. Detailed engineering drawings might be in yet another place online.

In some cases, the same item or process goes by different terms depending on the aircraft program or facility. Such inconsistencies establish a lack of uniformity and can stoke confusion when employees change programs and run into the mismatched language.

Boeing's instruction-related hurdles are daunting enough for seasoned workers. For the flood of new hires since the 2020 downturn and related rebound, they proved particularly problematic. New employees often struggled to get up to speed, Boeing found. In the most egregious cases, hard-to-follow instructions were simply not followed.

Each Boeing model requires thousands of installation plans that can vary by tail number.

A lack of clear documentation played a central role in the Alaska 737-9 blowout. A Boeing worker removed a door plug to fix a flaw during production. But the worker neither documented the removal nor reinstalled bolts in the panel once it was back in place following the repair.

Confusion over the "Perform Part or Assembly Removal" business process instruction (BPI) that should have governed the plug's removal and reinstallation dated back years, NTSB investigators found (*AW&ST* Aug. 12-Sept. 1, 2024, p. 24). The document has been modified since the Alaska accident, but the confusion and risk it created illustrate what Boeing is working to eliminate.

"We heard clearly from many of our team members that we have created a system over time that is incredibly complex to navigate," Kevin Stigerts, chief engineer of 737 production engineering, told *Aviation Week* during a visit in May to the company's production facility here.

In response, the company is improving the instructions that govern BCA and its factories.

The documents fall into two general categories. One is sets of individual aircraft production instructions that combine to form airframe-specific installation plans (IP). The other is command media (CM), the overarching

requirements that lay out everything from standing up a new production site to facility-specific quality management processes.

On IPs, feedback from front-line workers prioritized improving connections between general instructions and variable data.

"We will tell a mechanic on the floor to torque a nut, and we don't always provide the specific torque value in the installation plan, since there are a number of factors that come into play because of configuration variability," Stigerts said. "What we will tell the

The IP instructions revamp will streamline workflow and make required data accessible and intuitive for front-line employees. It also will standardize BCA processes and terminology, as nearly 70 years of manufacturing more than a dozen jetliner models within multiple production facilities has introduced variances within Boeing's network.

In one extreme case, the 787 program was developed with its own work instruction systems. While more advanced than legacy predecessors—787 mechanics can click on hyperlinks to



JENNIFER BUCHANAN/SEATTLE TIMES POOL PHOTOS

mechanics today is to reference the engineering [data]—pull up a table in a section of a document . . . and determine that value."

The mechanics are trained to perform such tasks. But given current technology, they should not have to.

"It's a fairly burdensome process to go through those hoops," Stigerts said. "When we complete this transformation, we'll have the underlying technology to link our engineering specifications and basically hyperlink the data from the spec right into the installation plan."

This slow technological evolution means the instructions, while all digital, still lean heavily on words and static images to convey information. The approach leaves too much room for complex language written by engineers but meant for front-line workers. It also fails to leverage more effective ways of illustrating concepts, such as videos or animated 3D graphics, that are second nature to younger generations.

access related data, for instance—it also introduced new terminology. At Boeing's 787 facility in North Charleston, South Carolina, plans for assembling and inspecting aircraft are not called IPs, but rather standard operating instructions.

The revamp will remove such variances. It also will course-correct some previous IP modernization efforts that failed to deliver desired improvements. Boeing will dial back specificity introduced in an "enhanced standard work instructions" initiative that sought to provide workers with more direction, Stigerts said.

"The thinking was that we should include everything that the mechanic needed, right down to the Q-Tips and [solvent] to clean off some excess sealant," he added. "We have learned that going to that extreme was actually a more burdensome experience for the users. A lot of what we're doing now is to unwind that but still balance it with the need to ensure that we have given them all the requirements they need."

Changes to the assembly and removal BPI illustrate Boeing's new direction. Before the Alaska accident, the document was about 60 pages long and covered multiple removal scenarios that varied based on perceived complexity, said Brion Baker,

New move-ready criteria are posted at each production line station.

director of quality governance for BCA. The simplified version shaved off 30 pages by adopting one process that covers all scenarios.

The update conveys that "we have one way, and this is the way to do it," Baker explained. "If you encounter this situation, here's an off-ramp. If you encounter that situation, here's an off-ramp. It gives them less information to consume and provides the information that they need."

Changes to CM documents came after an extensive review of existing content as well as consultation with other larger companies that completed similar initiatives. Boeing also created a "digital master architecture" that shows how each document relates to others in the CM ecosystem, Baker said.

"That's how we know that if we decide to change a link in the chain, we have high confidence that we will know what that affects and what else we have to change so we don't end up with a gap," he added.

The team then flagged about 950



documents, grouped into 10 general business processes—ranging from standing up a new site to managing product-specific regulatory requirements—that will receive at least some changes.

Next up is making the changes, document by document. That process began recently, starting with the instructions with the least amount of interconnectedness. Boeing estimates it will require several years to complete.

"We'll start with some of the more simplistic ones to give us an opportunity to learn so that we can iterate and improve," Baker said.

The IP updates are underway but will take longer due to sheer scope and the need for a more deliberate pro-

cess. The 737 MAX has thousands of IPs that technicians reference daily to do their jobs. Some are "basic and stable," Stigerts said, meaning they are largely the same regardless of variant or customer. Others are very specific.

The result is not just thousands of IPs, but thousands of potential combinations of IPs for a given airframe.

"We're not going to shut down 737 production for six months and flip over all the IPs," Stigerts said. "We're on a journey right now. We've made a commitment to the FAA over the next couple of years, and we're going to transform all these installation plans.

"We're doing several per month now," he added. "We're managing it in a way that we think is appropriate." 📧

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China's High-Speed Rotorcraft Demonstrators Emerge

- > HARBIN FLIES ADVANCED TILTROTOR
- > CHANGHE TESTS COMPOUND DESIGN

Chen Chuanren Singapore, **Tony Osborne** London and **Graham Warwick** Washington

By the time it withdrew from Afghanistan in 2021 after two decades of operating at high altitudes in harsh conditions, the U.S. Army was convinced it needed a new generation of rotorcraft with twice the range and twice the speed of its current helicopters.

The result was the Future Long-Range Assault Aircraft program and a fly-off competition between the Bell V-280 Valor advanced tiltrotor and the Sikorsky-Boeing SB-1 Defiant coaxial-rotor compound helicopter. The contest was won by Bell's V-280, now designated the MV-75.

With the pivot to the Asia-Pacific region, the MV-75's greater speed and range compared with the Sikorsky UH-60 Black Hawk helicopter are touted as essential to operations across the distances of the Pacific theater.

Now China has responded by flying rotorcraft demonstrators strongly resembling the Bell and Sikorsky designs—a tiltrotor developed by Harbin Aircraft Industry Group and a coaxial-rotor compound developed by Changhe Aircraft Industries Corp. Harbin and Changhe are helicop-



Changhe's coaxial-rotor compound helicopter resembles Sikorsky's 240-kt. S-97.

ILLUSTRATIONS BY COLIN THROM/AW&T

ter manufacturers within state-owned AVIC. Unattributed images of the demonstrators appeared on Chinese social media on Aug. 19 and 21, but AVIC has yet to acknowledge the flights publicly.

The aircraft represent a leap from the adaptation of French or Russian designs that until recently sustained the Chinese industry, including the Changhe Z-8 transport and Z-10 attack helicopters. Each AVIC subsidiary tends to pursue overlapping concepts independently, reflecting both internal specialization and Beijing's willingness to advance multiple technology pathways simultaneously.

Harbin's aircraft more closely resembles the design of Leonardo's AW609 civil tiltrotor. The Chinese tiltrotor has a smaller fuselage, retractable gear and T-tail. A major feature the aircraft shares with Bell's V-280 is engines that are fixed, while the proprotors and gearboxes tilt, compared with the tilting nacelles of the AW609 and original V-22 Osprey.

Leonardo's yet-to-fly Next-Generation Civil Tiltrotor (NGCTR) demonstrator, a modified AW609, has a similar

Russia's Seemingly Dormant Attack Helicopter Gains New Lift

- > THE UKRAINE WAR HAS RESHAPED RUSSIAN REQUIREMENTS
- > KAMOV AND MIL HAVE WORKED ON PREVIOUS HIGH-SPEED ROTORCRAFT CONCEPTS

Piotr Butowski Gdansk, Poland

Russia's effective use of loitering munitions and fiber-optic guided drones has upended thinking about the modern battlefield and sparked questions about the continued need for pricey attack helicopters. But Moscow itself does not appear ready to abandon that warfighting tool.

While it is increasingly tight-lipped about military development, Russia has launched a new combat helicopter program. The PAK AA—the Russian name for which means Future Air Complex of Army Aviation—joins next-generation programs such as the PAK DA bomber, PAK FA fighter and PAD DP interceptor.

Russia's radar design bureau Phazo-

tron-NIIR recently disclosed the program in an annual report outlining plans for 2025, including development of radar for a future army aviation platform it identified as the PAK AA.

There has been little public discussion about what a future Russian helicopter might look like. The head of Russian Army Aviation, Col. Yuri Borisikov, told *Krasnaya Zvezda*, the official Russian Defense Ministry newspaper, last year that different design and engine options were under consideration. The goal is to double the current equipment's speed and range, Borisikov said, suggesting that Russia is still keen on a high-speed system. The Pentagon, in contrast, abandoned its Future Armed Recon-

naissance Aircraft program, which eyed similar improvements.

Russia's attack helicopter fleet has felt the effects of the changing battlefield since the country's full-scale invasion of Ukraine. Moscow has lost about 100 attack helicopters since 2022. Ukraine's air defenses and small drones have forced Russia to operate rotorcraft farther from the front lines and to base them at airfields far into its own territory to avoid being hit. Russian helicopters are now conducting combat missions at distances of several hundred kilometers.

Those changes have reduced Russia's helicopter loss rate over the past year and could be driving requirements for the PAK AA, including the need for greater range and speed than the Kamov Ka-52 and Mil Mi-28N, which have maximum speeds of about 300 kph (186 mph) and combat radii using internal fuel of about 180 km (110 mi.).

Russia also is looking to arm the new helicopter with better, more autonomous weapons. The country largely relies on unguided rockets launched from helicopters that approach at low altitude, fire a salvo in a

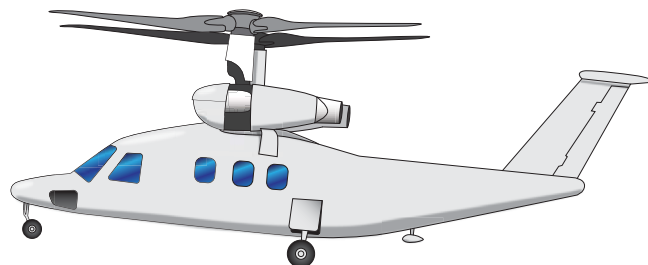
powertrain arrangement. Also similar to the NGCTR, the Chinese design has large flaps that are deflected in vertical flight to minimize proprotor download on the wing.

Harbin's aircraft is China's first full-scale tiltrotor to fly but is not the only one in development. Private company United Aircraft is ground-testing the R6000 in preparation for flight. The R6000 has a maximum takeoff weight of 13,200 lb., 300-kt. speed and 810-nm range, making it smaller but faster than the V-280.

Changhe's design closely parallels that of Sikorsky's S-97 Raider, built to demonstrate the X2 Technology high-speed coaxial-rotor compound helicopter configuration. The aircraft has a pair of rigid four-blade main rotors and a seven-blade pusher propeller for propulsion. Among detail differences from the S-97: The retracting main gear is located farther aft, engine inlet and exhaust are on the fuselage side, the horizontal stabilizer is braced and endplate fins oriented upward.

Both Chinese rotorcraft seem less focused on outright speed than the U.S. designs. The fuselage of the tiltrotor resembles that of AVIC's Harbin-built AC352 commercial helicopter, rather than Bell's more streamlined V-280. The rotor spacing and hub design on the Changhe aircraft appear less optimized for drag reduction than on Sikorsky's S-97 and SB-1.

The aircraft underline China's interest in developing rotorcraft with greater speed and range for military and commercial use given the country's size and geography. Chinese defense commentator Su Ming cautions that the demonstra-



Harbin's demonstrator most closely resembles Leonardo's AW609 civil tiltrotor.

tors should not be seen as a sign that fielding is imminent with China's People's Liberation Army. Instead, they represent an effort to explore technologies that can be refined and scaled once the underlying technologies are mature.

But the projects are more than showcases. In a 2024 paper in the academic journal *Acta Aeronautica et Astronautica Sinica*, Deng Jinghui—one of the chief designers of the Harbin Z-20, China's equivalent to the UH-60—argued that future battlefields will require rotary-wing aircraft capable of high speed and maneuverability, penetration, survivability and strike performance.

The coordinated demonstrations mirror a pattern seen across China's aerospace sector, in which major milestones are often clustered, as in December 2024's coordinated flights of new, low-observable combat aircraft from Chengdu Aircraft and Shenyang Aircraft. Although less dramatic, the advanced rotorcraft flights underscore the breadth of next-generation aerospace projects underway at AVIC. 🌐

PIOTR BUTOWSKI



Mil adapted an Mi-24 to an experimental, high-speed system that reached 407 kph in 2016, a record for Russian rotorcraft.

short climb while expending countermeasures, then quickly retreat at low altitude to avoid Ukrainian air defenses. The result has been low accuracy, except in the few instances when the Ka-52M and Mi-28NM use remotely guided Kh-39 LMUR missiles that have a range of up to 15 km.

With its front-line utility diminished, Russia, like other countries, is sending attack helicopters to hunt down enemy drones at a lower cost than using surface-to-air interceptors.

Moscow has not detailed whether Mil or Kamov is working on the PAK AA, but both have been exploring

technologies that could feed into the program. For instance, in 2008, Mil presented the Mi-X1, a high-speed helicopter with a single main rotor and a pusher propeller that is capable of reaching a maximum speed of 520 kph, and Kamov showed the Ka-92, with two coaxial counter-rotating rotors, capable of speeds up to 460 kph.

Russia launched efforts in 2011 to deliver a high-speed civil helicopter, which it abandoned three years later; some of the work informed a military project that led to the first flight of an experimental, highly modified Mil Mi-24 on Dec. 29, 2015. This featured

new main rotor blades and two heavily tuned Klimov VK-2500-01 engines as well as a narrow front fuselage with a single-seat cockpit. The helicopter was tested in wingless, standard-wing and extended-wing configurations, and it reached 407 kph in 2016, the highest speed ever for a Russian rotorcraft.

A high-speed combat helicopter project followed in August 2017 that aimed for a cruise speed of 400 kph, then-Russian Deputy Defense Minister Yury Borisov said. Kamov presented a Ka-52-based design using its signature coaxial rotors; Mil chose a classic configuration. Both designs sported large wings to relieve the main rotor in high-speed flight. Mil won the award in late 2018 and aimed to start production in 2025-28. The project likely stalled; the Phazotron report suggested only a recent revival of Russian interest in a high-speed system.

Russia has not detailed a timeline for the program, which is unfolding amid upgrades to the existing helicopter fleet. Phazotron also described radar modernization and support activities linked to the Ka-52 and Ka-27M naval helicopters. 🌐

ARRESTING DEVELOPMENT



SNC is promoting its Freedom jet as a challenger in the bid to replace the U.S. Navy's venerable T-45.

Brian Everstine Reno, Nevada

SNC has joined the competition to replace the U.S. Navy's T-45 Goshawk trainer and asserts that its clean-sheet design can handle the stress of carrier-representative landings the service has had to discontinue.

The company tells Aviation Week that it is offering an updated design of its Freedom trainer—originally proffered for the U.S. Air Force's T-X competition—for the Navy's Undergraduate Jet Training System (UJTS). The Freedom joins the Boeing T-7A Red Hawk, Lockheed Martin-Korean Aerospace Industries T-50N and Leonardo-Textron M-346N in the bid to replace the aging T-45.

While the three competitors have long been known, Nevada-based SNC only briefly teased interest in the pro-

gram two years ago before making a formal announcement in August to coincide with the Tailhook Symposium here.

"SNC decided years ago to follow the customer's lead," the company states. "Our approach for Freedom is rooted in a commitment to thorough preparation and strategic timing, rather than rushing to make public announcements."

SNC argues that its design has a unique advantage. As a part of the requirements process, the Navy backed

away from its goal to have the next trainer conduct field carrier landing practice (FCLP)—unflared landings on land like those a carrier-based fighter would have to make so at sea. Other competitors have said the requirement would demand extensive development work for the aircraft to survive such abuse. The T-45, for example, needed considerable engineering rework to the original BAE Systems Hawk design to enable carrier landings.

SNC tells Aviation Week that it "took a deliberately different approach to our design philosophy from the beginning" and is focusing on a robust aircraft to meet the demanding Navy syllabus.

"We designed Freedom to be a strong competitor for T-X," the company said in a statement. "However, at the same time, we also ensured that the aircraft maintained a firm footing

> A NEW COMPETITOR LOOKS TO UPEND U.S. NAVY TRAINER COMPETITION

> SNC IS THE ONLY CONTENDER WITH A CLEAN-SHEET DESIGN

> THE COMPANY ARGUES ITS ENGINE PICK REDUCES COST



SNC

to be fully capable of the demanding carrier touch-and-go landings and [FCLP]-to-touchdown landings for UJTS. Just one look at our landing gear configuration is a dead giveaway that we had the T-45 replacement program in mind a decade ago.”

The T-7, T-50 and M-346 under construction are variants of existing aircraft. SNC says the Freedom, which was not built in its original design for the T-X, is being developed for FCLP—something in which Navy aviators might be interested despite the increasing use of auto-landing systems on carriers.

“The most visible example of our purpose-built design for UJTS is the trailing-link landing gear and supporting structure, capable of carrier touch-and-go landings and FCLP-to-touchdown landings, and that is com-

patible with our 16,000-hr. service life airframe,” SNC says.

The Navy announced in a March 31 solicitation that it would no longer require FCLP, except to wave off, and would instead look for virtual practice as part of the UJTS. This allows production to begin more quickly ahead of a contract award expected in January 2027.

The decision was a sea change from a series of previous solicitations that highlighted FCLP. An August 2023 request for information called for 6-10 unflared landings per training flight, and such landings were required throughout the aircraft’s service life.

“SNC challenges the paradigm that industry requires a compromise to [the Chief of Naval Air Training’s] syllabus by delivering a purpose-built design optimized for the UJTS mission that includes carrier touch-and-go landings and FCLP-to-touchdown landings without compromise,” the company says.

The Navy has called for at least 145 aircraft as part of the UJTS, which would replace approximately 220 T-45s. Despite the aggressive schedule to field the system by 2030, the service has not outlined prospective funding in its budget plans. Naval Air Forces Commander Vice Adm. Daniel Cheever states in a white paper outlining the vision for Navy aviation that the UJTS will need advanced avionics and simulation capabilities, “providing a more realistic, effective and efficient training environment for the next generation of jet pilots.”

SNC says it has invested a significant amount of its own funding in the Freedom design. The aircraft, which appears to be smaller than its competitors, is designed for about 16,000 hr. of airframe life, double the Navy’s request during an April industry day for the program.

The company’s recent major programs appear to be diverging from traditional primes’ approaches in order to reduce costs for the government on such programs as the U.S. Air Force’s E-4C Survivable Airborne Operations Center and the U.S. Army’s High-Accuracy Detection and Exploitation System. SNC has been transparent about its intellectual property and modular open systems architecture to give the government more flexibility with upgrades, too.

One way SNC is making the case for its cost-effectiveness is with its en-

gine choice. The Freedom would be powered by two Williams FJ44-4M 3,600-lb.-thrust engines, which are smaller than the GE Aerospace F404 in the T-7 and T-50 and the Honeywell-ITEC F124 in the M-346. Besides offering fuel savings, SNC contends that two FJ44-4Ms are half the price of one F404 both in procurement and overhaul costs. The company projects a flight-per-hour cost of \$4,500, about half that of proposed F404- or F124-powered aircraft.

SNC says other offers are focused on traditional small fighter designs that are heavier and require engines that consume much more fuel, which could make them less reliable than the FJ44s. The Freedom will share its powerplant with business jets, such as the Beechcraft Premier and Cessna CitationJet, rather than fighters.

“SNC chose Williams International early in the conceptual design phase a decade ago because we were committed to providing uncompromising training performance and a substantial reduction in operating costs,” the company says. The smaller airframe is designed for efficient high-G maneuvers, SNC says. The Freedom is significantly shorter and lighter than the T-7.

The UJTS is expected to progress with a formal request for proposals in December. The 2027 engineering and manufacturing development award is also planned to cover procurement of the first low-rate initial production aircraft. While the Freedom has not entered production, SNC says it will be delivered and start flying on time.

SNC is teaming with multiple companies on the offer, although those partners have not been disclosed yet.

“It is clear to SNC that since early 2020, the Navy has been considering compromising its long-standing and important requirement to train with FCLP-to-landing,” the company contends. “It is important to the Freedom Team that the U.S. Navy has an option to continue its essential FCLP training and avoid the unnecessary risk and cost associated with foregoing that requirement in the [Chief of Naval Air Training] syllabus.

“As a clean-sheet design focused on the UJTS mission, the design features for FCLP-to-touchdown are minimal and affordable,” the company adds. “SNC believes FCLP-to-touchdown should be, at a minimum, a scored objective in the UJTS competition.”

Congress and Navy Support Shifts Momentum for F/A-XX

> BOEING AND NORTHROP GRUMMAN DOWNPLAY CAPACITY CONCERNS

> WHITE HOUSE AND PENTAGON URGE A PAUSE

Brian Everstine Reno, Nevada

Senior U.S. Navy aviators are preparing for an F/A-XX downselect to start moving on the eagerly awaited program as momentum shifts back toward an award that was expected earlier this year before being put on ice.

The need remains for a fighter on board the service's carriers to replace the Boeing F/A-18 and EA-18G, the commander of Naval Air Forces told Aviation Week. Although the choice of prime contractor to build the fighter awaits approval at senior levels of the Pentagon and the White House, he said the service is ready to get going.



Northrop Grumman pulled its proposal from the U.S. Air Force's Next-Generation Air Dominance program to focus on the Navy's F/A-XX.

NORTHROP GRUMMAN CONCEPT

"We're awaiting downselect of which prime is going to win the contract and that kind of stuff," Vice Adm. Daniel Cheever said on the sidelines of the Tailhook Symposium here Aug. 23. "That's a pretty high-up decision; there's a lot of stakeholders. . . . We're excited, once they do downselect, to move out on it."

The comments followed back-and-forth deliberations within the service, the Defense Department and the White House after a fiscal 2026 budget rollout halted progression as some officials raised concerns about industrial base capacity.

In a June briefing, a senior defense official told reporters that the Defense Department's fiscal 2026 request included just \$74 million to complete the design of the aircraft as a way of "maintaining the option for F/A-XX in the future." At the same time, the Pentagon was going "all in" on the U.S. Air Force's Boeing F-47. Defense and Navy civilian leaders have voiced concern about industry's ability to build both the F-47 and F/A-XX simultaneously, although companies have rejected the idea.

The White House called on Congress in a July 15 statement of administrative policy to reevaluate "the F/A-XX program due to industrial base concerns of two sixth-generation programs occurring simultaneously.

"Awarding the F/A-XX contract as written is likely to delay the higher-priority F-47 program, with low likelihood of improving the timeline to field a Navy sixth-generation fighter," the White House continued. "The administration

looks forward to working with Congress to identify an optimal path forward."

Leaders of both Boeing and Northrop Grumman are pushing back against this policy. Boeing Defense and Space CEO Steve Parker said June 16 that his company's strategy is to compete, win and execute both programs. "So yeah, absolutely, we can do it," Parker said. "So can the industrial base, and so can the engine manufacturers. So I don't see that as being an issue."

Despite the budget rollout and administrative position, several top uniformed leaders have voiced support for advancing the program. The Navy has a "validated requirement for carrier-based sixth-generation aircraft," Adm. Daryl Caudle, the new chief of naval operations, said during a Senate Armed Services Committee confirmation hearing on July 24.

"It is critical that we field that capability as quickly as possible to give our warfighters the capabilities they need to win against a myriad of emerging threats," Caudle said in submitted testimony.

Additionally, Adm. Samuel Paparo, commander of U.S. Indo-Pacific Command, put the F/A-XX on his unfunded priority list to Congress this spring.

Congress appears to be in favor of moving the F/A-XX forward, starting in the One Big Beautiful Bill Act by adding \$750 million for the project. Senate appropriators called for \$1.4 billion in a markup of the fiscal 2026 defense spending bill, while the House version added \$972 million. Both defense policy bills authorized increased spending.

Continuing the F/A-XX was a central theme of Tailhook, an annual gathering of naval aviators. At the event, Cheever told Aviation Week "the case is simple" that sixth-generation aircraft are needed to meet the threats on a timeline that the Defense Department needs.

"If you have air superiority, then you have sea control. Those things go together," he said. "So you need that fourth-, fifth-, sixth-generation mix. And as fourth-generation comes down in numbers, then you need that . . . fifth-, sixth-generation mix. And I think the Navy's done it well with the fourth-, fifth-, sixth-generation mix of what's coming."

The Navy is prioritizing range and survivability for the aircraft. The service has said the F/A-XX targets an increase in range of about 25%, which is expected to be larger than other carrier-based fighters. The aircraft will be powered by a derivative of existing engines for which GE Aerospace and RTX's Pratt & Whitney are both in the running.

The F/A-XX is the closest to a decision among the high-priority acquisition programs for the Navy's aviation forces, along with a new trainer and a longer-term goal to replace Sikorsky MH-60 helicopters.

Cheever said he is "pretty excited" about how the Trump administration and Defense Department leadership are looking at acquisition.

"I think we're on the cusp of moving with more speed, more purpose, more focus, more priorities for what's needed, when it's needed," he said. "And also, if you move faster, sometimes your costs actually go down, because you move at speed instead of stretching these things out longer and longer. So there's excitement there, or at least there's excitement for me for what we can do in the future and in the next, literally, year to months." 📷

Gallery See some of what exhibitors displayed at the Tailhook Symposium: [AviationWeek.com/Tailhook-2025-gallery](https://www.aviationweek.com/Tailhook-2025-gallery)



The Future of Air Defense: IAI-ELTA's Cutting-Edge Multi-Sensor Radar Solutions

Advertorial

» In an era of rapidly evolving threats, where drones, cruise missiles, and ballistic salvos redefine the battlefield, IAI-ELTA Group stands at the forefront with its revolutionary radar technology. At the heart of this technological leap lies the ELM-2084 Multi-Mission Radar (MMR) and its latest evolution, the Multi-Sensor MMR (MS-MMR).

Transforming Modern Defense with Multi-Sensor Synergy

The MS-MMR represents a game-changing advance in radar technology. By combining multiple sensors into one cohesive system, it provides unparalleled precision and comprehensive coverage against a spectrum of threats.

"We are witnessing increasingly complex scenarios," explains Eyal Shapira, General Manager of Air Defense and Naval Radar Systems at IAI-ELTA. "From low-signature drones flying mere meters above ground to long-range ballistic missiles, today's radars must detect, track, and classify targets with unmatched speed and accuracy."

This new system fuses data from various sources, including radar, electro-optical sensors, and Signal Intelligence (SIGINT), to deliver a unified and highly detailed situational picture. By seamlessly integrating with advanced weapon systems, the MS-MMR ensures precise and timely interception decisions, embodying the principle that as Mr. Shapira notes: "for multi-challenges, you need a multi-solution".

A Proven Legacy of Excellence

IAI-ELTA's radar systems are no strangers to high-stakes performance. The MMR family has been a cornerstone of Israel's multi-layered air defense, powering systems such as the Iron Dome, and David's Sling. The MMR's global footprint spans numerous customers, reinforcing its reputation as a trusted solution in real-world combat scenarios.

"Our radars are the eye and brain behind every interception," notes Shapira. "Whether it's the Green Pine in the Arrow system or the MF-STAR on naval platforms, these technologies provide the precision and reliability our customers depend on in critical moments."

The MS-MMR's introduction addresses the increasingly sophisticated challenges posed by adversaries. Modern threats like supersonic cruise missiles and swarm attacks by drones demand a new level of agility and intelligence in air defense systems. The MS-MMR's real-time capabilities enable it to adapt to these evolving challenges. As Shapira puts it, "We are not just building radars; we are building solutions that think, evolve, and keep us a step ahead."

The system's ability to classify threats accurately and optimize resource allocation across a network of radars creates what Shapira describes as a "radar beehive." This interconnected network ensures seamless operation, even in the event of individual unit failure.

Global Impact and Future Horizons

From military installations to civilian infrastructure, IAI's radar systems protect critical assets



Credit: IAI-ELTA Group

worldwide. With over 250 units sold to 20 customers worldwide, ranging from NATO allies to Asian navies, the MS-MMR is set to redefine air defense capabilities globally. As Shapira reflects on the challenges faced, he highlights the importance of adaptability: "The world's battlefields are changing daily, and so must our systems."

As threats grow more sophisticated and diverse, IAI's ELTA Group continues to pioneer advancements in radar technology, providing nations with the tools to safeguard their skies. The MS-MMR is not just a technological achievement; it serves as the foundation for ensuring the readiness of nations to face any scenario. As demonstrated in Israel, where prolonged conflict involved thousands of attacks from multiple fronts, readiness proved to be the most critical factor in safeguarding the future of nations and their people. This system embodies the principle that resilience and adaptability are essential for maintaining security in an increasingly complex world.

Meet IAI's Air Defense experts at Hall 3, Booth #S-3-230 – or connect directly: market@elta.co.il



Credit: IAI-ELTA Group

FROM FICTION

- > LASER WEAPONS EARN THEIR COMBAT CREDENTIALS
- > U.S. SPACE FORCE HUNTS FOR LASER WEAPON TECHNOLOGY
- > THE UK BOOSTS ITS DIRECTED-ENERGY INVESTMENT PLAN

Robert Wall and **Tony Osborne** London

Laser weapons since at least the 1990s have come with the promise of arriving on the battlefield within five years. Decades later, those five years are finally up.

The U.S. and Israel have used these directed-energy weapons in combat, and a Chinese system sold to Saudi Arabia may have achieved its first combat kill.

Laser weapon technology is coming of age as demand surges for the equipment that promises lightning-speed engagement, multishot capability and relatively low cost per kill—especially as military planners are looking for ways to handle drone swarms or missile barrages cost-effectively.

The cost per shot is about \$1, says Andreas Schwer, CEO of Electro Optic Systems (EOS), which recently secured a first order for its 100-kW anti-drone laser system. Others have put costs that do not amortize development or procurement bills slightly higher but well below those of missiles.

Recent conflicts in the Middle East have propelled the technology from the laboratory to the battlefield. The Israel Defense Ministry in May said it had engaged “scores of enemy threats” using a high-power laser known as Iron Beam. The ministry said the engagements were the first for the Rafael-built

system after Israel’s Air Force and Directorate of Defense Research & Development accelerated its fielding due to the war in Gaza.

Although the government did not explicitly mention Iron Beam in the May 28 statement, a video accompanying the announcement showed a beam-control turret typically associated with the system. The infrared video shows a drone in flight and the laser slowly burning through the uncrewed aircraft’s left wing, causing it to spiral out of control and crash.

Rafael officials, who are selling the Iron Beam laser adjunct to the country’s Iron Dome air and missile defense system, say it costs less than \$20 per shot. That is a fraction of the tens or hundreds of thousands of dollars a missile can cost and an important shift in the battlefield math when trying to counter threats that cost only hundreds or thousands of dollars themselves. The laser costs do not include the development and production bill of deploying the system at the outset.

Rafael has designed the system to split the laser beam and closely track

EOS is planning further high-power laser demonstrations in the coming months to woo customers.

each strand to measure how atmospheric diffraction affects the level of energy on target to compensate rapidly for any degradation.

The U.S. Army, meanwhile, deployed four Stryker-vehicle-mounted RTX High-Energy Laser Weapon Systems to Central Command in 2024. The 50-kW system, which the Army calls Directed-Energy Maneuver Short-Range Air Defense, has been used in test firings and operational intercepts, program officials have said.

The trial deployments focused on ensuring the systems can be used against drones and to assess the utility in the field for equipment that can require almost clean-room-like facilities to produce and repair. For longer-term use, the Army is looking to make it possible for soldiers to repair equipment in the field—particularly the sensitive optics—that can still have high failure rates, Col. Adam Miller, deputy director for directed energy for the Army’s Rapid Capabilities and Critical Technologies Office, told the Space and Missile Defense Symposium in Huntsville, Alabama, in early August.

TO REALITY

Despite the system's reliability issues, the experience has helped convince the Army to pursue a program to buy the equipment at scale, Lt. Gen. Robert Rasch, director of the Rapid Capabilities and Critical Technologies Office, said at the event. The new equipment should be more reliable and easier to maintain, he noted.

The service also wants to expand the lethality of the equipment. Maj. Gen. David Stewart, director of the Pentagon's Joint Counter-UAS Office, said at the forum that the laser systems are effective against smaller drones, but there is interest in expanding that to engage larger, higher-flying systems. The Army, for instance, is working on 300-kW laser systems.

Other countries are also looking to diversify their laser-weapon applications. Elbit Systems, a key supplier to Rafael on Iron Beam, is working on an airborne version for the Israeli Air Force that has attracted interest abroad, Elbit CEO Bezahel Machlis said on an Aug. 13 earnings call.

Rafael has introduced the Lite Beam, a 10-kW-class, vehicle-mounted laser system more specifically aimed at the counter-UAS market and to address other low-altitude airborne threats. It can also engage some ground targets. The system is supposed to be able to acquire and intercept targets at more than 3 km (2 mi.) and is designed for use on tracked and 8 X 8-, 6 X 6- and 4 X 4-wheel fighting vehicles.

Rafael also used the International Defence Exhibition & Conference in Abu Dhabi this year to showcase a mobile, 50-kW laser system with a touted range of several kilometers. The truck-mounted system comes with a 250-mm aperture beam director to engage UAS and other aerial or ground threats, the company said.

The technology's promise is spurring other governments to look at buying the equipment. Machlis said there is strong interest in both Iron Beam and the airborne system outside of Israel.

EOS CEO Schwer said the company expects a wave of orders after the disclosure of a launch deal for its 100-kW counterdrone laser system on Aug. 5

from an unnamed European NATO member. "We expect first clients to order lower quantities to get used to the system," he said during an Aug. 7 investor briefing, noting that they are expected to follow with larger deals. Two potential clients have indicated they could buy 100 systems over 10 years to protect air bases and critical national infrastructure, such as airports.

The U.S. Army deployed four laser systems to Central Command in 2024.



U.S. DEFENSE DEPARTMENT

Due to the demand signal, EOS is looking into industrializing production, which should help drive down system costs 20-40% through economies of scale, Schwer said. The production site in Singapore can handle 4-5 products, and EOS has room to double throughput. Schwer noted that he expects many buyers to opt for local production, however.

EOS has designed the system to be scalable up to 150 kW, which could reduce engagement time to 1 sec. or less from 2-3 sec. or extend the engagement range to around 6 km from 2-3 km. Each system can engage about 20 drones per minute and comes with enough battery power for about 300 engagements. A site-protecting system plugged into a power grid would not be limited in the number of engagements.

The container-housed system can be loaded on a truck for mobility. To help protect the system from attack,

the beam director can be retracted to make it harder to differentiate from a regular container.

Interest in laser weapons is not limited to counterdrone applications. The U.S. Space Force, for instance, has kicked off an effort to determine how to use lasers and other systems to deter or disrupt an adversary's systems or to safeguard its own.

The service is trying to engage U.S. startups and small businesses to acquire existing technology that is "compact, low-cost and high-energy," according to the service's Space Security and Defense Program. The interest spans ultra-efficient pump diodes

and high-energy-density optics for lasers, low-cost beam directors and compact, ruggedized packaging for 2-micron fiber-laser amplifiers.

The UK, trying to keep pace with laser developments, has earmarked almost £1 billion (\$1.3 billion) to directed-energy weapons, including the MBDA DragonFire program. The country said last year that it would deploy the DragonFire at sea and is working to have it on Type 45 destroyers starting in 2027, after accelerating the fielding almost five years. The initial system that has entered production will represent a minimum deployable capability that is to be upgraded.

UK defense procurement minister Maria Eagle has told lawmakers that DragonFire fired more than 300 times and defeated 30 drones in a recent trial, demonstrating its reliability and ability to engage targets even in adverse weather.

A second, smaller laser developed by Raytheon has also been tested against aerial moving targets in the UK as part of the Project Swinton

The UK has decided to deploy its DragonFire technology at sea.

effort to develop a battlefield anti-drone laser system. The 15-kW laser, first tested in 2024, uses Raytheon's High-Energy Laser Weapon System, developed in the U.S. but integrated with a UK-developed command-and-control system and a Blighter search radar, and then fitted onto a Wolfhound Protected Patrol vehicle. It can be fitted to smaller vehicles as well.

MBDA has also been working on laser weapons in Germany for over a decade, and last year teamed with Rheinmetall to bring the technology into naval use. Their system has undergone testing on the German Navy's Sachsen frigate involving more than 100 laser firings. MBDA also has partnerships in Italy with Leonardo and in

France with Safran to work on other laser weapon applications.

China's Poly Technologies developed a vehicle-mounted anti-drone laser, called the Silent Hunter, that has been exported to countries including Saudi Arabia. The Royal Saudi Air Defense Forces revealed at the World Defense Show event in Riyadh last year that they had used the system to hard-kill a one-way attack drone. One

of the laser systems was also used to protect that event, operating alongside U.S.-supplied Patriot anti-ballistic missile systems (*AW&ST* Feb. 12-25, 2024, p. 36). More recently, the Silent Hunter system may have been exported to Russia—imagery from there showed the laser being used to down a Ukrainian one-way attack drone. 🇷🇺

—With Brian Everstine in Washington



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USAF F-16 Contract Opens the Door for a Helmet-Mounted Cueing Rival

> RED 6 PLANS TO INTEGRATE AN AUGMENTED REALITY SYSTEM ON THE LOCKHEED MARTIN FIGHTERS

> HELMET PRODUCTION IS EXPECTED TO RAMP UP IN 2027

Steve Trimble Washington

Red 6 launched seven years ago with the idea that a new helmet-mounted display with augmented reality vision can help train military pilots. Now the company thinks the technology could offer a generational improvement in actual dogfighting in combat.

A new contract signed by the Orlando, Florida-based company with the U.S. Air Force's Air Combat Command (ACC) and the Air Force Research Laboratory offers the first clue about the technology's expanded potential. The deal requires Red 6 to integrate the Airborne Tactical Augmented Reality System (ATARS) into the Lockheed Martin F-16.

In a stroke, the agreement advances the ATARS helmet beyond purely training roles and makes Red 6 a rival of the Vision Systems International Joint Helmet-Mounted Cueing System series, the standard combat helmet for more than 20 years for U.S. F-16s, Boeing F-15s and F/A-18s.

But can a helmet originally designed to bolster training step into operations, enabling combat pilots to aim their missiles by simply looking in the direction of the targets?

"It turns out that the byproduct of doing augmented reality really well is that you can do next-generation helmet-queuing, but you can do it to a far higher standard," Red 6 CEO Daniel Robinson says.

ATARS is designed to project three-dimensional, augmented reality images onto a pilot's visor, allowing them to see and interact with simulated objects, including aircraft.

The core of the technology is Red 6's Enhanced Visual Environment headset, which is due to enter production for the Air Force's Northrop T-38 Talon trainer fleet next year. Red 6 advertises

the headset's display as the brightest in the defense market, at 18,000 nits, or twice the brightness level of an outdoor display in a sports stadium. That extraordinary brightness means the

eye movement, which offers a straightforward path to enabling helmet-mounted cueing.

"As we envision this, yes, it's going to be a training system, but it's also going to be an operational helmet as well," Robinson says. "The ability not just to render in two dimensions, but to render in three dimensions and to take contextual information, offers us a whole new paradigm in how we think about not just helmet-mounted cueing, but situational awareness, looking at the battle space, understanding the electromagnetic spectrum, the ability to see the threat environments."



The ATARS helmet is designed to display on the visor data from the mission systems, not just simulations of partner and adversary aircraft.

Red 6 helmet displays objects that the pilot can see on the brightest day with the sky as the background.

In the short term, the Air Force plans to use the ATARS technology to improve training. Instead of waiting for other aircraft to become available, T-38 pilots can take off and interact with simulated partners, including collaborative combat aircraft, or adversaries in the sky.

The same technology could be used for operations. By integrating with mission systems, such as the radar, infrared search-and-track sensor or electronic support measures, the helmet can display real enemy aircraft on the pilot's visor. The technology already syncs the display to the pilot's

"The by-product of augmented reality is you can do helmet-queuing, but 10 times better than anything out there right now," Robinson adds.

Red 6 plans to launch production of the ATARS helmet for the T-38 in the second quarter of 2026, even as testing continues over the next 12 months for F-16 integration. As ATARS production starts ramping up in 2027, the ACC's F-16 units could become a customer.

"What's great about going into the F-16 is . . . it unlocks the fighter community," Robinson says. "Because if it works in the F-16—and we believe it adds as much value as it's going to, which we have no doubt—then the logical next steps are into the other fighter communities." 🛩

Concerns About Funding and Politics Cast Shadow on European F-35 Buys

➤ SPAIN WANTS TO KEEP ITS DEFENSE EUROS IN EUROPE

➤ SWITZERLAND HAD EXPECTED A FIXED-PRICE F-35 DEAL

Tony Osborne London

European procurements of Lockheed Martin's F-35 Joint Strike Fighter have been roiled by questions about the aircraft's future in both Spain and Switzerland.

The issues boil down to funding and politics. Spain concluded that it would be best to spend defense funds in Europe, perhaps by acquiring more Eurofighters and investing in the pan-European Future Combat Air System (FCAS). In Switzerland, an unex-

pected price rise in the country's F-35 procurement is prompting ministers to reexamine their options.

Madrid's decision to discount the U.S.-made fighter could have far-reaching implications, including ending the country's fixed-wing carrier aviation capability, currently provided by the soon-to-be-retired McDonnell Douglas AV-8. After years of flying a mixed fleet of European and U.S. types, the Spanish Air Force could become uncomfortably reliant on a single-type front-line combat aircraft fleet. Spain had been widely expected to adopt both the conventional-takeoff F-35A and the short-takeoff-and-vertical landing F-35B for its air force and navy, respectively, replacing the McDonnell Douglas F/A-18 Hornet and the AV-8, but Prime Minister Pedro Sánchez's government has dismissed that option.

simply not compatible with the Spanish economy and welfare state. He was subsequently admonished by U.S. President Donald Trump, who suggested Spain could pay more in trade deals because of its unwillingness to pay up for European defense.

Spain has long had a hot-and-cold relationship with the F-35. Military officials were reluctant to discuss the platform, even though many had concluded it was the only real option. Some Spanish defense commentators have called the F-35 Voldemort, the primary villain in the *Harry Potter* books referred to as He Who Shall Not Be Named, because of concerns about reactions of politicians and workers' unions. Spain is also worried about losing its role on the FCAS, a project considered crucial for the country's aerospace industry.

Observers point out that a future Spanish government could reverse the plans—the next general election is expected in the summer of 2027. Or Spain's hand could be forced if neighbor Portugal decides to buy the F-35, or if Morocco, which has requested to purchase the F-35, receives the green light to do so.

Switzerland, meanwhile, faces a potential increase of 1.3 billion Swiss francs (\$1.6 billion) in its purchase of 36 F-35As. Lawmakers believed they had secured a fixed price of 6.035 billion Swiss francs when the Foreign Military Sale (FMS) agreement was signed in September 2022, so they expressed shock when the U.S. Defense Security Cooperation Agency advised them of a possible raw material and energy-induced price rise in June.

The Swiss government pushed back and sought independent legal consultants, who backed up Bern's claims. But with no legal recourse in an FMS deal, the officials resorted to diplomatic negotiations, including a conversation between Swiss Defense Minister Martin Pfister and U.S. Defense Secretary Pete Hegseth, to no avail.

Bern declared on Aug. 13 that the U.S. was unwilling to "deviate from its stance" that Switzerland did not have a fixed price secured for its F-35s.

The government still wants to proceed with its F-35 buy, undeterred by the 39% trade tariffs imposed by the Trump administration, although some lawmakers have suggested canceling the F-35 deal in response. Bern is looking at alternative options, which could include a reduction of the number of aircraft purchased or partial compensation of the additional costs through offset deals with Lockheed Martin, Pfister told a press conference following the announcement.

Switzerland says that terminating the F-35 contract would have considerable consequences, as the country could not police its airspace after 2032, when its current fleet of F/A-18s is withdrawn.

A purchase of new fighters has been controversial in Switzerland. A September 2020 referendum to buy such aircraft garnered just 50.1% of the vote (*AW&ST* Oct. 12-25, 2020, p. 59). The F-35 selection prompted a campaign to halt the procurement, but the government said the movement did not obtain the required number of signatures. 🇮🇪

The Swiss government remains committed to the F-35 despite price rises and tariffs, but will it stick to plans to purchase all 36 aircraft?



ALDO WICKI/SWISS DEPARTMENT OF DEFENSE, CIVIL PROTECTION AND SPORT

InsideMROTM

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Asia-Pacific

ENGINE MARKET ADAPTS

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Provenance Efforts**

**Korean Air Expands
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Approved: EASA & FAA for LEAP Engines

IAI-Aviation group, BEDEK MRO, a world-class aerospace leader for more than 70 years, has received EASA and FAA certification to perform QT level maintenance for CFMI LEAP-1A/- 1B Engines and is in the final stages of extending this certification to full overhaul capability. IAI's existing list of capabilities includes CFM56-3/5/7, V2500 & PW4000 Engine Overhaul.

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MRO 54	Green Advances
MRO 56	Betting on Digital
	ENGINE EVOLUTION
MRO 58	Rival Opportunities
	ENGINEERED
MRO 60	Cutting Complexity
	MARKETPLACE
MRO 64	Lighting Innovations
	VIEWPOINT
MRO 65	Jonathan M. Berger, Alton Aviation

MAINTENANCE CHECK

CF6-80C2 HPT Blade

A single high-pressure turbine blade made by Chromalloy for the General Electric CF6-80C2 illustrates several airline aftermarket dynamics underway. How?

First, the existing fleet of aircraft and engines continue to fly due to passenger traffic demand and airframe and engine production problems that slow fleet renewal and growth efforts. Second, lower fuel prices lately also make operating current-generation fleets more affordable, so until new aircraft and engine production rates ramp up, those assets will continue to operate.

Third, many aircraft lessors, as a result, are seeing high lease renewal rates. Air Lease Corp. customers are choosing "to extend rather than let aircraft go to competitors or other airlines," company CEO John Plueger said on an Aug. 4 earnings call.

Although Airbus and Boeing plan to increase production rates, they are falling "far from their aspiration production rates," says Plueger, who expects supply constraints "for the next 3-4 years," if not longer.

Fourth, for aftermarket providers, this means additional airframe heavy checks and engine overhauls that were not forecast. And of course, that necessitates material.

Frankly, the engine OEMs and their suppliers face tough choices today due to strong demand for both new and existing engines material. Sometimes it must feel like being forced to choose a favorite.

Especially for mature engines, operators want to minimize materials costs where they can, so they seek repairs, used serviceable material or module swaps. But until retirement rates increase, used serviceable material will be constrained, which opens the door to increased use of parts manufacturer approval (PMA) parts.

This leads us back to that Chromal-



Chromalloy has developed end-to-end capabilities for its CF6-80C2 first-stage high-pressure turbine blade.

CONTINUOUS IMPROVEMENT HAPPENS DAILY IN THE AVIATION AFTERMARKET."

loy PMA CF6-80C2 first-stage high-pressure turbine (HPT) blade, which celebrated its 20th anniversary in March after flying 1 billion flight hours without any airworthiness directives.

I toured Chromalloy's three Tampa, Florida, facilities in June and saw many of the 200 processes required to manufacture turbine blades, including the new platinum aluminide and electron beam physical vapor deposition thermal barrier ceramic coating machines (MRO40).

By adding the coating capability in Tampa, Chromalloy no longer needs to send blades to its New

York coating facility. This decreases production time and tightens process controls by keeping the end-to-end capabilities colocated. From the alloy to the coating, each step of a part's provenance is known.

That is important as the industry adopts digital record keeping to accelerate part-tracing modernization efforts, which hopefully will prevent another AOG Technics from happening. See Sean Broderick's investigative article detailing efforts underway (MRO14).

Enjoy this *Inside MRO* issue, and I hope to see you at AeroEngines Europe and/or MRO Asia-Pacific! ☺

—Lee Ann Shay

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HIGHLIGHTS

Boeing Predicts Small Dip in Demand for Technicians

Boeing recently released its 2025 outlook for pilots and technicians through 2044, showing slight increases in demand for commercial aircraft cabin crewmembers but slightly less demand for pilots and maintenance staff in the next 20 years.

The latest outlook forecasts that the commercial aviation workforce will grow by 710,000 maintenance technicians, 660,000 pilots and 1 million cabin crewmembers through 2044, with an overall total of 2.37 million personnel. Last year's

report forecast demand for 716,000 new technicians, 674,000 new pilots and 980,000 new cabin crewmembers.

The differences reflect minor variations in Boeing's forecast for commercial aircraft demand. The commercial market outlook declined 1% year over year in 2025, and demand tilted slightly in favor of larger widebody aircraft, Chris Broom, Boeing Global Services' vice president

Boeing expects demand for 710,000 new maintenance technicians over the next 20 years.

of commercial training solutions, told reporters at a press conference during the Experimental Aircraft Association's AirVenture event in Oshkosh.

Boeing predicts that demand for technicians will be highest in Eurasia and China, requiring 165,000 and 131,000 technicians, respectively. North America follows closely behind, with a forecast need for 123,000 new technicians.



TOM TRACY PHOTOGRAPHY/LAMY STOCK PHOTO

Ethiopian Airlines Expands Addis Ababa MRO Facilities

Ethiopian Airlines Group recently opened three new maintenance facilities in Addis Ababa to expand its technical capabilities and boost third-party MRO services across Africa.

The more than \$150 million investment includes a two-bay general maintenance hangar, a component repair workshop and a central warehouse. Construction was completed over three years in partnership with China National Aero-Technology International Engineering Corp., China Communications Construction Co. and Dar Al-Handasah Consultants.

Ethiopian now has eight hangars in the capital, enhancing its capacity for full-scale aircraft maintenance.

The approximately 161,000-ft.² warehouse includes an automated storage and retrieval system for refining spare parts management and streamlining maintenance operations.

Russia's S7 Plans To Close CFM56 Blade Repair Shop

Russia's largest private airline group S7 is closing its subsidiary S7 Space, which had developed expertise in repairing the high-pressure compressor blades in CFM56 engines.

Parts of S7 Space will be absorbed by S7 Engineering, a part of MRO provider S7 Technics, according to a document on the website of Russia's national tax service.

Andrey Balashov, head of the process engineering department at S7 Space, tells Aviation Week the reason for S7 Space's closure was the high cost of its engineering efforts. It had used reverse engineering to master from scratch the "restricted" engine component repairs that can normally be performed only by the original manufacturer, he says. 🌐

CONTRACTS

Caerdav signed a general terms agreement with **AerCap** to perform Boeing 737 and Airbus A320 end-of-lease/transition checks.

Cebu Pacific selected **Lufthansa Technik** to provide integrated consumables and expendables supply support for its Airbus fleet.

Epcor was selected by **Riyadh Air** for APS5000 auxiliary power unit maintenance in support of its Boeing 787s.

FL Technics Wheels and Brakes was selected by **AirExplore** to provide 737-800 landing gear component maintenance.

GE Aerospace secured an agreement with **Cathay Pacific** to provide GE9X MRO for 35 Boeing 777-9s.

General MRO Aerospace won a **Lufthansa Technik** contract to provide hydraulic, pneumatic and electromechanical component maintenance.

HAECO and **Liebherr-Aerospace** partnered to collaborate on Comac C909/C919 hydraulic component repair and overhaul.

JetBlue Airways expanded its deal with **Trax** to add the software provider's eMobility app and cloud hosting.

Jordan Airmotive expanded its partnership agreement with **AJW Group** to include CFM International CFM56-7B maintenance and overhaul.

Lufthansa Technik was selected by **PAL Express** to perform Airbus A320 component support.

MAAS Aviation secured a contract extension from **Ryanair** for Boeing 737 painting through 2035.

Magnetic Line signed a two-year **Air Transat** contract to provide Airbus A321LR line maintenance at Berlin Brandenburg Airport.

Source: SpeedNews

Inside Delegation's Decline

The last five years have brought significant changes to how regulators review and approve products. In the U.S., the FAA's shift has been nearly unavoidable for large projects—namely, new aircraft or major changes that need supplemental type certificates.

The Aircraft Certification, Safety and Accountability Act of 2020 (ACSAA) is driving many of the updates. ACSAA adds requirements to review human-factors-related assumptions in safety assessments, including maintenance-related actions. It also reverses a yearslong trend under which the Organization Designation Authorization (ODA) program steadily expanded applicants' privileges to approve their own products.

Delegation, which permits the regulator to offset limited resources by leveraging industry expertise to act on its behalf, started in the 1920s. Product certification designees debuted in the 1940s.

BOEING



New product approvals are taking longer than ever, partly because of additional FAA scrutiny mandated by a 2020 law.

Further developments occurred in the late 1990s. An FAA rule-making advisory committee recommended creating the ODA program to consolidate and streamline disparate processes. The agency acted in 2005.

Meanwhile, Boeing was exploring far more substantive changes. The company hired Craig Beard, a well-respected former head of FAA certification, to author a white paper on the ODA concept that incorporated even greater levels of delegation.

Beard's Certified Design and Production Organization envisioned granting type certification applicants the same privileges as production certificate holders. The most significant step would be allowing applicants to issue type certificates for their own designs "without further showing." Beard's 1998 paper purposely used the same three-word phrase found in FAA Part 21 that allows Boeing and others to issue airworthiness certificates for each new aircraft rolling off production lines.

Beard envisioned the FAA certification process evolving in the same way: expand delegation of agency authority so a company's designated representatives—members of an approved ODA—could deem a new product compliant with regulations.

Not surprisingly, Boeing embraced the idea and took its case to Capitol Hill. In 2003, as part of the landmark Vision 100—Century of Aviation FAA Reauthorization Act, and even before ODAs were codified, the FAA was given the authority to begin issuing certified

design organization (CDO) status starting in 2010. CDOs were essentially equivalent to Beard's concept.

The seven-year phase-in gave the FAA time to define the program's specifics, which it did with the help of a CDO rulemaking committee. The group's 2008 report largely embraced the CDO concept, including the critical "no further showing" aspect.

But with the ODA concept freshly minted, the FAA held off on CDOs. In 2012, industry successfully lobbied lawmakers to renew their call for CDOs in another FAA reauthorization bill. Delegation steadily expanded, although not all the way to Boeing's CDO vision. But the concept was not dismissed.

Then came the two fatal Boeing 737 MAX 8 accidents in October 2018 and March 2019. Among the ramifications were detailed examinations of how the FAA certified the 737-8.

The findings were eye-opening. Boeing consciously masked changes to the 737 design—notably the Maneuvering Characteristics Augmentation System implicated in both accident sequences—that needed more scrutiny. Boeing's motivation was to minimize new and costly training for operators. Its actions obscured a questionable system that, given appropriate analysis by either ODA members or the FAA, might not have been deemed safe.

Boeing's actions offset 80 years of progress by the FAA's delegation program and brought an end to the concept that the company had hired Beard to develop.

ACSAA put limits on delegation, not only keeping the FAA involved but requiring more input from the agency on specific issues, such as human-factors-related assumptions in system safety assessments. ODA oversight changed as well.

Beard saw delegation's expansion as a logical progression within FAA requirements. If a manufacturer's quality system is sufficient to ensure that airworthiness certificates are issued to aircraft that conform to type design, why can the same system not ensure that the type design conforms to applicable regulations?

But as the 737 MAX saga showed, the process works only if the applicant prioritizes compliance over everything else, including costs and speed. This was not lost on Beard. "Safety cannot in any way be compromised in the interests of establishing a more expeditious and efficient process for type certification," he wrote.

Boeing got its priorities wrong. One result: Product certification is now more cumbersome.

"[CDO] truly had huge potential to make things less costly and easier for the FAA to oversee," says Mike Borfritz, a former FAA and Boeing engineer who assisted Beard on the white paper. "But whatever trust Congress had in our industry and the FAA was washed away, and the congressional action imposed a burden on both industry and the FAA."

Borfritz is now CEO of Kilroy Aviation, an FAA ODA that specializes in helping companies obtain supplemental type certificates. While the certification process is more cumbersome, Borfritz says Congress' ACSAA crackdown has not wreaked havoc everywhere.

"If you're an ODA and do your job properly, this additional oversight shouldn't be a problem," he says. "It's sad that the concept of a [more] powerful delegation option has disappeared. But the fact is the current delegation system is very robust. We can work within it and thrive." 🍷

—Sean Broderick

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ARSA UPDATE

Tipping Forward

WHILE DETAILS OF LAST YEAR'S CHANGE 10 TO THE FAA and European Union Aviation Safety Agency's Maintenance Annex Guidance for new safety management system requirements captured attention, the agencies' Technical Implementation Procedures Revision 7.1, which took effect in June, was equally earthmoving.

The Technical Implementation Procedures (TIP) clarified language for acceptability of new modification and replacement parts consumed during maintenance by U.S.-based repair stations for which an FAA-European Union Aviation Safety Agency (EASA) dual release will be

institute the newly allowed procedures and for clear guidance that parts released prior to the MAG change would not require such documentation.

In 2016, the FAA confirmed that ARSA's first New Article Inspection Form, the E100, was an acceptable method of compliance for inspecting new parts under the MAG. The form outlined a procedure for certificate holders to make continue-in-service determinations on articles consumed in maintenance subject to the U.S.-EU bilateral.

Six years after confirming the E100's acceptability, the FAA backtracked and withdrew its support of the process. Once again gathering its coalition, ARSA highlighted the FAA's and EASA's problematic confusion between exporting a part and exporting maintenance during which that part is consumed.

The latest TIP revision clarifies language relating to parts consumed in maintenance for which an FAA-EASA dual release will be issued.

Although the problem began with the MAG, the TIP could solve it.

The strategy that was recognized in 2015, realized in 2016 and rejected in 2022 has been rejuvenated in this year's TIP Revision 7.1 clarifying language for acceptability of new modification and replacement parts consumed in maintenance for which an FAA-EASA dual release will be issued. That language should be carefully reviewed. Suffice it to say, it allowed ARSA to update and rerelease its New Article Inspection, now on what the association calls Form 103. 🗨

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

Brett Levanto is vice president of operations of 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.



LINDSAY BJERRREGAARD/AVIATION WEEK NETWORK

issued. Paragraph 7.10.4.2 provides that, except for critical parts manufacturer approval and life-limited parts, which still must be accompanied by an FAA Form 8130-3, all others need to be "accompanied by [a broadly defined range of] documentation that ensures both traceability to the FAA-approved Production Approval Holder (manufacturer) of the part and conformity to its approved design." When documentation is missing but part-marking or technical or design data is available, repair stations may perform an inspection and determination of suitability for installation.

For a little history on the issue of when an FAA Form 8130-3 (or EASA Form 1) must accompany a new part used in maintenance, go back to 2015 and Change 5 to the Maintenance Annex Guidance (MAG). ARSA led an industry coalition providing both short-term relief and long-term strategy. The group helped production approval holders (PAH) issue authorized releases under early adoption of §21.137(o), requesting time for PAH to



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Falling Behind

MRO spending might lag fleet growth in the Asia-Pacific region until after 2034

BRIAN KOUGH

The Asia-Pacific region and China are projected to account for 30% of global commercial aviation MRO demand in the next 10 years. Their aftermarkets are expected to grow at only 2.3%—relatively low on the global stage, considering the expected expansion and size of the future fleet.

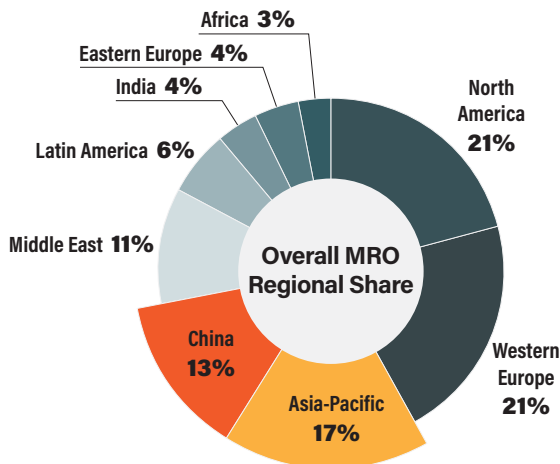
Aircraft OEMs have a backlog of 5,300 jet and turboprop aircraft scheduled to be delivered to the region in the next decade, but the Aviation Week Network's 2025 Commercial Fleet & MRO Forecast projects the number to rise—to 6,500 aircraft—after orders increase. The fleet gains should result in a strong 3.6% compound annual growth rate (CAGR) after retirements, freighter conversions and storage activities are tallied.

While Comac has nearly 1,500 firm orders for the C919 and C909, Airbus product orders outnumber those by nearly 500 aircraft. Boeing faces stiff competition geopolitically with Comac in the region, but its orderbook still matches Comac's. Airbus' A320-family aircraft are its most popular narrowbodies, while its A350 is the most popular widebody; Boeing's 737 and 787 are its most popular narrowbody and widebody, respectively.

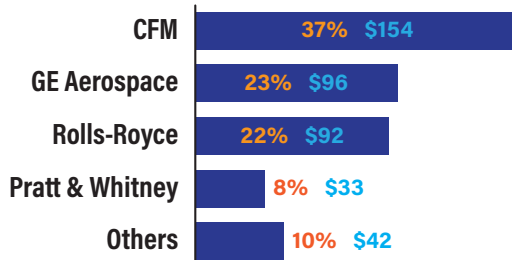
China and the Asia-Pacific region are forecast to generate \$417 billion in MRO demand over the next decade after 80,200 major service events and their unexpectedly low CAGR. Given the rapid pace of anticipated new aircraft, maintenance spending is not likely to catch up to the fleet growth until beyond the forecast period.

Nearly \$221 billion of the overall projected maintenance demand will be related to engine maintenance. Removing narrowbody engine durability technical upgrades, engine demand

Asia-Pacific Commercial MRO Demand, 2025-34



Engine MRO Share and Dollar Demand (U.S. Billions)



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

Maintenance requirements for GENx and GE90 engines contribute to GE Aerospace's expected \$96 billion in MRO demand over the next decade.



requirements are forecast to climb more quickly than the whole. Growing at 2.6% CAGR, the maintenance category increases rapidly on a constant dollar basis through the 10-year forecast period, with the demand shared among a few manufacturers.

CFM International engines are expected to account for almost 40% of the requirements, at \$154 billion, reflecting the number of narrowbodies powered by Leap engines. Widebody engine-makers follow distantly behind. GE Aerospace powerplants

such as the GE90 and GENx used on the Boeing 777 and 787, respectively, should push requirements to \$96 billion over the decade.

Rolls-Royce engines are projected to exceed \$92 billion in requirements. Rolls' Trent series powers the Airbus A350 and A330, and it is an option choice for the 787. Pratt & Whitney's engines will accumulate \$33 billion on a constant dollar basis over the next decade. Pratt's PW1000G is an option for the Airbus A320, and its PW4000 powers multiple widebody aircraft. ✈

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Korean Air

Jongseok “Jason” Yoo, executive vice president and chief safety and operating officer at Korean Air, details the airline’s ambitious MRO growth plans to Executive Editor **Lee Ann Shay**.

What MRO work does Korean Air perform in-house and what does it outsource? For

airframe maintenance, we perform all of our own line maintenance in-house. We also leverage this to provide third-party line maintenance support for numerous carriers operating various aircraft types at Incheon International Airport and our key domestic hubs, including Incheon, Gimpo, Busan and Jeju. For heavy maintenance, we perform the majority of checks in our own facilities. We also operate a dedicated aircraft painting business. Our primary strategic focus, however, is on the engine MRO sector. We are concentrated on developing high-value engine repair capabilities and actively service a mix of our own fleet and engines from customers around the world across the six types in our current portfolio. We currently hold full overhaul capabilities for the Pratt & Whitney PW4000 (94-, 100-, and 112-in. variants), the PW1100G-JM, the



KOREAN AIR PHOTOS

Jongseok Yoo, executive vice president and chief safety and operating officer.

the groundwork for developing Trent XWB capabilities starting in 2029.

In component maintenance, our in-house capabilities [after the merger with Asiana Airlines] now cover over 2,000 part numbers, which contributes directly to our fleet’s on-time performance and reliability. However, like others in the industry, we face challenges with newer aircraft platforms due to the OEMs’ growing control over

the aftermarket. This often leads to longer lead times and higher costs for outsourced repairs. To counter this, we are focused on strategically internalizing more of these capabilities through targeted investments and new partnerships with OEMs and leading MRO providers.

In the defense sector, where effective life-cycle sustainment is critical to operational readiness, Korean Air serves as South Korea’s leading provider of military MRO and advanced performance upgrades.



Korean Air will paint about 60% of its aircraft with the new metallic livery in-house.

[CFM International] CFM56-7B and the GE [Aerospace] GE90. Our road map includes developing capabilities for next-generation powerplants. We are on a clear road map to add the next-generation CFM International Leap-1A/B and GE GEnx-1B/2B engines to our portfolio by 2028, and we signed [a memorandum of understanding] with Rolls-Royce to join the Rolls-Royce MRO network, which lays

Our legacy in this field spans more than four decades, beginning with depot-level maintenance on U.S. Air Force F-4 Phantoms in 1979. Since then, we have serviced over 5,500 military aircraft for both Republic of Korea and U.S. armed forces, including key platforms like the F-15, [Lockheed Martin] F-16, A-10, [Lockheed] P-3C and [Sikorsky] CH-53 and UH-60 helicopters. This extensive

experience has established our facility as the largest military MRO hub in the Asia-Pacific region.

We are increasingly focused on complex modification and upgrade programs, a capability underscored by our recent contract award for the UH-60 Black Hawk performance enhancement program. Looking ahead, we are actively involved in strategic opportunities such as the Republic of Korea Air Force’s F-16 Service Life Extension Program and next-generation projects for electronic warfare and airborne control platforms. These programs are key to solidifying our role as a premier MRO specialist supporting the nation’s defense infrastructure.

Since Korean Air’s merger with Asiana, is Korean Air performing some of its maintenance, too? Post-merger, we

have established a close and systematic maintenance partnership to ensure operational continuity and the highest levels of safety across both carriers. While we each operate as distinct Approved Maintenance Organizations, we have a comprehensive mutual support agreement that allows us to synergize our efforts across aircraft, engines and components.

This partnership is already yielding tangible results. For example, we are providing engine maintenance support for Asiana’s [Pratt & Whitney] PW4090 fleet and have established mutual leasing arrangements for both PW4168 and PW4090 engines to optimize fleet availability. We are also providing reciprocal line maintenance support for each other at airports worldwide. A key synergy is the joint in-sourcing of component repairs; for items both airlines previously sent to third-party vendors, we are now combining our in-house capabilities to improve quality control and reduce costs.

What is the status of the livery rebranding, which includes metallic paint? How much of the repainting will Korean Air perform in-house? The fleetwide livery rebranding program is progress-

ing well. As of early August, we had repainted 13 of the 131 Korean Air aircraft designated for the update, and we have a comprehensive plan to apply the new livery to the Asiana fleet as well. To execute this ambitious program efficiently, we target a pace of about 50 aircraft per year. While we have the full

capability to paint our entire fleet in-house, we are balancing our internal capacity with external support to accelerate the timeline. Approximately 60% of the work will be performed in our own hangars, with the remainder being handled by trusted overseas service providers.

The new livery is a significant evolution for our brand. It transforms our iconic “blue top” symbol, a hallmark of Korean Air for over four decades, into a contemporary, custom metallic blue. This requires a more complex, three-stage application process than conventional liveries. After the standard basecoat, we apply an intermediate metallic paint layer before finishing with a protective clearcoat. This additional step is essential to achieve the precise color depth and a finish that represents our modernized brand identity.

Is Korean Air planning to add any new airframe or component MRO capabilities or modify any of its four maintenance facilities? We have a comprehensive strategy for expanding both our MRO capabilities and capacity, which is backed by significant, active investment.

With our fleet set to continue growing following the integration with Asiana, we are expanding our domestic airframe maintenance infrastructure to handle the increased volume. We are advancing plans with Incheon International Airport to construct a new hangar in the airport’s Advanced Aviation Complex. This facility on a 70,000-m² (750,000-ft.²) site will feature a 2.5-bay layout with integrated support facilities, and we are targeting it to be operational by 2030.

In component maintenance, our focus is on integration and synergy. We plan to relocate some of our component repair shops from Busan to our new engine MRO facility when it opens in 2027. The broader vision is to consolidate our component functions—currently spread across Gimpo, Incheon and Busan—into a unified MRO complex adjacent to the new engine center. We are pursuing this as a collaborative effort, intending to develop this maintenance campus in partnership with leading OEMs and global MRO providers.

We hold repair certifications not only from [the Korean Ministry of Land, Infrastructure and Transport] but also



Korean Air’s MRO capabilities include full engine overhaul, including testing.

from the FAA, European Union Aviation Safety Agency and Civil Aviation Administration of China, which allows us to support numerous global customers. As we prepare to expand component MRO, we are looking for more than just transactional service agreements; we are offering strategic partnerships to grow together in the component aftermarket.

These initiatives in airframe and component MRO, in addition to our major engine facility expansion, are part of a cohesive plan to build a complete and advanced MRO portfolio that will enhance our operational efficiency and define our competitive position in the market.

What is the status of the new purpose-built engine MRO center in Unbuk?

Our new engine MRO center in Unbuk represents a strategic initiative to enhance operational agility, efficiency and global market reach. The facility is strategically located on Yeongjong Island, positioned 7 km (4 mi.) from Incheon International Airport Terminal 2, providing optimal logistics connectivity for international engine movements.

The project represents an investment of 578 billion won (\$439 million), spanning 140,000 m² across two underground levels and five above-ground levels. Construction commenced in March 2024, with facility completion scheduled for [the fourth quarter of] 2026 and full operational activation targeted within 2027. Upon completion, this will become the largest dedicated engine maintenance center in the Asia-Pacific.

The facility is designed to consolidate our previously distributed engine operations into a single integrated location. This includes relocating engine

and module maintenance plus parts repair operations from Bucheon, engine test operations from our existing Unbuk site, and component repair functions from Busan. This integration will significantly enhance process efficiency and scalability, supporting our long-term goal of increasing annual engine output from the current capacity of around 130 engines per year to a future target of 500 engines.

What truly sets this facility apart is its foundation as an integrated, next-generation smart MRO hub. We are investing heavily in advanced technologies for our new facility. This includes the implementation of a smart factory system, fully integrated with a next-generation information technology (IT) platform.

We are working with Ramco to build a fully dedicated IT system for our technical operations. Beneath it, we will develop a layered IT infrastructure to enable smart factory functionality at the shop floor level. Key features of this smart factory integration will include:

- Automated warehouse systems linked directly with production execution.
- Automated guided vehicles for transporting parts and tools.
- Radio-frequency identification real-time tracking for part location, job progress and traceability.
- Big data analytics to improve planning and performance.
- Environmental, social and governance management tools to optimize energy use, environmental protection and workplace safety.

This facility is being built from the ground up with digitalization and automation at its core, positioning us at the forefront of the industry’s digital transformation. 🌐

Tracking's Time

Is parts integrity finally having its moment?



Digitizing maintenance and other aircraft records would help streamline MRO visits and transactions, such as lease transfers.

CHRIS RANK/AIRBUS

SEAN BRODERICK WASHINGTON

Years from now, when seamless digital record transfers are as routine as clouds in the sky, many will cite the AOG Technics fraud in 2023 as the event that sparked a fundamental shift in how aviation keeps tabs on aircraft assets.

They will be right—sort of.

AOG Technics, a London-based company that passed off thousands of engine parts with fake documentation over several years, did not teach aviation supply chain stakeholders that simplistic records falsification is a risk (*Inside MRO* November 2023, p. MRO20). Nor were aircraft parts specialists caught off guard that their business, like most others, attracts criminals who exploit opportunities.

Rather, the hard lessons are that gaps in the asset exchange process are wide enough to permit a simple scheme to ground hundreds of aircraft and prompt a global outcry and steps to ensure it cannot happen again. And while regulators spread the word when fraud is suspected and promote initiatives such as accredited vendor programs, there is little they can do to prevent criminals from seeking opportunity.

“This is something that has happened in the past, but not on this scale or safety risk level,” GA Telesis Digital Innovation Group President Jason Reed tells *Inside MRO*. “That was the differentiator.”

Industry has responded in two ways.

The most visible action was the formation of the Aviation Supply Chain Integrity Coalition (ASCIC) to study how un-

authorized parts enter the supply chain—and how to stop them. The group's October 2024 final report is proving to be just the start of its efforts (page MRO18).

But behind the scenes, companies are accelerating asset tracking and tracing modernization initiatives that have been in the works for a decade or more in some cases. Crucially, and thanks in large part to the AOG Technics saga's magnitude, manufacturers and aircraft operators—the key stakeholders at each end of the supply chain—are finally showing levels of interest that justify development efforts.

“Data transfer, blockchain, moving away from paper but still providing the level of confidence that paper brings—these were all being discussed,” Aviation Suppliers Association President Michele Dickstein says. “But now they're being embraced on a much larger scale, and I feel that we may see many of these ideas come to fruition.”

The shifting landscape has prompted GA Telesis to go all in on an ambitious idea it had been considering for nearly a decade. The aftermarket services specialist publicly announced plans to develop a parts provenance and records (PPR) system at the 2024 Farnborough Airshow. An Ankara, Turkey-based development team began full-time work late last year on the system, called the Worldwide Integrated Lifecycle and Blockchain Unified Registry (Wilbur). A proof of concept was completed in May, Reed says.

The company then used its Flight Solutions group to test the system, populating Wilbur with component data from its Quantum enterprise resource planning (ERP) system.

“All the history, every ounce of engineering and maintenance that's gone on job cards, everything in the history that a part has—it is now in the blockchain,” Reed says. “So now everything that's in GA Telesis' ERP system—hundreds of thousands of parts sitting in [our facilities]—they all now have a digital twin in Wilbur. We haven't rolled it out

to the world, of course, but we created the proof of concept with the digital twin.”

The next step is reporting and mapping other GA Telesis business processes and integrating them into Wilbur. “We’ve finished the whole reporting process,” Reed says. “We’re mapping it all into the blockchain right now.”

If all goes as planned, a minimum viable product version of Wilbur will be ready by year-end. The company then plans to round out the system’s capabilities by working with airlines and lessors to integrate their processes. Eight large airlines have asked to participate in the pilot program, and top-tier manufacturers are showing interest as well, Reed says.

“We will start working with some airlines to pilot, mapping their entire process on the flight line, in their [maintenance hangars and so on], throughout the rest of the year,” he adds. If all goes well, Wilbur could go live for external use in 2026. “We are rolling on quite quickly,” Reed says.

The concept behind Wilbur is both simple and ambitious. Every aircraft part has a non-fungible token (NFT), or digital twin. At birth, when it is created, the NFT contains manufacturing specifics, such as part and serial numbers, as well as the information found on an FAA 8130-3 or other approved airworthiness review certificate (ARC). As the part moves through its service life, every event—bills of material, maintenance records, service bulletins—is fed to the digital twin.

The result is a digitized version of paperwork for every part. Full articles, such as individual airframes and engines, have their own digital twins that include compilations of each part’s unique NFT. When assets change hands, the digital twin—and not boxes full of paper records or digital folders stuffed with PDFs—goes with them.

GA Telesis first broached the idea of building what it considers a Web3-based PPR system about 10 years ago, Reed says. In GA Telesis’ view, Web3’s blockchain-based protocols and user-owned data are a beneficial shift from Web2’s standards, where data control and ownership are more centralized.

Wilbur aligns with several of ASCIC’s recommendations, including long-term targets of developing a database of parts with back-to-birth records and more effective parts traceability systems. The benefits to industry include less fraud and more seamless transactions.

“Our No. 1 priority is safety and security in the industry,” Reed says. “That is the prime reason Wilbur was developed. Secondary to that, there is going to be an amount of efficiency that customers will gain from this.”

Others are on a similar path.

SkyThread has developed a blockchain-based system to track transactions at the part level. The company’s “4P” utility layer captures data in four general categories: planes, parts, people and places.

Digital twin records start with a part’s basic information. For new parts, that includes the part number, serial number, manufacture date and Commercial and Government Entity code. For parts already flying, operators’ systems provide additional data, such as installation dates and exact aircraft or engine serial number.

Such transactions as sales and repairs are added to the record, and stakeholders—an operator that purchases the part after it has been used and returned to airworthy condition, for example—can validate information.

“You have to bound the problem,” SkyThread co-founder and Chief Strategy Officer Chuck Marx says. “Pillar 1: Make

the part. Pillar 2: Fly the part. And you must know the status and condition of every part flying today and the authentication of that part when it was manufactured. It’s as simple as that.”

Launched in September 2022, SkyThread has several customers. AFI KLM E&M and Parker Aerospace announced in the fall of 2024 that the airline engineering company would use SkyThread to track and trace Parker-made Boeing 787 spare parts.

Parker now populates SkyThread as parts are made, but it input a bunch of existing records as well. AFI KLM will have access to the information and update it as parts are installed and repaired.

Concern about data permission—specifically a part’s status visibility to others that may access the blockchain—has slowed the project, however. SkyThread and Parker are developing revised permissions to address that.

DATA DIFFICULTIES

The SkyThread-Parker-AFI KLM collaboration serves as a cautionary tale for PPR developers. Obtaining data will be challenging unless all stakeholders are confident that their information is both secure and visible only to those that need it. But it also underscores the benefits that tracking and tracing bring to the top of the supply chain.

Aircraft and engine manufacturers collect and share reams of data on their products through health monitoring programs. Knowing a component failed is not the same as knowing why it failed, though. For suppliers such as Parker, part-level data combined with aircraft- or engine-level information is critical to understanding the product life cycle and how to improve it.



Capturing every event a part goes through, from installation to retirement, is the key to ensuring reliable traceability.

“In the parts track-and-trace world, the answers that we’re looking for live outside the four walls of our organization,” says Jeff Smith, head of digital product programs at Parker Aerospace. “That means I’ve got to work in collaboration with the people that have the part when it’s not in my possession to be able to fill in some understanding about it.”

As a supplier to nearly every major aircraft program, Parker’s de facto customer base of end users is large. Data from any of them bolsters product support efforts, but creating a digital connection with all of them is impractical. SkyThread and similar efforts fill the gap by providing not only a purpose-built platform, but also an independent steward.

LANDSAU BIERREARD/AVIATION WEEK NETWORK

“It makes no sense for me to go through and have intimate data integrations with 140 operators. That’s just not going to be feasible,” Smith says. “Why would they share that with me and not with others? Having a third-party

actor in this equation to be [an] intermediary . . . place to store this data” is more prudent, he adds.

Parker’s SkyThread-backed track-and-trace system is playing a key role in helping CFM International proactively manage a Leap product durability issue. Parker and GE Aerospace, a 50-50 partner in CFM alongside Safran, manufacture Leap fuel nozzles under their Advanced Atomization Technologies (AAT) partnership. The Leap nozzles have shown to be prone to accumulating hardened fuel deposits, or coking, under certain operating conditions.

Redesigned fuel nozzles and installation of a new reverse bleed system component will address the issue long-term. But until engines are upgraded, they are prone to needing fuel nozzle swaps at irregular intervals, depending on operating conditions and other factors. By leveraging its track-and-trace operation alongside GE Aerospace’s vast data-gathering capability under the umbrella of their AAT collaboration, Parker can collect precise in-service details and help operators avoid unexpected downtime.

In a perfect world, Parker would obtain not just a part’s most recent status, such as hours and cycles, but valuable insight like on which engine it was installed and the exact position. The usage data helps Parker build and refine models that help operators avoid surprise interruptions by telling them when nozzles will need to be swapped.

When operators do not exchange part data, the ramifications often go beyond not having detailed insights. Smith says his team of four dedicated to the Leap program average a combined 11 hr. per day just tracking down in-service data—copies of ARCs, nonincident reports, hours and cycles information—required to begin work on a part.

“If I don’t have that, I can’t start the MRO process, so [the part] is in quarantine,” he says. “I have hundreds of nozzles sitting on a dock somewhere that I can’t do anything with because I have to go chase this information from operators.”

The issue contributes to aftermarket supply chain bottlenecks, including extended turnaround times about which operators are quick to complain. “If you want me to improve my turnaround time, share this data with me,” Smith says. “I can have these nozzles move through the system faster. That means I have to have less product set aside in quarantine, and I can move them quicker to you.”

Rolls-Royce has seen the light—and is sharing it with its customers. The engine OEM has used software from QOCO since 2018 as part of its IntelligentEngine digitization initiative. Finland-based QOCO’s software specializes in centralized data-exchange and integration among operators, MRO providers and manufacturers. Its Aviadex.io service moves data among the three groups, giving each stakeholder insights into engine performance, maintenance needs and other important variables.

German airline Condor used Aviadex.io to automate engine data transfer, starting with its Rolls-Royce Trent 7000-powered Airbus A330neo fleet in May 2023. QOCO’s process replaced Condor’s manual email-and-PDF workflow to move information between the carrier’s AMOS maintenance software and Rolls, which uses the data to help direct customer support.

DIVING INTO RECORDS

The Condor example highlights the scale of the challenges in digitization and data-exchange. Before working with information technology (IT) departments to connect ERPs

STANDARD AERO VIA ASCC

1. Approving Civil Aviation Authority/Country Transport Canada		2. AUTHORIZED RELEASE CER FORM ONE	
3. Organization name and address  STANDARD AERO LIMITED 33 ALLEN DYNE ROAD WINNIPEG, MANITOBA, CANADA, R3H 1A1 AMO 22-58			
4. Item 01	7. Description BLADE,FAN	8. Part No. 6018T30P06	
12. Remarks TSN: 9453.6 TSO: 0.0 CSN: 12760 CSO: 0 ATA 72-21-00 The product identified has been overhauled in accordance with GE Manual SEI-756 Rev.61 dated 01 February, 2017 and the current maintenance rules of the Canadian Aviation Regulations. The product is approved for return to service in compliance with TCCA CAR 571, and EASA Acceptance Certificate number EASA.145.7059. All pertinent details of the work performed are on file at this Organization under work order No. (TCN) YY100240. MOMENT WEIGHT: 15227 G-INCHES			
1. Approving Civil Aviation Authority/Country Transport Canada		2. AUTHORIZED RELEASE CER FORM ONE	
4. Organization name and address  STANDARD AERO LIMITED 33 ALLEN DYNE ROAD WINNIPEG, MANITOBA, CANADA, R3H 1A1 AMO 22-58			
6. Item 01	7. Description PROPELLER	8. Part No. S15500-3	
12. Remarks TSN: 9453.6 TSO: 0.0 CSN: 12760 CSO: 0 ATA 61-13-12 The product identified has been overhauled in accordance with current maintenance rules of the Canadian Aviation Regulations. The product is approved for return to service in compliance with TCCA CAR 571, and EASA Acceptance Certificate number EASA.145.7059. All pertinent details of the work performed are on files at this Organisation under work No. (TCN) YY100240.			

A valid StandardAero ARC (top) for an overhaul fan blade notes the specific OEM repair manual referenced when performing the work. On the same ARC falsified (bottom) that was created to go with a propeller that StandardAero did not service, the repair manual reference was replaced with generic language.

STANDARD AERO VIA ASCC

14a. ☒ CAR 571.10 Maintenance release. ☒ Other regulations specified in block 12. Certifies that, except where otherwise specified in block 12, the described in block 12 was performed in accordance with Canadian Aviation Regulations.	
14b. Signature 	14c. Approved
14a. ☒ CAR 571.10 Maintenance release. ☒ Other regulations specified in block 12. Certifies that, except where otherwise specified in block 12, the work identified in block 12 was performed in accordance with Canadian Aviation Regulations.	
14b. Signature 	14c. Approved

The falsified ARC’s signature block (top) used a scan taken from the original StandardAero form (bottom). But the falsified signature’s color on the forged ARC did not match the color of the original.

to external databases or hashing out access permissions, digital records management vendors need the basics: aircraft, engine and part data in a secure, digital form. And too often these days, that work starts with PDFs, spreadsheets or even paper.

"Any time we need full traceability of material, where are you going to get it? It's in documents," says James Boccarossa, founder and CEO of ProvenAir Technologies. "That's where it sits." Boccarossa came to aviation in 2014, joining landing gear material provider Air Spares Unlimited after two decades in tech and software development. He was not prepared for the technological step-down that came with his career change.

Despite aviation's strict regulations and need to back high-dollar asset transactions with detailed records, it relied heavily on simple spreadsheets—or worse, boxes of paper documents. Human error—mistyped serial numbers and cycle counts, for example—was common. Validating records as part of asset sales or lease transfers means "box diving" through paper records, scanning documents and reviewing spreadsheets for perhaps days at a time, Boccarossa says. Often, third-party consultants are hired, adding more humans—and more risk.

"We're talking about assets that might be worth millions of dollars, and their records are just getting emailed around or stored in the same cloud-based services where you keep wedding photos? That's crazy to me," he says.

Boccarossa shifted his focus from running one aviation company to addressing an industry-wide problem. He spear-



Parts awaiting shipment or service often sit idle awaiting validation of records—many of them still on paper.

headed development of what he calls an "ingestion engine" with two primary functions. It needed to handle as many document formats as possible and use a proprietary algorithm to organize them and flag possible anomalies. Issues such as different serial numbers on service records for the same part, or a cycle count progression that jumps by a factor of 10, needed to be pointed out for human review.

"Granted, most of the time it's a typo," Boccarossa says. "But I've never read a quality manual that says it's OK to have typos in a few serial numbers." His creation spawned

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ProvenAir, founded in 2018. The company has about 30 customers, including large airlines and MRO providers.

Most of ProvenAir's customer use cases revolve around asset transactions. One U.S. major airline selling off engines from a retired aircraft fleet turned to the company when would-be buyers repeatedly flagged possible records issues and demanded financial concessions to close deals. The carrier loaded records for every engine into ProvenAir, which both flags issues to rectify before a sale and provides an organized set of digitized documents to include in each deal.

INDUSTRY COOPERATION

While ProvenAir and other vendors work to drive digitization one customer at a time, a small informal working group is tackling a project with broader ramifications. Prompted by the AOG Technics case and backed by ASCIC, the group is developing a standardized electronic ARC (e-ARC).

The working group includes Boeing, one of its largest airline customers, and a digital materials transaction platform provider. Its goal: Take the same ARC that has been an industry staple for nearly 50 years and improve its data quality and security.

"There is this desire in the industry to increase the amount of information that's moving with a product, whether it's an airplane or a component," Mark Yerger, an MDY Services principal and former FedEx senior vice president of technical operations, said on a digitization webinar hosted late last year by the International Society of Transport Aircraft Trading. "We want to try to make that easier



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to manage, not harder to manage. And I think this system gives us a really good start on how to do that."

The e-ARC contains the same data as the current 8130-3 and similar forms. But it captures and stores additional information, such as when and where repairs were made, and other relevant notes.

"As an engineer, I've always wanted to . . . get more granular in those blocks about what happened in repair or what happened in manufacturing," said Yerger, who is supporting the working group. "The rest of the players on the team have agreed that we've got to get better configuration [data], better repair history, better reliability information. So this new form

Leading From the Front

Aviation Supply Chain Integrity Coalition works to help implement its recommendations

SEAN BRODERICK WASHINGTON



SEAN BRODERICK/AVIATION WEEK NETWORK

Aviation office bookshelves are stacked with issue-specific reports developed by groups of industry experts and anchored by recommendations about how to make meaningful improvements. In most

cases, the final product comes out, and the experts move on, leaving others to tackle the recommendations—and the reports to gather dust.

The Aviation Supply Chain Integrity Coalition (ASCIC) is taking an

active role to ensure its final report stays dust-free and, more important, becomes the playbook for both short- and long-term change.

Issued in October 2024, ASCIC's final report concludes with 13 recommendations broken into three categories: vendor accreditation, document traceability and nonserialized parts traceability. The recommendations are also split into three timelines: short-, medium- and long-term.

Both Boeing and Airbus are part of the supply chain integrity coalition, which aims to change how parts are tracked from the production line to the boneyard.

Nearly one year after the report's issuance, industry has made considerable progress on short-term tasks and even a few medium-term ones.

"Site visits, webinars on best practices and meetings have been a few of the activities during 2025," ASCIC said in a statement. "The coalition will issue a progress update this fall, including specific implementation initiatives by members and industry."

and format has a container for all of that useful information, where today it says a repair is on file at a certain location.”

Two of ASCIC’s recommendations mention e-ARCs specifically, and several others are related. The coalition’s one-year update planned for this fall is expected to include details on the e-ARC working group’s efforts.

The working group’s goal is to create an e-ARC with no technological barriers, such as IT requirements, that would shut out smaller vendors and stakeholders. The coalition’s recommendations include other initiatives aimed at companies of all sizes. Among them is developing and improving industry training programs.

During a mid-August ASCIC webinar, Brent Ostermann, StandardAero’s vice president of product assurance and quality, shared the framework for the company’s comprehensive training for employees who receive parts. The four-day course helps standardize receiving and quality inspection protocols for its 500 receiving clerks and 350 quality inspectors, plus some quality managers and installers across 50 sites, Ostermann said.

StandardAero’s parts-receiving procedures differ based on the material’s source. New OEM parts are handled one way, and others—used serviceable material, parts manufacturer approval parts—have their own protocols. The manual process is backed by checks and balances, such as a database with an approved vendor list. But its role in preventing unauthorized parts from getting on aircraft is indispensable.

The AOG Technics scam was exposed when a TAP Air Portugal mechanic sensed something was off with a part that its paperwork indicated was new. It turned out to be a

used part that, like thousands of others, was passed off as new by the vendor with falsified records—scanned ARCs that were altered using nothing more than a laptop and some image-editing skills.

Ostermann shared a similar example from StandardAero’s network. A French parts buyer purchased a propeller from a UK-based broker. A quality manager from the French company, which, like StandardAero, has a mandatory quality training program, handled the propeller. The manager knew StandardAero serviced propellers but was not sure about this particular model. The French vendor contacted StandardAero’s corporate quality team.

“We determined that the [ARC] for the propeller was falsified,” Ostermann said. “It was a part that’s not on our capabilities list.” The part came with a falsified Transport Canada Form 1 seemingly issued by StandardAero. But a close inspection found several anomalies. The fake form lacked a repair or overhaul manual reference, and the work order number did not match StandardAero’s protocol. The part number is not on the company’s capabilities list, and the signature was in a different color than is usual. Someone had taken a valid StandardAero ARC for a GE Aerospace CF34 fan blade and modified it to appear as if it went with the propeller.

“With a little bit of awareness and a little bit of education, we were able to avoid this one,” Ostermann said. “The original [ARC] was easily falsified in four different blocks, . . . and not all changes were easy to identify to the untrained eye. Having an educated and knowledgeable . . . staff [and] network of suppliers was very important to this situation.”

RECOMMENDED ACTIONS

RECOMMENDED ACTIONS		
SHORT TERM	MEDIUM TERM	LONG TERM
Promote industry use of suppliers that meet FAA and EASA standards	Establish industry oversight body of accreditation organizations	Establish database of accredited vendors to verify identities and quality management standards
Establish feedback loop between parts installers and accreditors		
Document Traceability and Verification		
Expand use of digital authorized release certificates (ARC) and increase the use of digital authorization tools	Establish industry-standard documentation requirements to ensure consistency across the industry	Establish voluntary industry database of back-to-birth parts documentation
	Digitize existing and past parts-related documents	
	Develop and adopt industry-wide use of software database to verify key ARC fields	
Nonserialized Parts Traceability		
Further strengthen training materials, programs and best practices	Improve real-time data sharing to identify unapproved parts	Development of new technological solutions to improve parts traceability
Verification and auditing of scrap materials and recycling vendors		

Source: Aviation Supply Chain Integrity Coalition

While the coalition is waiting for its one-year update to expand on industry accomplishments, some details have emerged (page MRO14).

StandardAero in mid-August shared its rigorous “Check for Acceptance” training program, mandatory for any-

one receiving parts. The webinar supported ASCIC’s short-term recommendation to improve training and best practices, particularly among smaller vendors that may not have established training programs.

Boeing is working with a major op-

erator and a digital information exchange specialist to develop electronic versions of authorized release certificates (e-ARC), including 8130-3s and Form 1s, that capture more data and are encrypted. While the e-ARC concept is not new, the 2023 AOG Technics scandal, in which a fraudulent parts broker sold thousands of parts backed by falsified ARCs, has accelerated its development (*Inside MRO* November 2023, p. MRO20).

ASCIC, formed in response to the saga that brought global attention to parts tracking and validation shortcomings that are all too familiar to aviation stakeholders, also is growing (*Inside MRO* April 2024, p. MRO20). The group’s one-year progress report is expected to confirm

at least four new members, including one large U.S. airline and a supplier-focused trade association. They will join founding members from Airbus, American Airlines, Boeing, Delta Air Lines, GE Aerospace, Safran, StandardAero and United Airlines.

Rising With the Tide

ST Engineering continues its growth trajectory despite ongoing tariff uncertainties

CHEN CHUANREN SINGAPORE

With a footprint that spans Singapore, China, Vietnam, the U.S. and Europe, ST Engineering boasts one of the largest MRO networks worldwide, logging more airframe maintenance labor hours than any other provider. But the introduction of tariffs under the Trump administration's "Liberation Day" trade measures has added new layers of complexity to an already disrupted industry grappling with war, sanctions and inflation.

ers—a segment that requires fewer imported materials compared with engine and component work.

Although ST Engineering considered relocating aircraft to less affected jurisdictions early on, Lam explains that such moves could have complicated reexportation, especially when authorities require verification of U.S.-sourced parts.

"Unfortunately, the best way is to swallow the tariffs—and the costs will then be passed down to the paying

84,000-m² (904,000-ft.²) airframe maintenance facility at Singapore Changi Airport. The site is being built in anticipation of the closure of Paya Lebar Air Base, where ST Engineering is headquartered.

Lam says the company will aim to retain its capacity in Singapore, a location highly desired by some customers that seek quality, reliability and time savings.

Despite identifying India as a fast-growing market, ST Engineering has no immediate plans to establish a footprint there. The company supports such Indian carriers as Akasa Air through its facilities in Singapore and China.

"I think the Indian civil aviation ministry is very progressive, but of course, they are dealing with a very challenged market—infrastructurally and policy-wise," Lam says. "To establish a footprint in India requires sufficient workload to support the infrastructure investment. So that's something we're actively considering all the time—and when the timing is right."

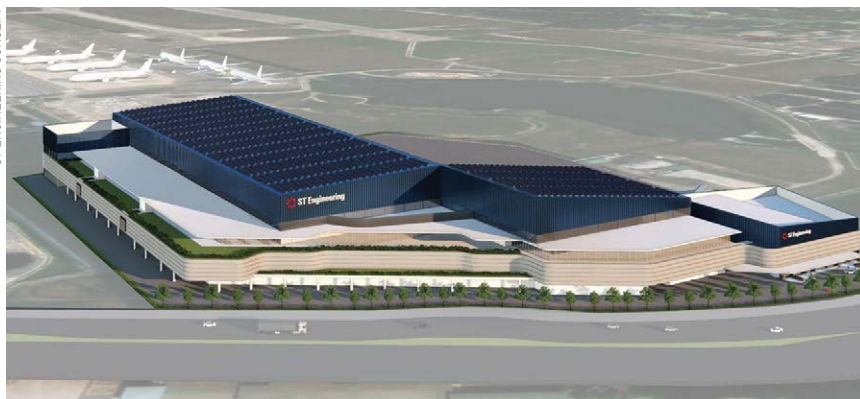
ST Engineering is building a new airframe maintenance facility at Singapore Changi Airport.

On the passenger-to-freighter side, Lam acknowledges that the pace of Airbus A321 conversions has slowed, driven by a lack of available feedstock. This shortage stems from delays in new aircraft deliveries, which in turn delay retirements.

Still, ST Engineering continues to explore new programs and ventures. Most recently, its Middle River Aerostructure Systems was selected in July to design and manufacture the exhaust nozzle for JetZero's Z4 full-scale blended wing body demonstrator.

ST Engineering is also prioritizing workforce and technology investments. "Whether times are good or bad, attracting and retaining a skilled, educated workforce remains crucial," he says. "The application of [artificial intelligence] digital tools would obviously augment the [labor] side but also provide an avenue to increase efficiency, raise quality and improve productivity."

Lam says adding AI tools will enable ST Engineering to deliver smarter equipment and improve engagement with customers as well through enhanced data processes. ☛



"The aerospace industry is very resilient, very robust," Jeffrey Lam, president of commercial aerospace at ST Engineering, tells *Inside MRO*. "But when you have so many events happening at once, it really took a hit on the market. It affected everybody—from airlines' access to spare parts, if available and at higher cost, to OEM supply chains. And then it impacted MRO, because sourcing costs have the risk of increasing overnight."

Lam notes that one facility in Asia had to suspend operations temporarily as both ST Engineering and its airline customer grappled with uncertainty over tariff applicability. While operators sought clarity, many turned to their own spares pools to maintain continuity.

Operations in the U.S. were less affected, Lam says, since ST Engineering's facilities there primarily handle airframe maintenance for U.S. carriers—

customers," Lam says. The company has reached cost-sharing agreements with some airline customers and continues to negotiate with others across various programs.

Lam expects costs across the supply chain to continue rising, although the effects of inflation and tariffs are becoming increasingly difficult to distinguish.

As part of its long-term growth strategy, ST Engineering is constructing a third hangar at its facility in Pensacola, Florida, which will feature two widebody bays and bring the site's total to four hangars upon completion. The company is also consolidating U.S. operations by transferring heavy maintenance, modifications and engineering services at VT Mobile Aerospace Engineering in Mobile, Alabama, to Pensacola and San Antonio.

Looking beyond the 2030s, ST Engineering is constructing a new

Shifting Priorities

Airlines across Africa are investing in newer fleets, and their MRO arms are boosting capabilities in preparation

KEITH MWANALUSHI LONDON

As African carriers invest in next-generation aircraft, the continent's MRO market stands on the cusp of change. Modern fleets promise efficiency gains, but they also bring fresh challenges and new opportunities for the maintenance sector.

number for the type to 16. Air Algerie placed an order for 16 new ATR 72-600s in July—the largest ATR order ever made in Africa; deliveries are scheduled for 2026-28. TAAG Angola Airlines continues to take deliveries of new Boeing 787s and Airbus A220s to

ing and cost," Fathy says, noting that it helps minimize reliance on external service providers for routine and many nonroutine maintenance activities.

At the unit and workshop level, EgyptAir M&E is enhancing its in-house maintenance capabilities through targeted investments in tooling, advanced technologies and personnel training. These efforts may also include expanding physical infrastructure to support future growth, he says. "Our goal is to increase the scope and complexity of the maintenance tasks we can perform internally, thereby enhancing our self-sufficiency and operational efficiency across all levels of

African carriers, such as TAAG Angola Airlines, are taking on new fleets and revising their maintenance strategies to support them.



TAAG ANGOLA AIRLINES

Africa's airlines have long relied on aging aircraft cast off by other markets, a consequence of stubborn industry hurdles: high operating costs, scarce financing, weak aviation infrastructure and passenger bases with limited financial means to fly.

Change, however, is in the air. As mostly Chinese-backed infrastructure projects reshape airports and routes and a young, increasingly aspirational population is eager to travel, the continent's aviation market is entering a new phase—one that could finally break the cycle of secondhand fleets.

Recent orderbooks and delivery trends show that several African operators are making the leap to newer-generation aircraft. In June, EgyptAir announced an order for six additional Airbus A350-900s as part of its expansion strategy, bringing its total

replace its older fleet. Airlink in South Africa has also just finalized a lease for 10 new Embraer 195-E2s for its long-term requirements.

FLEETS IN TRANSITION

EgyptAir will primarily rely on its in-house maintenance capabilities to ensure the airworthiness and operational readiness of its new A350 fleet, says engineer Ibrahim Fathy, chairman and CEO at the airline's MRO arm, EgyptAir Maintenance and Engineering (M&E). The capabilities that support this strategy include state-of-the-art facilities, experienced technicians, comprehensive warehouses and specialized equipment to perform a wide range of maintenance tasks directly, he says.

"This approach allows us to maintain tight control over quality, sched-

our maintenance operations," he says.

TAAG Angola Airlines is planning to support its incoming fleet of 787s and A220s in two integrated steps. The initial focus is on strengthening internal training programs to ensure that the team can independently manage routine maintenance tasks, including line maintenance, troubleshooting, defect rectification and A checks.

Under its partnership programs with Airbus, Boeing and lessors, TAAG is carrying out intensive training for its technical team. It has already certified technicians for both fleets, enabling the airline to operate the new aircraft types. "The second step, which is also in progress, will be to ensure that our technicians and maintenance processes are certified for base maintenance [C checks] in the midterm," says João Semedo, the

EgyptAir is progressing through its service-entry program for the Airbus A350-900.

AIRBUS



airline's chief maintenance and engineering officer.

Additionally, TAAG is banking on the new hangars and support workshops under construction at the recently opened António Agostinho Neto International Airport in Angola's capital, Luanda. Reportedly, the new surrounding buildings are already in partial use by the local maintenance and engineering directorate.

Managing the complexity inherent in the simultaneous entry into service of two new fleets—in addition to the transition to a new airport—has created several technical, financial, commercial and operational challenges for TAAG. "It's not easy to identify one particular MRO-related lesson, because it's a highly complex process that spans all areas of the company and has demanded a lot from everyone," Semedo says.

However, he acknowledges that managing finite and scarce human resources might be the most significant lesson TAAG is drawing from this complex challenge. This effort encompasses coordinating training schedules, maintaining shift coverage to prevent disruptions across two airports located 50 km (31 mi.) apart and addressing the logistical demands inherent in such operations.

RELIANCE ON OEM SUPPORT

The Airbus A330neo has gained notable traction among African carriers; Air Mauritius, Air Senegal and Uganda Airlines are already operating

the type. Air Cote d'Ivoire has ordered two A330-900neos—one of which has reportedly completed its first flight in Toulouse. Air Algerie has also placed an order to replace its current fleet of A330-200s, further demonstrating the aircraft's appeal across the continent for long-haul expansion and fleet renewal strategies.

Due to ongoing technological improvements and a deep understanding of its design, the A330's maintenance costs have consistently decreased. A330neos delivered in 2020 already offered a 20% lower airframe direct maintenance cost compared with earlier models, according to Airbus. The A330neo reduces these costs by an additional 5%, achieved through extended maintenance intervals, introduction of new components, such as improved bleed systems, sharklets and a redesigned pylon and center wingbox as well as fewer fatigue-related tasks.

Although African carriers have not disclosed specific maintenance savings, the OEM says industry feedback indicates the A330neo's design advantages are translating into measurable cost reductions.

Meanwhile, ATR says its African fleet of about 110 aircraft plays a "central role in connecting communities" across the continent, but supporting those turboprops from an MRO perspective poses unique challenges. Unlike long-haul aircraft that can cycle through major hubs between flights, ATRs often operate between second-

ary and tertiary cities, requiring operators to ferry aircraft outside their networks for heavy maintenance.

That gap is narrowing as the continent builds more regional MRO capacity, with hubs now established in Algeria, Ethiopia, Mauritius, Morocco, South Africa and Tanzania. ATR's support strategy combines logistical and technical channels, including the dispatch of tools and equipment from its Paris hub, tailored consulting and the deployment of Regional Field Service Representatives (FSR). These FSRs, ATR says, are "the primary technical point of contact" and deliver hands-on assistance to keep dispatch reliability high, even in infrastructure-limited regions.

With fresh ATR deliveries on the horizon—including the 16 ATR 72-600s for Air Algerie, a recent arrival for Afrijet/FlyGabon and the first ATR in the Kenyan market for Renegade Air—ATR is confident that MRO capabilities will scale accordingly. "The demand for infrastructure will continue to grow," the manufacturer says, "and the necessary capabilities will follow to sustain these expanding fleets."

EgyptAir is currently progressing through its entry-in-service (EIS) program for the A350-900; the first aircraft is scheduled for delivery in December.

Meanwhile, EgyptAir M&E's push to develop strong in-house maintenance capabilities has been met with mixed levels of support from OEMs. Fathy reports that some OEMs have provided the necessary assistance, offering technical guidance, specialized training and access to proprietary tools and documentation. This collaborative approach has been instrumental in helping the Egyptian MRO build and certify its internal maintenance processes for certain aircraft types and components.

"Their willingness to share expertise and resources has significantly accelerated our progress in achieving self-sufficiency," he says. However, he notes that other OEMs do not offer capability access to third parties—which, in this context, refers to operators seeking to develop in-house capabilities rather than relying solely on their authorized service centers. "This stance can present challenges, as it may limit our ability to perform certain complex repairs or overhauls internally, requiring us to continue



TURKISH TECHNIC

MRO THAN EVER



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AOG SERVICES | LANDING GEAR SERVICES | TEAR DOWN SERVICES



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outsourcing these tasks,” he stresses.

EgyptAir M&E says it continues to engage with all OEMs to explore opportunities for greater collaboration and access to the resources required to expand its in-house capabilities across the entire fleet.

TAAG currently benefits from comprehensive support under OEM EIS programs, but in the medium- to long-term,

FlyGabon has taken delivery of a factory-new ATR42-600 while transitioning from the ATR42-500 series.

the airline is preparing to take on the broadest possible scope of maintenance in-house. Semedo notes that for major components and highly complex rotables, such as engines and auxiliary power units, TAAG will continue to rely on strategic “pool parts agreements” with OEMs and other providers.

SPARES AND LOGISTICS ISSUES

Spare parts availability and cost are a key concern in Africa. Semedo notes that the logistics and supply chain issues that have affected the industry globally are more acute in Africa. TAAG aims to maintain a balanced yet robust spare parts inventory while preserving pool and by-the-hour agreements for supply and recovery. He adds that the airline has made a substantial financial commitment to initial provisioning, closely following each manufacturer’s guidelines, par-

ticularly their recommended spare parts lists.

Meanwhile, EgyptAir M&E’s membership in the International Airlines Technical Pool reflects its commitment to collaborative operational

ATR recommends that operators keep a dedicated stock on-site. This proactive measure helps minimize the risk of prolonged AOG events, especially in remote or infrastructure-limited locations.



TRUENOORD

support, giving it access to a wider pool of technical expertise and spare parts—an advantage during unexpected maintenance events, even for aircraft types it does not operate but might service through codeshares or industry partnerships.

To minimize aircraft on ground (AOG) events and optimize parts distribution, ATR has established an around-the-clock spare parts delivery system. According to ATR, it is committed to providing an initial response within 45 min. and to preparing the shipment for pickup within 4 hr. from its logistics hub in Paris.

For mission-critical components,

Even in Africa’s more infrastructure-limited regions, Airbus takes a multipronged support approach, says Joep Ellers, the OEM’s airline marketing director for Africa. This strategy includes deploying FSRs to provide on-site technical expertise, offering robust component support and delivering flexible flight-hour contracts that guarantee spare parts availability along with engineering and repair services. “Furthermore, Airbus actively engages in MRO coordination to help airlines establish and enhance their maintenance capabilities, working with local partners where possible,” he adds. 🛩

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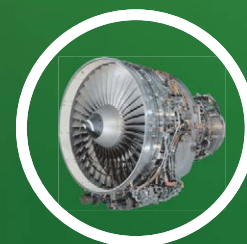
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Hiring Drive

India's aviation regulator hopes to boost its staff numbers to ensure continued readiness

SWAATI KETKAR MUMBAI

India's Directorate General of Civil Aviation is operating with nearly 55% of its technical positions vacant, posing considerable challenges to managing regulatory oversight demands amid rapidly growing air traffic and airline operations.

In response, Indian authorities have announced plans to recruit 190 personnel to fill key vacancies within the Directorate General of Civil Aviation (DGCA). These are primarily positions to be filled by technical experts responsible for critical tasks, such as airworthiness oversight, flight inspections, aircraft incident follow-up and safety audits. Recruitment for these roles, however, is proving to be challenging due to the

highly specialized qualification requirements.

During a session of India's lower house of Parliament, DGCA officials clarified that, although the staffing shortfall is substantial, many of the positions were only recently added, and the recruitment process is ongoing. The agency says it is exercising considerable diligence in sourcing candidates, particularly for roles that affect passenger safety and require deep expertise in aircraft systems, regulatory protocols and risk management.

Despite the staffing shortage, the DGCA continues to conduct regular inspections and has mechanisms in place for real-time and unannounced checks, including spot audits, night

surveillance operations and stringent post-incident protocols. If an inflight malfunction is reported, the DGCA follows standard global procedures guided by airframers, such as Boeing and Airbus, with additional regulatory scrutiny layered in before an aircraft is cleared for further operation, according to the agency.

The DGCA says these safety and oversight procedures remain robust, even as the volume of operations in India's aviation sector continues to grow at one of the fastest rates globally. Filling workforce gaps will be crucial to ensuring continued regulatory readiness in the face of expanding air traffic and fleets within an increasingly complex maintenance and operational ecosystem.

India's aviation industry, while on a steep growth trajectory, is grappling with a shortage of skilled technical personnel—especially aircraft maintenance engineers (AME), licensed technicians and regulatory compliance experts. The gap is more pronounced in smaller cities, where many new regional airports are being

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developed under India's connectivity plans.

Training infrastructure, certification delays and limited availability of practical on-aircraft experience during AME training have exacerbated the challenge. Many MROs and OEMs operating in India cite difficulty in recruiting certified staff even for entry-level positions, particularly in avionics and composite repair.

The situation mirrors global trends: Post-pandemic recovery has led to increased demand for licensed maintenance technicians and safety inspectors, but the number of qualified professionals has not kept pace. Boeing's latest Pilot and Technician Outlook forecasts demand for 710,000 new maintenance technicians through 2044, 45,000 of whom will be needed in South Asia.

The DGCA's recruitment efforts and other government-led initiatives to

boost aviation education and streamline certification frameworks aim to narrow this gap over the medium term. However, industry experts maintain that building a sustainable techni-

cal workforce in the industry will require coordinated long-term planning, international partnerships in training and stronger links between aviation training schools and MRO providers. 



OMR AERO TECHNIC

Aviation stakeholders in India have been opening more training schools to address a shortage of qualified aircraft maintenance staff.



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High Plateaus

Lessors are weighing how the aftermarket and supply chain factor into engine values

ALEX DERBER LONDON

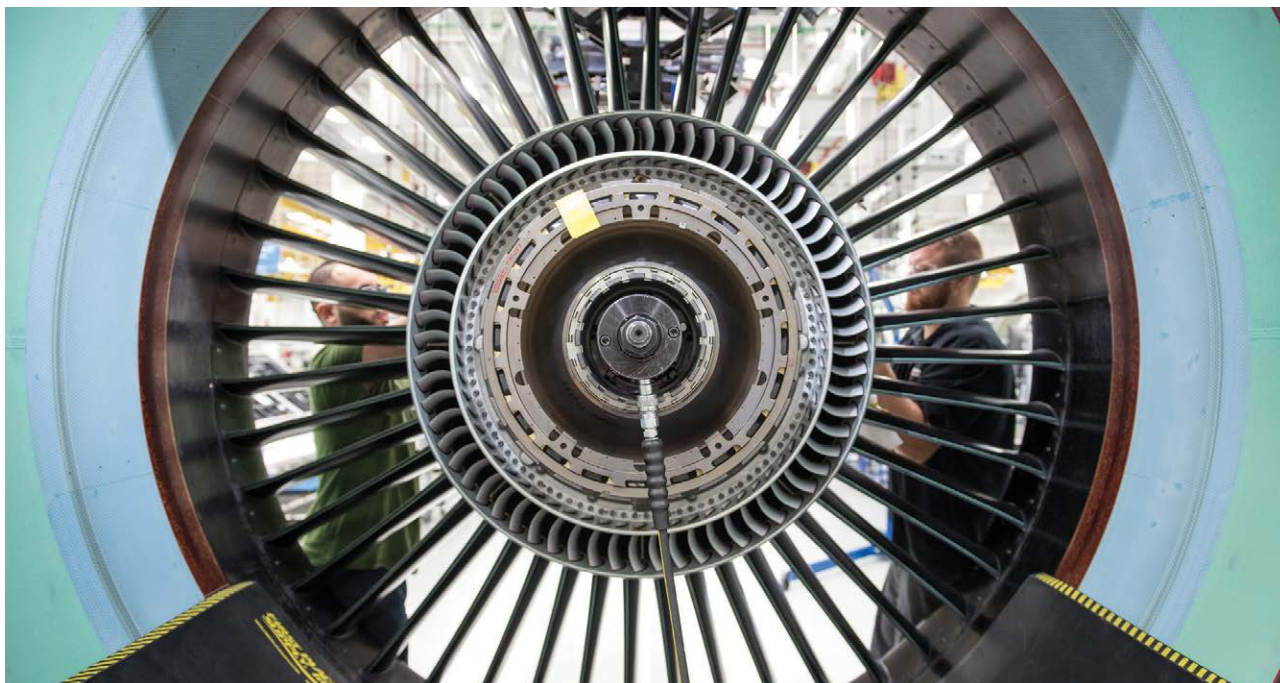
Europe plays a significant role in the global aeroengine market as home to some of the world's biggest OEMs, MROs and lessors. During Aviation Week Network's recent Engine Leasing, Trading and Finance Europe event here, experts predicted inflection

Joe Hussar, head of portfolio at Engine Lease Finance Corp., told *Inside MRO* he expects spare engine rentals to remain at their current high level. "Lease rates overall have stabilized, although there are still areas of further growth with some sectors, such

exclusively comprises new-technology equipment, but the investor is considering assets like the CFM56 and V2500, "given the strength in these markets expected over the next handful of years," Managing Partners Mathew Adamo and Jared Ailstock said.

"Given the current supply-demand dynamics, we see strong demand and valuations holding up for current-generation engines into the early part of the next decade," they told *Inside MRO*. Adamo and Ailstock cited the V2500's strength on the Airbus A321neo and popularity for freighter conversions, plus the CFM56-7B's status as the sole engine on the Boeing 737NG family.

PRATT & WHITNEY



Pratt & Whitney geared turbofan inspections have increased demand for spares and longer operation of older engine types.

points for a market that has delivered sky-high demand for new- and current-generation engines in recent years.

Rolls-Royce & Partners Finance Managing Director Bobby Janagan said that airlines can no longer absorb cost increases from items like leasing, maintenance and interest rates, which leaves little room for further engine lease rate growth.

Willis Lease Finance Chief Commercial Officer Dan Coulcher agreed that lease rates are plateauing "at a high level," but said he has no concerns about demand for current-generation narrowbody engines such as the CFM International CFM56 and International Aero Engines V2500 over the next five years.

as in select widebody types, and the ubiquitous narrowbodies continue to exhibit signs of growth," he said.

Jaisal Kerai, assistant vice president of trading at parts and leasing specialist AerFin, shared that sentiment, asserting that ongoing supply chain challenges in the new-build and maintenance markets will underpin healthy values of popular current-generation assets for some time.

"We don't anticipate a market correction until around 2030, due to the engine backlog, limited MRO slot availability and persistent material supply issues," he told *Inside MRO*.

Kerai's view is popular, even among owners specializing in the latest engines. AIP Capital's engine portfolio

However, some are more cautious about the endurance of current-generation values. Magnetic Leasing CEO Alex Vella warned at Engine Leasing, Trading and Finance (ELTF) Europe that current-generation engines could experience discounting starting in 2028 if the market expects demand to begin to drop off in 2030. He also suggested that the first sign of a downturn could be equilibrium between repair shop capacity and material supply, with no considerable demand-supply imbalance.

In Europe, there are signs that some popular engines may have passed their peak. "V2500 demand in Europe has softened, which may lead to lower monthly lease rates and greater engine

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availability in that region,” Kerai said.

Overall, though, Europe remains “an area of stability” for engine leasing, Hussar said. Approximately 25% of Engine Lease Finance Corp.’s placements this year have been in the region. “We have seen an increase in lease inquiries coming from Asia and the Americas as compared to last year, although the expectation is that Europe will remain an active market with significant opportunities over the next 12-24 months,” he added.

TURNAROUND TIMES

Europe boasts strong engine maintenance capabilities, as many OEM shops as well as airline-affiliated and independent MRO providers offer services from module changes to full overhauls. Like the rest of the world, however, the region has suffered from tight capacity and extended turnaround times resulting from new-generation durability problems, prolonged operation of current-generation equipment and continuing supply chain problems.

AerFin projects that softening V2500 demand in Europe could lead to lower monthly lease rates and greater availability in the region.

“Turnaround times for heavy shop visits remain lengthy—at least 50% longer than pre-COVID levels—provided a slot can be secured,” Kerai said. “Factors such as powder metal issues [on the Pratt & Whitney geared turbofan] and the soft life adjustment of [high-pressure turbine] blades have led to more engines requiring heavy shop visits earlier than expected.”

He also noted that a tendency toward heavier worksopes has pushed some MRO providers to reject hospital visits and other lighter work as they focus labor and resources on heavier events.

This comes as demand rises for lighter worksopes, shorter builds, green-time leasing and module exchanges. John White, vice president of trading at AerFin, noted at ELTF Europe that performance restorations have fallen to about 7,000 cycles from about 10,000. Short-build engines “don’t make much sense economically,” countered SMBC Aero Engine Leasing Managing Director Roger Welaratne. “Either you do a full visit or sell it for parts.”

While module swaps remain a valid alternative to full performance restoration to achieve time and cost savings, some of those advantages are being eroded, said David Rushe, vice president of engine group and originations at Magellan Aviation. “Even module swaps can be 3-4 months now for a [low-pressure turbine] swap, which means you’re losing some of those marginal gains,” he said.

Green-time leasing is also challenging. Many of the spare cycles accumulated during the pandemic have been used up, and lessors are increasing green-time terms to 12 months from 3-4. “Green-time leasing remains strong in Europe and the Middle East, particularly for CFM56-7B engines, with

about shop visits for the CFM Leap.

Even so, some MRO providers are struggling to develop a business case to add Leap or GTF capabilities. Julius Bogusevicius, head of engines at FL Technics, pointed out that until more repairs are developed, any work on new-generation engines will be limited to swapping out old parts for new, for which an MRO cannot do much more than bill for labor.

Both Hussar and Kerai noted that material supply remains a challenge for the current generation, meanwhile. “Many engines [are] experiencing work stoppages or delays in induction until materials arrive,” Kerai said. “[Used serviceable material] availability remains tight as operators look to



DPA PICTURE ALLIANCE/ALAMY STOCK PHOTO

most operators seeking 12-month terms or longer,” Kerai said.

Yet the overall maintenance outlook is brightening, Hussar said. “[Turnaround times] in the overhaul market continue to improve with capacity at both independent and OEM shops, which have made a positive impact on the backlog of engines requiring maintenance,” he noted.

Hussar added that shop visit costs have remained predictable for current-generation engines, while OEMs have made some progress toward reducing the volatility of maintenance costs for newer equipment.

Of course, maintenance remains very expensive on newer engines, given the lack of repairs available in the marketplace and the reliance on new replacement parts.

“Once they open the engine, you open your checkbook,” Welaratne said

implement cost-saving measures to keep the current-generation engines flying,” Hussar added.

NEW-GEN ENGINES

Mandated inspections and durability problems on the GTF and Leap have bolstered demand for spare engines so much that values for a pair of these types have approached those for whole aircraft. It was in this climate that AerFin announced in July a deal to part out a handful of Airbus A320neo airframes.

However, OEMs are promising improvements as they roll out new durability upgrades. Leap-1As are now all manufactured with an improved high-pressure turbine blade certified late last year, and CFM anticipates a similar certification this year for the Leap-1B blade, which it expects to double the Leap family’s time on wing.



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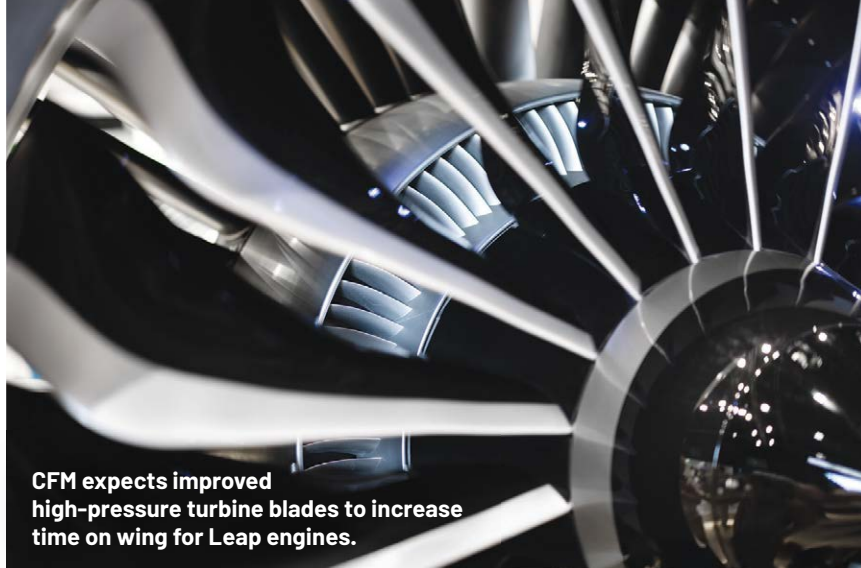


IT'S PRIME TIME FOR CLARK

Pratt & Whitney also is hoping for almost doubled durability when its first GTF Advantage engines enter service in 2026. Throughout this year, operators are receiving interim upgrades during shop visits that should extend maintenance intervals 40%. Starting next year, they will have the option to acquire a new hot section upgrade that captures most of the GTF Advantage benefits for their existing fleet.

"Time will tell if the improvements materialize," Hussar said. "If history is a guide, based on where the new-gen engines are in their respective product life cycles, the expectation is that the durability improvements will deliver measurable performance enhancements. The impact on the wider leasing market will be a positive development for both airlines and engine lessors that need cost and on-wing predictability to thrive."

AIP Capital also expects the new-gen engine market to "normalize," although Adamo noted that durability problems and other issues create a favorable environment for lessors.



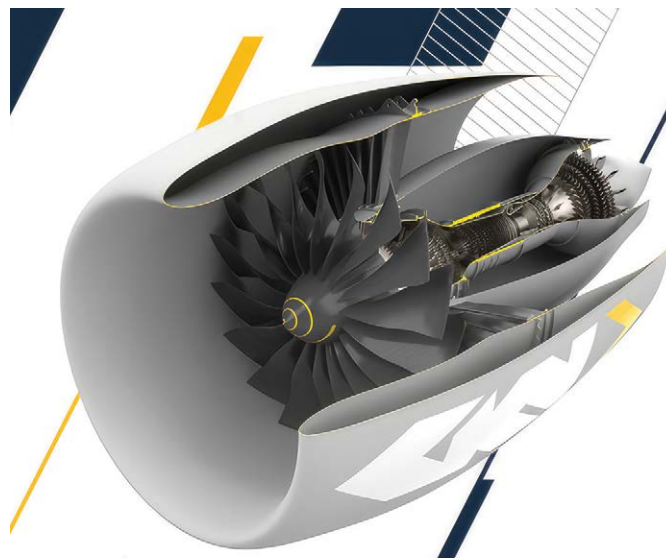
ADRIEN DASTÈ/SARRAN

CFM expects improved high-pressure turbine blades to increase time on wing for Leap engines.

"Our initial investment was largely motivated by our observations of the teething problems experienced by the new-gen engines," he said. "These issues are not evenly distributed, and the [Pratt & Whitney] product line has experienced more severe issues to date than Leap engines and the [Rolls-Royce] product line. Owning spare engines during a period of high amounts of unscheduled engine removals and high demand for quick-turn

[shop visits] creates a favorable rental market for short-term spare leasing."

In the longer term, Adamo said he expects AIP Capital to use "the spares purchased today to support scheduled maintenance events when those start to come due in 5-7 years." Those assets include 10 Leap-1Bs that AIP ordered from CFM last year. Adamo added that AIP's portfolio will continue to skew toward new-generation engines. 



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Oldies—Still Goodies

Until more legacy aircraft retire or travel slows, providers will be busy servicing popular engines

SEAN BRODERICK WASHINGTON

Demand for legacy engine services is showing no signs of slowing. Global travel remains strong amid macroeconomic uncertainties, while supply chain challenges are hampering new aircraft deliveries.

At CFM International, annual engine shop visits are still expected to peak in the next few years, with near-term volumes at an additional 600 shop visits by 2028 compared with projections made in March 2024. CFM joint partners GE Aerospace and Safran now expect peak annual visits to top out at around 2,500 before settling back to 2,000 by 2030.

term there, I think that program is going to continue to have strength, frankly, beyond where we thought it would 3-4 years ago.”

Narrowbody platforms are not the only beneficiaries. Ghai reported “similar dynamics” in GE’s GE90 fleet, citing “continued strong demand for freighter aircraft coupled with a more gradual widebody production ramp” on current-generation long-haul aircraft.

Overall, persistent, strong global traffic demand is keeping many older aircraft in service. Global revenue passenger kilometers were up 5% in the first half of 2025 year over year, Inter-

Olivier Andriès said on a late July earnings call.

Tier 1 manufacturers are reporting general improvements within the supply chain with a few exceptions, such as the aerospace-grade fastener shortage resulting from the SPS Technologies fire in February. In some cases, current engine programs are taking priority over legacy models, hampering efforts to reduce turnaround times.

The slow pace of retirements puts even more pressure on part producers to supply new material for legacy engines in lieu of used serviceable material. When suppliers must choose between allocating production capacity or raw materials to parts for new engines or their predecessors, the current generation often wins out.

Pressure to address durability issues on the newest engines leaves overhaul shops making similar trade-offs. “We continue to hear about MRO capacity scarcity, such as for the CFM56, as resources continue to be diverted to support the Leap engine,” Herbert wrote.

Engine-makers’ trade-offs are creating opportunities for other suppliers. Chromalloy has unveiled parts manufacturer approval (PMA) parts for two CFM56 vanes and a V2500 Stage 1 high-pressure turbine (HPT) blade in the last four years. An application for a much-anticipated CFM56 HPT blade is with the FAA, and approval is anticipated this fall.

Chromalloy plans to develop five total CFM56 PMA parts through a joint venture with FTAI Aviation. FTAI receives the parts at a discount for its engine module rebuilds, swapping out refreshed modules with spent ones, continuing the cycle—and providing an alternative to traditional, full overhauls that take longer and cost more.

“While industry issues of multiyear delays in new aircraft deliveries and the durability of new technology of engines are well known, advancements in CFM56 and V2500 engine maintenance, such as the availability of module swaps [and] development of new PMA parts, is allowing more airlines to economically reinvest in their existing fleets for longer than they originally planned,” FTAI CEO Joseph Adams said on a late July earnings call. “As the [Boeing] 737NGs and [Airbus A320neos] age, people are more and more likely to outsource more and more activity. Market share is not a static number.” ☒

Southwest Airlines is one of many carriers operating older aircraft longer due to delivery delays and strong passenger demand.



SOUTHWEST AIRLINES

“So that is fewer retirements and . . . the airlines keeping their fleets longer,” GE Aerospace Chief Financial Officer Rahul Ghai explained on a mid-July earnings call. “Even some of the lessors talk about it. . . . Their renewal [rates] are close to 90%, 95%, where they were just 30-40% a few years ago.”

Pratt & Whitney parent RTX is seeing a similar trend on the International Aero Engines V2500, the other major legacy narrowbody engine family.

“[We] continue to see strength in that program,” RTX President Chris Calio said on a late July earnings call. “We’re . . . halfway through the year and feel really good about the 800 or so shop visits that we forecasted for the year. When you look a little bit longer-

national Air Transport Association data shows.

“The primary risk to the aftermarket fundamentals remains passenger travel,” RBC Capital Markets analyst Ken Herbert wrote in a mid-July analysis. “While indicators and industry commentary have been mixed, we have yet to see a clear sign of a more pronounced slowdown in travel demand” through the end of 2025.

Airframers are slowly ramping up deliveries, but bottlenecks remain. The number of engineless Airbus A320neos—mostly awaiting CFM Leap-1As—has steadily increased throughout the year and surpassed 60 by July 31. CFM intends to catch up in the fourth quarter, Safran CEO

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New Horizons

Sustained demand for engine services in the Asia-Pacific region is bringing a wave of investment in building new shops and expanding existing locations.

JAMES POZZI LONDON

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CHINA

BAESL Beijing Aero Engine Services Co. Ltd. (BAESL), a joint venture between Rolls-Royce and Air China, is expected to start operations late this year but is not expected to reach its full capacity of 250 annual shop visits until the mid-2030s. BAESL is to overhaul Rolls-Royce Trent 700 engines for the Airbus A330, after which Rolls wants to expand its capabilities to the Trent XWB-84 for the A350 and the Trent 1000 for the Boeing 787.

GE AEROSPACE



HAECO HAECO Engine Services in Xiamen expanded its agreement last year with GE Aerospace until 2040 for GE90 offload work. The provider also secured its place in the future GE9X repair network.

MTU



MTU Maintenance Zhuhai In March, the MTU Aero Engines-China Southern Airlines joint venture opened its new MTU Maintenance Zhuhai Jinwan facility, with a focus on Pratt & Whitney PW1100G geared turbofan engines. The engine shop is the German MRO provider's second in China and is expected to support up to 260 annual visits once ramped up to full capacity.

MALAYSIA

GE Aerospace The company's site in Subang, Malaysia, first established in 1997 as a Center of Excellence for CFM56 engines, is poised to grow. It now employs more than 700 local staff. Last year, the engine-maker invested \$45 million across four sites in the Asia-Pacific region as part of a broader \$1 billion investment plan over five years to expand its global MRO network.

SINGAPORE

Eagle Services Asia Pratt & Whitney's Eagle Services Asia business increased its geared turbofan engine repair capacity by two-thirds last year after expanding its shop in Singapore.

ESA



SOUTH KOREA



KOREAN AIR

Korean Air South Korea's flag carrier is building a new engine maintenance cluster in Unbuk, scheduled to open in 2027. It is investing 578 billion won (\$416 million). Once operational, the facility is expected to raise Korean Air's annual engine shop visit capacity to 360 powerplants from 100. Korean Air maintains Pratt & Whitney PW4000 and PW1100, CFM International CFM56 and General Electric GE90-115B engines and plans to add GEnx and CFM Leap-1B capabilities in the coming years.

JAPAN



MITSUBISHI HEAVY INDUSTRIES AERO ENGINES

MHIAE Mitsubishi Heavy Industries Aero Engines (MHIAE) completed the expansion of its engine maintenance shop in Komaki in 2023. This is expected to increase MHIAE's commercial engine MRO capacity to more than 10 engine units per month by 2026 from 5-6, before ultimately reaching 15 units per month. The shop services Pratt & Whitney PW4000 and PW1100G-JM as well as International Aero Engines V2500 engines.

HONG KONG



HAESL

HAESL HAECO's Hong Kong Aero Engine Services Ltd. (HAESL) joint venture with Rolls-Royce started handling Trent 1000 engine modules this year and plans to grow the portfolio further.



SAESL

SAESL Rolls-Royce and SIA Engineering's joint venture, Singapore Aero Engine Services Ltd. (SAESL), is investing \$180 million to expand its Singapore facility, adding capacity for engine inductions, logistics and large component repairs. SAESL, a specialist in Trent engine MRO, expects to add about 40% extra capacity once the expansion is completed around 2028, enabling it to service more than 400 engines annually.

Manufacturing Mastery

Very few companies perform end-to-end production of high-pressure turbine blades

LEE ANN SHAY TAMPA, FLORIDA

High-pressure turbine blades in aviation engines have a tough job: They extract kinetic energy from hot gas and convert it into mechanical torque. To do this, they operate in temperatures that can exceed 2,900F, and they face significant mechanical stress.

cooled, externally thermal barrier-coated high-pressure turbine blades,” Chromalloy CEO Chris Celtruda says. “At the heart of Chromalloy is that capability.

“We believe that we are the last vertically integrated provider of pro-

the application of platinum aluminide and electron-beam physical vapor deposition (EBPVD) thermal barrier ceramic coating for high-pressure turbine blades,” he adds.

The barrier to entry to manufacture these blades is extremely high, but at the same time, the demand for PMA blades is high. As engines stay on wing longer, operators extend the life of mature assets and supply chain constraints become the new norm, operators are seeking alternatives to OEM parts for mature assets.

For all these reasons, Chromalloy continues to invest in manufacturing capabilities and capacity for PMA engine parts.

TAMPA EXPANSION

Chromalloy has spent \$200 million in the last 10-15 years on three facilities in Tampa, Florida, to bring high-tech turbine blade manufacturing capabilities in-house. The latest, a turbine

High-pressure turbine blades undergo about 200 steps as part of their manufacturing at Chromalloy.

blade production facility, introduces EBPVD thermal barrier ceramic coating capability, which Chromalloy had had only at its site in Rockland County, New York.

The new facility is designed to produce up to 100,000 blades annually. “Our plan is to produce 20,000 blades at this site next year and rapidly increase production in the following years to get up to the 100,000-blades annual volume,” says Vijay Jayachandran, ex-

Because of this, few companies design and manufacture high-pressure turbine blades for aviation engines. Fewer companies produce single-crystal blades, and even fewer manufacture the parts from start to finish—including smelting metal, growing the single crystals, creating wax cores to create air passageways, applying platinum aluminide, machining and drilling air holes and applying ceramic coating. Add to that work the requirement of being an FAA-certified manufacturer with parts manufacturer approval (PMA), and the number drops to single digits.

Achieving this entire end-to-end process is very complex and expensive.

For these reasons, “You can probably count on one hand the number of countries (let alone companies) on this planet that successfully have created the capability to design and manufacture single-crystal, internally

prietary superalloy smelting; single-crystal, multicore airfoil casting; finish machining and drilling; as well owning

Chromalloy’s new machine has brought EBPVD thermal barrier ceramic coating capability to Tampa.



IAI enhances LEAP Engine Maintenance



IAI-Aviation Group, BEDEK

MRO is offering maintenance services for CFM International's Leading-Edge Aviation Propulsion (LEAP) engines, enhancing its commercial engine MRO capabilities. The services encompass the LEAP-1A and LEAP-1B engines, which power the Airbus A320neo and Boeing 737 MAX – two of the most widely operated narrow-body aircraft worldwide.

IAI's addition of LEAP maintenance

reflects a broader shift in the aviation industry toward newer, more fuel-efficient engines. IAI views this activity as strategically important, as operators worldwide are dealing with prolonged turnaround times for engine maintenance due to industry-wide capacity and supply chain bottlenecks. IAI's capabilities will help ease this pressure by offering shorter turnaround maintenance options for LEAP engines.

Following audits and certification by the FAA and EASA, IAI is

authorized to perform maintenance on both LEAP variants. In preparation, the company expanded its infrastructure, invested in dedicated tooling, and trained specialized teams in cooperation with Safran, the engine's manufacturer. The initial service offering includes Quick Turn (QT) operations - worksopes that allow engines to return to service much faster than more extensive shop visits.

QT maintenance has become a challenge

in the LEAP support network, often acting as a bottleneck in global engine availability. IAI's capability in this area is expected to facilitate faster induction times and increased engine availability for operators facing tight flight schedules and rising demand.



Credit: IAI

IAI also collaborates with Safran

to enhance its involvement in LEAP engine support. The aim is to establish full overhaul capability, including test cell operations, within the next year. The company intends to expand into GTF engine services as those fleets mature.

With this step, IAI aims to give airlines another option for maintaining the latest generation of engines - supported by decades of technical experience and a growing global support network.

Yaacov Berkovitz, Executive VP and General Manager of IAI's Aviation Group: "IAI Aviation

Group's BEDEK MRO draws on more than 70 years of maintenance, repair and overhaul experience in supporting the aviation industry's evolving requirements. Our teams service a wide variety of engines, including the V2500 and PW4000, the full CFM56 family (series -3, -5, and -7) and are now adding the latest LEAP models, ensuring reliable support across multiple platforms".

For further information, please contact IAI's global MRO experts at Aviation_Group@iai.co.il

ecutive vice president for engine parts and programs.

Adding the coating capability in Tampa to contain the whole blade production shaves off 3-4 weeks, says Mike Zerbo, Chromalloy site leader.

Chromalloy is qualifying the coating processes and machines part by part. Its first legacy part, the GE CF6-80C2 first-stage high-pressure turbine blade, was recently approved and is now fully produced in Tampa. The blade first received FAA PMA approval on March 5,

and people to manage the more than 200 steps of manufacturing high-pressure turbine blades. “Some of these pieces of equipment are very expensive, and you don’t just plug them in and they work,” Celtruda says.

The \$17 million “EBPVD machine got kicked off before this building was built because it took four or five years to build,” Zerbo says. “It was built and assembled in Germany, disassembled, brought over here and then reassembled.

parts are available,” Celtruda says. “That’s something that I think is missing today in the OEM part of the supply chain, because that chain is just so long,” as different companies provide the alloys, castings, heat treatment, thermal spray and more. Managing the logistics and lead times with various companies doing different steps of the process takes time, and those companies’ “capabilities are effectively in the three buildings” in Tampa, he says.

REDUNDANT CAPABILITY

For Chromalloy’s newest BELAC facility in Tampa, a lot of analysis went into figuring out the most efficient flow of parts. “All of our equipment is intended to be able to cycle between different part numbers quickly, so between that and the short lead time,

Water flow inspections ensure correct hole sizes.

we can react quickly to changes in the market and scale up or down for different product families,” Zerbo says.

“But [Murphy’s law] will come and sit on our head at some point, so our Nevada operation is buying the same [electrical discharge machining] and hole drillers [and eventually the grinders],” Celtruda says. “We have the ability to transfer the programs back and forth. [This] effectively second-sources ourselves.”

Going forward, if Chromalloy has redundant capability, it plans to have the same equipment at each site to enable easy transfer of work as needed, he notes.

The company’s Nevada facility currently provides castings for turbine vanes and nozzles.

As Chromalloy creates more PMA parts, it will have extra capacity in Tampa for more equipment. It plans to continue investing there to meet market needs, Jayachandran says.

Chromalloy sees demand for all its PMA engine parts, with the CF6-80C2 “a really strong mover.” A second blade for the V2500 pre-select and select is also popular, he says. Even parts for older engines, such as the CF6-50, are in demand.

In addition to its aviation parts, Jayachandran says “we are seeing a strong pull” for aero-derivative turbines, such as the GE LM2500 and LM6000, used for data centers in the energy sector. ☺

LEE ANN SHAY/AVIATIONWEEK



2005. It is now a big volume part for Chromalloy and has flown more than 1 billion flight hours in the past 20 years without any airworthiness directives. The company produced its first PMA blade—a first-stage high-pressure turbine for the CFM International CFM56-3 engine—in 2002.

Following the -80C2 coating approval, “it will be sequential after that for the rest of the turbine blade family that requires this type of thermal barrier coating,” Celtruda says. Chromalloy hopes to finish qualifying all its legacy aerospace parts in 2026.

“That helps us react to the market faster because we don’t have the lead times of shipping parts back and forth,” he says. The equipment in Tampa is newer and more automated, which also helps with consistency.

Chromalloy has invested \$30 million in its new BELAC coating facility and machines and expects that to grow to \$50 million by the end of 2026.

It takes time to create the high-tech capability and invest in the machines

“And it takes dedicated people developing the skills alongside these investments,” he adds. “That is why it’s so hard for the industry to flex capacity, because there’s a craft piece that goes along with the technical piece.”

Controlling the whole end-to-end manufacturing process also helps provide parts availability assurances. “Although we can’t guarantee availability, we have the ability to control the processes to where we can promise with a much higher level of accuracy when a part is going to be available,” Celtruda says.

For instance, Chromalloy co-produced two new PMA parts—the first-stage CFM56 vane and the second-stage International Aero Engines V2500 blade—last year while it was seeking FAA approval, which enabled it to ship the new parts the day after it received FAA production release.

Channel partners, such as AAR and Killick Aerospace, work with Chromalloy to manage inventory stocks, “but we make sure that the

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Conversions and Capabilities

STS Aviation Services looks to change focus and expand



STS' facility in Birmingham, England, has been converting Boeing 737s to E-7A Wedgetails since 2020.

BOEING

JAMES POZZI BIRMINGHAM, ENGLAND

STS Aviation Services, the European MRO business of the U.S. STS Aviation Group, will target further after-market expansion on the continent by building up its aircraft passenger-to-freighter programs in Manchester, England, while transitioning its facility in Birmingham, England, to full-time defense activity from commercial maintenance.

The parent company, headquartered in Jensen Beach, Florida, established its European operation in 2019 after acquiring MRO provider Apple Aviation, which operates three base maintenance locations in the UK in Birmingham, Manchester and Newquay (its headquarters), along with several domestic and line stations in Europe.

In addition, STS built up engine capability last year by acquiring UK-based GT Engine Services and is actively exploring several opportunities across the aviation industry to continue its growth momentum.

In light of Europe's shop visit demand, Simon Morton, managing director for STS Aviation Services in the UK,

says it will aim to add further capabilities and people to its existing UK sites to meet sustained demand across programs. Morton notes that there has been strong demand at its UK base maintenance sites so far this year.

"We've inducted 47 aircraft across our three facilities, and we expect that number to exceed 60 by year-end," he says. "Demand is strong, and we anticipate further growth moving forward."

STS acquired the 200,000-ft.² hangar in 2019 from Monarch Aircraft Engineering, after UK carrier Monarch Airlines ceased operations. Commercial MRO there heavily focuses on Boeing aircraft, especially 737NG and 757s. The facility's commercial capabilities include base maintenance services, aircraft modifications, structural repairs and engine changes for the Boeing aircraft types as well as for Airbus A320-family and A330 aircraft.

Since the summer of 2020, STS has had a partnership with Boeing to convert 737s to Boeing E-7A Wedgetail airborne early warning and control aircraft for the UK Royal

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Air Force. Since then, the facility has maintained a 50-50 work split between the Wedgetail conversions and commercial base maintenance services up to C check level.

In the long term, STS intends to change the focus of the Birmingham facility by transitioning it to solely defense activities. Plans are underway, and that process is expected to continue through year-end. STS says it has ceased taking commercial maintenance slot bookings for the upcoming winter maintenance season. “We do have limited winter availability in both Manchester and Newquay, but demand means operators are booking slots further ahead than they did a few years ago,” Morton says. As Birmingham transitions to defense work, commercial activity has been relocated to other UK facilities.

Since establishing an MRO operation in Manchester in late 2022, after leasing a vacant hangar formerly occupied by the defunct UK leisure airline Thomas Cook, STS has added new capabilities to the facility, which primarily services Airbus narrowbody aircraft.

To help meet capacity targets, the business moved some capabilities across from its Shannon-based STS Aviation Services Ireland business, which focuses on specific aircraft components. In the past 2.5 years, the Manchester facility has expanded into composite repairs, interior trim work and component painting covering engine nacelles and interiors that supports narrowbody aircraft checks.

These functions will also support aircraft conversion activity at the Manchester facility, which has been turned into a hub for passenger-to-freighter (P2F) conversions. In Oc-

tober 2022, STS signed a multiyear agreement with Mammoth Freighters to undertake Boeing 777 P2F conversions in Manchester through a double production line for the 777-200LRMF and 777-300ERMF models.

STS started its first conversion for U.S.-based cargo carrier Mammoth Freighters—an ex-Delta Air Lines-operated 777-200LR aircraft—in the summer of 2024. Morton says STS has two P2F conversions underway in Manchester, both of which are progressing on schedule. “We expect the first aircraft to depart in [the third quarter] and the second early [in the first quarter of] 2026,” he says. He adds that more aircraft for conversion are scheduled for induction.

The company’s target conversion time is approximately 5.5 months now. “As we ramp up throughput and continue to expand our workforce, we expect to see these timelines improve,” Morton says. “The learning curve from our first few inductions will allow us to streamline processes and achieve even greater efficiency.”

Noting the challenge of skills recruitment, particularly since the COVID-19 pandemic further hit the UK MRO industry’s long-existing talent shortages, Morton says the company is looking to recruit additional resources and specialist skill sets to meet demand on both its P2F and defense programs.

In the UK, STS employs approximately 580 people, and with the growth of the company’s P2F and defense programs, Morton says he anticipates that number will rise to about 700 by year-end.

Its May 2024 acquisition of GT Engine Services, an engine repair specialist based at Stansted Airport 30 mi. east of London, added valuable engine capabilities to the company’s portfolio. STS will inherit capability for the repair and management of several narrowbody and widebody engine types, including the CFM International CFM56 and Leap; GE Aerospace CF34 and CF6, International Aero Engines V2500, Pratt & Whitney geared turbofan and PW4000 and Rolls-Royce RB211 and Trent 700 engines. GT Engine Services’ core specialist services include engine checks, bore-scope inspections, module changes, top and bottom case repairs and storage and preservation work. The company also has the capacity to store up to 150 engines on-site with space for about 20 engines in its repair workshop.

“Adding a dedicated engine capability was a natural extension of our existing MRO services,” Morton says of the acquisition, after which STS immediately began integrating its operations. “[GT Engine Services] also brought a strong customer base with significant crossover, making the acquisition a seamless fit.”

Morton says the business is expected to help boost STS’ future engine output. “We’re already working to expand into on-wing support while adding additional engine capabilities to meet growing demand,” he notes.

STS also plans to add more line stations to its existing network in Europe, the Middle East and North Africa. It operates four line stations in the UK and four overseas. “Over the next 12 months, we plan to expand both domestically and internationally to strengthen our global support network,” Morton says.

“We are actively planning to add two new line stations in Europe over the next 12-18 months,” he says. STS is exploring further opportunities in Asia and the Middle East, viewing them as growth markets for line maintenance support and longer-term partnerships, Morton explains. ☛



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Heading North

KF Aerospace boosts its aftermarket capabilities to support growing airline projects

KF AEROSPACE PHOTOS

LINDSAY BJERREGAARD CHICAGO

Canadian MRO provider KF Aerospace is bolstering its capabilities, rolling out new technologies and expanding its workforce and training programs to support its airline customers.

The company secured several new maintenance projects in 2024 with domestic carriers, such as Air Canada, Flair Airlines and WestJet. KF Aerospace says it will expand its support of Air Canada, including adding X-ray and engine services for the airline's Airbus A320s.

KF Aerospace is supporting WestJet's integration of the fleets of now-defunct low-cost carriers Sunwing Airlines and Swoop. It is also performing modification projects for Air Inuit and Air North as both airlines expand their fleets. These projects include Boeing 737-800 Combi conversions for Air Inuit and supplemental type certificate prototyping for in-seat power on Air North's fleet.

Following the 2024 renewal of its 10-year contract with Purolator, which provides cargo services across British Columbia, KF Aerospace is converting several ATR 72-500 aircraft to freighter format to replace its aging Convair CV-580 fleet. The company has converted one ATR 72-500F at its Kelowna International Airport (YLW) headquarters and plans to convert two more this year.

"We expect both remaining ATR 72-500 freighters to enter service by the end of this year," a representative for KF Aerospace tells Aviation Week Network. "The second ATR—a bulk

loader—is already painted and undergoing final maintenance checks and testing at our Kelowna facility."

KF Aerospace's YLW facility is its largest, with a staff of 775 to support maintenance services, aircraft maintenance training, cargo operations, aircraft leasing, charter services, supply chain operations and other business segments. The company says its second largest base, in Hamilton, Ontario—which has 221 employees and of-

KF Aerospace introduced an in-house Boeing 737 fixed-base simulator to train staff on engine run procedures.

fers a range of maintenance, training and supply chain services—will soon have an expanded role in C checks and quick-turn maintenance.

According to a representative, KF Aerospace is actively hiring and expanding its teams to meet strong demand for services from commercial customers and military partners. "As the demand for high-quality MRO services grows, we're focused on sustainable expansion—investing in both our people and our facilities," KF Aerospace President Gregg Evjen adds. "With strong partnerships and a growing defense portfolio, KF Aerospace is well positioned to support the next generation of aircraft maintenance and engineering in Canada."

One way that it will support this growth is through expanded training

The company's Hamilton base will soon have an expanded role in C checks and quick-turn maintenance.

offerings. In 2024, KF Aerospace introduced a 3D printer for instructional models as well as simulator software for flight deck training. The company implemented an in-house Boeing 737 fixed-base simulator at YLW to train staff on engine run procedures—something that previously required sending aircraft maintenance engineers to Calgary, Alberta.

In 2024, KF Aerospace partnered with the Canadian Council for Aviation and Aerospace to launch an online aircraft structures technician training program. The aim was to help employees—particularly those based in remote and northern communities—to meet educational requirements without having to pause their careers. This year, the partners plan to launch an online mechanics program.

Beyond online training, KF Aerospace is rolling out new technologies to streamline maintenance and supply chain operations. The company intends to introduce a new tooling management system at its YLW and Ham-



ilton facilities to improve tool tracking, calibration, forecasting, reservations and availability. A representative says the phased rollout of the system is part of KF Aerospace's broader effort to enhance operational efficiency and support long-term growth. For instance, the company plans to continue expanding its use of digital tools, including paperless task cards and automated planning systems.

Jill Stuart, KF Aerospace's supply chain manager, says the company will also strengthen its compliance efforts under Canada's Bill S-211 to ensure ethical sourcing and responsible supply chain practices. ☞

Seeking Standardization

Kim Ernzen joined StandardAero as chief operating officer in June 2024. She discussed how the company is harmonizing its operating processes across more than 50 facilities with Inside MRO contributor **Keith Mwanalushi**.

What factors necessitated the need to harmonize StandardAero's operations? Over the past 15 years, our growth and acquisition strategy has fueled innovation and expanded our market presence. However, it has also introduced operational complexity, particularly due to varying operational processes and [enterprise resource planning] systems across some of our MRO sites. At the same time, ongoing supply chain disruptions continue to impact the aviation industry.

In response, we are taking proactive steps to reduce turn times by improving the processes within our control. Through in-depth analysis, we identified a significant opportunity to drive synergies by sharing best practices, enhancing efficiency through process standardization and ultimately elevating the customer experience. This led to the launch of the StandardAero Operating System (SAOS) initiative.

How did you prioritize which sites or engine programs to standardize first? Prioritization began at the project level using an impact-effort analysis. Each project was evaluated against six weighted criteria, resulting in a composite score that positioned it on a 2 X 2 matrix measuring business impact versus ease of implementation. Projects offering high impact with lower implementation complexity and risk were prioritized over those with lower return or higher complexity.

Once project precedence was established, pilot sites were selected based on alignment with each site's strategic objectives, overall project value, key dependencies and the availability of site resources. Projects are being implemented in a vertical deployment model: Following successful implementation at the pilot site, the same project is then rolled out across the remaining sites. This approach accelerates benefit realization across the organization, compared to the traditional method of sequential,

end-to-end implementation at individual locations.

The SAOS began rolling out in 2024 to develop a unified operating model. What models or frameworks influenced it? The process began with the selection of a representative sample of key platforms across the organization, reflecting those critical to meeting our customers' needs and supporting our strategic growth objectives. A cross-functional team of senior leaders conducted comprehensive, end-to-end operational assessments at each site, which included system and process evaluations, maturity analyses and identification of opportunities for technological advancement.

We involved site leaders early in the process to make sure the SAOS initiative wasn't seen as a top-down directive.

StandardAero's legacy sites, with over a century of operational history, combined with the deep expertise brought in through acquisitions over the past decade, provided the team with a broad base of knowledge. This collective insight enabled the development of a robust road map to guide our transition toward a unified operating system. To lead this critical initiative, I have appointed a senior director of SOAS, Tanis Hastman, to ensure our continued progress and long-term success.

How are legacy sites adapting to the SAOS compared with newly built or acquired facilities, such as San Antonio and Dallas-Fort Worth? With a long-standing culture rooted in Six Sigma Lean principles and a strong continuous improvement program, we have consistently maintained operational independence while adhering to a



STANDARDAERO

shared standard across the organization. SAOS is a natural extension of this foundation: Driven by an engaged, cross-functional steering committee, SAOS ensures alignment across the enterprise, bridging gaps between legacy operations and newly acquired sites. A key strength of SAOS is its scalability: As we continue to grow, the standardization of our operating processes will be essential to the seamless integration and long-term success of future acquisitions.

What were the most significant challenges you faced in harmonizing processes across so many diverse facilities? The project is still in the early stages of implementation, which gives us the advantage of proactively anticipating and planning for potential challenges. One key area of focus in our risk management plan is managing cultural and operational differences between the facilities. Each site has developed its own way of working over the years, with different systems, local regulatory requirements and even varying attitudes toward process change. We're focused on ensuring that standardization is viewed neither as a loss of autonomy nor as an indication that the site's current methods aren't effective.

To mitigate this risk, we started by involving site leaders early in the process and made sure the SAOS initiative wasn't seen as a top-down directive, but rather a collaborative effort. We conducted gap assessments to understand each facility's specific needs, which will help us customize the rollout without compromising on global standards. We have a cross-site steering committee and are focused on transparency and communication to increase trust, gain alignment and manage change.

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Have you observed measurable improvements in turnaround times, quality or cost efficiency since implementing SAOS? Not yet, but that's to be expected, given where we are in the implementation process. SAOS is still in the early phase of implementation, and while we've laid a strong founda-

fully establishing SAOS within our engine services business, where the majority of our operational process variations exist. This allows us to refine the framework, validate its effectiveness and build the right support systems before scaling further. That said, the principles behind SAOS—

a benchmark system is absolutely a possibility, and even an aspiration. While the primary goal of the SAOS is to standardize and optimize our own operations, the structure, governance and scalability that we're building into the system have broader implications. The MRO industry continues to face



STANDARDAERO

StandardAero has more than 8,000 employees across more than 50 sites around the world.

tion by defining processes, aligning governance and launching projects at a few initial pilot sites, it's too soon to see measurable, enterprisewide improvements in key metrics like turnaround time, quality or cost efficiency. That said, as we move into broader deployment, we fully expect to start capturing quantifiable improvements, and we've built performance measurement into the framework to demonstrate progress as implementation matures.

Do you plan to extend SAOS beyond engine services into other business units, such as component repair or avionics? Right now, our focus is on

standardization, efficiency and governance—are absolutely transferable to our other business areas such as component repair services.

What is the long-term vision for SAOS? Do you foresee it evolving into a benchmark system for the broader MRO industry? Our vision is to establish a single, streamlined and efficient operating system that is built on standardized processes, common tools and unified governance to deliver quality, speed and scalability across the organization. Part of our long-term vision includes embedding the implementation of the SAOS system into our integration playbook for future acquisitions, which will continue to be a key driver behind StandardAero's growth. As such, yes, SAOS evolving into

common challenges, including supply chain disruptions, fragmented systems, variability in quality and increasing customer expectations.

SAOS is designed to directly address these by aligning processes, integrating technology and enabling more agile, data-driven decision-making. If successful, we believe that SAOS could serve as a model—or even a benchmark—for how MRO organizations can evolve from legacy operational models to more modern, scalable and customer-focused systems.

That said, our focus remains on executing SAOS effectively within StandardAero first. Industry recognition will follow if we can demonstrate clear, measurable improvements in performance, efficiency and customer satisfaction. ☒



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Homegrown in Honolulu

Hawaiian stakeholders have launched a new program to tackle the state's aviation workforce challenges

LINDSAY BJERREGAARD CHICAGO

Despite having a robust, interisland aviation ecosystem, Hawaii has faced challenges finding and training enough talent to maintain its aircraft due to a shortage of local Part 147 schools and certified technicians.

Hawaiian Airlines and the Pearl Harbor Aviation Museum (PHAM) in Honolulu have teamed up to build a homegrown program to remedy the situation.

Students will have the opportunity to earn high school diplomas and FAA airframe and powerplant licenses simultaneously.

Rojo Herrera, Aviation Pathways program director at PHAM, tells Aviation Week Network that many people do not realize how much Hawaii's population relies on air travel. "We have people who work on one island that fly weekly and stay for a week doing certain jobs, and they'll

come back home on the weekends," he says. "It's not like we just have some international traffic—there's a lot of interisland traffic. We have a day-in, day-

However, due to the state's limited training infrastructure and industries, young people often relocate to the U.S. mainland for more career opportunities.

"In the state of Hawaii, we have limited resources for training and development of pilots and mechanics," says Jadyne Yomono, talent outreach program manager at Hawaiian Airlines. "We do a lot of recruitment across the nation, but we would love to be able to hire more talent locally and to see more of our local potential talent remain here. We always run the risk of



PEARL HARBOR AVIATION MUSEUM PHOTOS

out, very robust requirement for people to support our interisland travel."

talent not returning when they leave the state, so it's really important for us to support programs throughout the state that are willing to uplift our communities and bring and retain talent here."

PHAM had been working with youth to inspire passion for aviation through various exhibits, field trips and summer camps, but in 2019 it

Pearl Harbor Aviation Museum hopes to expand enrollment for its second cohort of students.

came together with stakeholders from Hawaiian Airlines, Hawaii Community College, the U.S. Education Department, the FAA, the U.S. Civil Air Patrol and the Aircraft Owners and Pilots Association to consider how the state could create better local opportunities for training.

PHAM first launched a Pilot Pathway program in 2023 to provide local opportunities for high school and



college-age students to obtain a private pilot license. The museum has launched a two-year airframe and powerplant (A&P) Pathway program in partnership with

Hawaiian Airlines hopes the new program will help it hire more local maintenance talent.

Hawaiian Airlines that will prepare high school students to obtain their FAA A&P licenses.

Due to the state's lack of Part 147 schools, PHAM and Hawaiian contacted Western Maricopa Education Center (West-MEC), a technical school in Arizona that runs its own Part 147 program for high school students, for guidance.

Troy Gabaldon, West-MEC's central campus administrator, says the decision was made to launch the A&P Pathway program using West-MEC's Part 147 certification and curriculum to simplify the process. "It's like an extension of West-MEC in Hawaii," he says, noting that his school will initially help Hawaiian and PHAM with the program's launch. The aim is to set up the program to establish its own certification in a couple of years as it matures.

The first cohort of 12 students has started classes at the program's facility in the Hawaii Civil Air Patrol building in Honolulu, which has been equipped with classrooms, lab space and storage, as well as a variety of training equipment, including a donated Beechcraft Travel Air and a Van's RV-12 light sport aircraft. Students will spend the first half of the day Mondays through Thursdays learning about aviation maintenance before going back to their regular high schools or distance learning programs to earn their high school diplomas simultaneously.

To help launch the program in its first year, Hawaiian Airlines is providing one of its own technical training instructors as PHAM builds its A&P

teaching staff. Hawaiian and Alaska Airlines will sponsor toolboxes for first-year students.

"As far as getting certification at the end of the second year, [students] will

to a full class size of 20-24 students in its second cohort. He expects to replicate PHAM's success with its Pilot Pathway program, particularly in giving students opportunities to learn from

Hawaiian Airlines professionals and to visit the carrier's facilities. "When our pilot cohorts go and see it there [Hawaiian Airlines facilities], they truly come back with a new vision of possible future life, and I just

Hawaiian and Alaska Airlines are sponsoring toolboxes for first-year students.

know it's going to be the same—or probably even better—for our A&Ps," he says.

"We're excited about the opportunity to make investments here locally, in our backyard," Yomono adds. "We have a good amount of employees who have relocated from the mainland and programs in place that

provide a support network or a support group to help employees who are relocating from the mainland assimilate to the community here, but that still doesn't replace the familiarity that a local community member who has grown up here, seeing and flying on Hawaiian Airlines planes, and who is now a mechanic here, has.

"We are grateful for both pools of employees, but we are excited about the opportunity to grow our local pool." ☺



HAWAIIAN AIRLINES



sit for their [FAA] oral and practical examination, just as if they've gone to a community college or to a school on the mainland to get their A&P," Herrera says. "They could be 18 years old, starting a whole new life here in Hawaii with a ticket to work at Hawaiian or some other location. We feel like it's a major shift in thinking for a lot of young people here who don't want to be a pilot but who like fixing things."

Herrera hopes to grow the program

Green Advances

Digital technologies are enabling more sustainable component repairs

KEITH MWANALUSHI LONDON

MROs are tapping more digital technologies to enhance sustainability in the component repair process. Technologies such as predictive analytics and artificial-intelligence-driven logistics planning are helping maintenance providers meet increasingly urgent environmental goals.

“Digital technologies are fundamentally transforming our approach to sustainability in component repair by enabling smarter, data-driven decisions that reduce waste and optimize resource use,” says Veslav Blažević, chief production



FOKKER SERVICES GROUP

Fokker Services is considering AI's potential to help it make smarter component repair decisions.

officer for base maintenance at FL Technics. The Lithuanian MRO is actively integrating data analytics into material procurement planning to reduce surplus stock. “We only stock what's truly needed and [are] reducing surplus that might expire unused,” he adds.

In the workshop environment, FL Technics also is tapping into environmental data to refine energy use in real time. “We analyze data from curing equipment to dynamically adjust curing times based on local environmental conditions,” Blažević explains. In addition, the company uses inspection data to identify nonconformities in previous repairs, allowing it to trace root causes and prevent repeat failures. “This continuous improvement loop enhances repair reliability while avoiding redundant rework and associated resource waste,” he states.

Similar trends are taking shape at Lufthansa Technik (LHT) with the company's digital Aviator platform. According to Dania Dawood, senior manager for strategy, Aviator “uses advanced data analytics and predictive maintenance algorithms to create a more efficient and sustainable repair network.” The system calculates failure probabilities for components, helping maintenance planners avoid premature removals. This data-led approach “maximizes component operating hours, minimizes material waste and avoids unscheduled aircraft downtime,” Dawood says.

Another innovation at LHT is its dynamic line replaceable unit planning system, which uses artificial intelligence (AI) to project future repair events. “This enables more efficient movement of pool parts across the network, reduces unnecessary material usage and improves overall planning accuracy,” Dawood says.

In North America, GA Telesis is taking a deep dive into failure data to enhance its provisioning strategies. Jason Reed, president of the company's digital innovation group, says his data science teams are focused on optimizing repair and procurement decisions. “We are creating the most efficient repair strategies, along with parts procurement needs, months in advance,” he says. By mapping historical trends across environments and failure modes, GA Telesis ensures that tooling, testing and parts are aligned ahead of time, Reed says.

This preemptive provisioning reduces downtime and waste while increasing responsiveness, given today's supply chain pressure, Reed says. “Our data analysis enables



GREGOR SCHLÄGER/LUFTHANSA TECHNIK AG

Lufthansa Technik is using data within its Aviator platform to maximize component operating hours and minimize material waste.

us to drive our initial provisioning phase months in advance, ultimately positioning ourselves as ready for any potential repair scope that may come through the door,” he says.

Insights from metrics such as mean time between unscheduled removals and component utilization are also allowing greater confidence in extending time on wing, Reed says. “Our teams can successfully anticipate accurate needs for the life and service of a component, allowing for both efficient repair [turnaround times] and maximum on-wing utilization of the component after it leaves our facilities,” he says.

Digital technologies also play a key role in advancing Fokker Services' sustainability objectives by enabling more accurate forecasting of future used serviceable material demand based on operational planning. The company says this proactive sourcing approach supports greater material reuse while ensuring high delivery performance.

“Looking ahead, we see strong potential in AI and historical data to enhance diagnostics, improve fault isolation and support smarter repair decisions,” says Fokker Services Group Chief Financial Officer Niels Westpalm van Hoorn.

He adds that investing in energy efficiency, waste reduction and digital process improvements often leads to leaner, faster and more cost-effective operations. “Many of our sustainability initiatives actually enhance—rather than hinder—core MRO performance,” he says. ☼

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Betting on Digital

AAR acquires a second MRO software provider to expand its digital portfolio

LINDSAY BJERREGAARD CHICAGO

LEE ANN SHAY WASHINGTON

AAR Corp. is extending its digital growth strategy in the latest MRO industry software acquisition. The Illinois-based company purchased Aerostrat, an aviation maintenance software provider in Seattle, on Aug. 11 for \$15 million plus contingent consideration of up to \$5 million to complement and expand its Trax subsidiary offerings.

while also refining and adding solutions.” At the same time, it plans to “tightly couple” Aerostrat with Trax so customers can leverage the products, an AAR spokesperson says.

Although the companies have been familiar with each other for five years, “serious conversations started around six months ago, and it clicked,” AAR says. “This is a natural fit for both companies.”

In its annual 2025 financial report released on Aug. 5, Holmes noted: “After two years of investment, Trax has experienced significant growth, and our acquisition thesis has been confirmed [through new services and contracts], and we have nearly doubled Trax’s revenue since the acquisition.”

When Trax was acquired, its revenue was about \$25 million; Holmes said it is now about \$50 million.

This year alone, Trax signed new maintenance software contracts with Amerijet International Airlines, Cathay Pacific, Delta TechOps, JetBlue and SIA Engineering. The

software companies also align with AAR’s efforts to digitalize its business as it works to become a paperless MRO.

The aftermarket has notably seen several other major MRO software acquisitions, consolidation and integration in recent years. Global ERP software specialist IFS acquired artificial intelligence-powered MRO software provider EmpowerMX in 2024.

The prior year, Lufthansa Technik partnered with Flydocs and Swiss-AS to integrate both companies’ software products under its Aviator digital platform. Also in 2023, aviation software provider Vervon acquired Rusada—developer of

the popular Envision maintenance and engineering software—and rebranded the product as Vervon Tracking+. Three years before the Rusada acquisition, Vervon bought Flightdocs, a provider of aircraft maintenance tracking and inventory management software. ☒

AAR CORP.



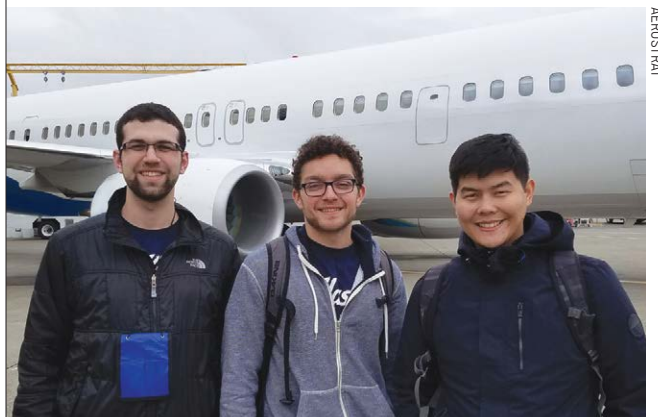
AAR purchased Trax in 2023 for \$120 million and has since doubled that company’s revenue to \$50 million.

Founded in 2015, Aerostrat’s publicly disclosed customers include Azul Brazilian Airlines, FedEx Express and JetBlue Airways. Aerostrat’s flagship software, Aerros, provides long-range heavy maintenance planning functionality to operators and MROs. The company says its software operates agnostically, so it can work with any enterprise resource planning (ERP) system a customer uses.

The transaction is AAR’s second MRO software acquisition in recent years, following its 2023 purchase of Trax. AAR President, CEO and Chairman John Holmes told Aviation Week Network the deal advances AAR’s digital strategy to increase internal efficiencies and develop new digital sources of revenue, which often have high margins.

Aerostrat’s Aerros supports 5,000 aircraft and complements Trax’s ERP and line maintenance planning applications, in particular. It is unclear how many customers overlap between Aerostrat and Trax, but AAR did say the acquisition creates “scope opportunities” for both sets of customers.

As with its acquisition of Trax, AAR “will focus on accelerating [Aerostrat’s] growth by expanding its customer base



Aerostrat’s three founders—from left, Elliot Margul, Cody Morris and Frankie Angai—first presented their new maintenance software concept at a 2016 event.

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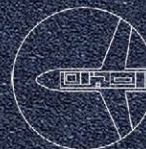
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Rival Opportunities

Eve Air Mobility tests Beta Technologies motors for its eVTOL air taxi

GRAHAM WARWICK WASHINGTON

Beta Technologies was founded in 2017 to develop electric propulsion systems, not just electric aircraft, and its engine-first strategy is beginning to pay off.

Rival electric vertical-takeoff-and-landing (eVTOL) startup Eve Air Mobility plans to test Beta's lift and propulsion electric motors on its en-

are being installed on the full-scale engineering prototype in Brazil after completing extensive ground tests at the supplier's facilities, Bordais said.

"In parallel, we signed with Beta an agreement to test their propulsion electric motors on our prototype," he said. "Nidec continues to be committed and involved with our eVTOL, and

together so that they stop aligned with the airflow to reduce drag in the cruise. "This is a design that generates less vibration and is quieter than the previous configuration," Bordais said. The new lift prop is being ground-tested on Eve's truck-mounted propulsion test rig.

The engineering prototype is on track to fly by year-end with both Nidec and Beta motors installed, he said. The first of five planned conforming prototypes for development and certification testing is planned to fly by the end of 2026, and Eve is still targeting certification in 2027.

Eve spent \$57 million on operations in the second quarter, almost twice its cash consumption in the first quarter. But Chief Financial Officer Eduardo Siffert Couto told analysts that the \$83 million consumed in the first six months of 2025 "can be considered as a normalized level for our current development stage," and Eve expects to end the year at the lower end of its full-year guidance of \$200-250 million spent.

The startup ended the quarter with \$242 million in cash and a total liquidity of \$375 million, including bank credit lines and grants. "We have plenty of cash to get us to the end of 2026," he said. "If you add the standby facilities we have already signed and the recent grant that we raised, . . . we're talking about almost \$400 million, which gives us two full years, to mid-2027." Eve still needs to raise more funding to get to certification but has options thanks to being part of the Embraer group, he added.

Bordais welcomed rival eVTOL developer Joby Aviation's acquisition of the passenger business of urban helicopter service provider Blade Air Mobility, which signed a letter of intent with Eve for 50 eVTOLs.

"We welcome very much this news about Joby investing in Blade," he told analysts. "I think this is exactly proving the point we have been saying since the beginning: There is a transition happening in the electrification of vertical flight from the helicopter to eVTOL, and this is the proof of it."

Bordais does not see the Joby acquisition taking Blade out of its backlog of 2,800 preorders: "It's a ride-sharing platform. It's like . . . Uber asking their drivers to drive only Toyotas. You need all the OEMs. Each eVTOL has its mission. Blade is multi-OEM, so we don't see it as an issue today for us." ☒

Eve is ground-testing the four-blade, stop-fold lift propeller for its eVTOL air taxi using a truck-based propulsion rig.



gineering prototype as an alternative to units from Japanese motor manufacturer Nidec Corp.

"Beta comes in with a proven and mature solution to the distributed propulsion of an eVTOL with the same lift-plus-cruise aircraft configuration, and this will give Eve operating flexibility and optionality in our program," Eve CEO Johann Bordais told analysts on an Aug. 6 earnings call.

Beta has flown multiple generations of its propulsion and lift electric engines on conventional- and vertical-takeoff-and-landing (VTOL) and eVTOL versions of its Alia electric aircraft. The U.S. startup is now certifying its H500A propulsion motor with the FAA, with the V600A lift motor to follow.

Eve's eVTOL configuration has eight lift propellers on wing booms and a pusher propeller for cruise propulsion. The original Nidec lift motors

they bring engineering and production expertise."

Beta brings a startup mindset and "adds agility to our program with a proven and tested track record of lift-plus-cruise eVTOL flights along with their strong relationship with the FAA," Bordais added.

Beta became the first manufacturer to accomplish transition between vertical thrust-borne and horizontal wing-borne flight with a piloted eVTOL in April 2024; its Alia A250 demonstrator flew on both the V600A lift and H600A propulsion motors.

Eve has tested the pusher propeller on the full-scale prototype and has now installed and powered up the first Nidec lift motors. These drive a two-blade lift prop on the prototype, but Eve has moved to a four-blade propeller for the conforming aircraft.

The new propeller is fixed pitch, with a mechanism that scissors the blades

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Cutting Complexity

Nacelles adapt to accommodate electrification and increased performance requirements

PAUL SEIDENMAN AND DAVID SPANOVICH | SAN FRANCISCO

The next generation of nacelles is evolving as new materials become available that promise greater durability, resistance to the effects of harsh operating environments and weight reduction. At the same time, modern nacelle architecture is transitioning toward fewer moving parts as the industry trends toward more electrification and less hydraulics.

the fan cowls, inlets and thrust reverser assemblies on the Boeing 787, Airbus A350 and A320 and the Embraer E2 regional jet family, she says.

“Collins Aerospace is working on a thermoplastic nacelle structure to enable faster production and better durability,” Brabon says. “We have already achieved Technical Readiness Level (TRL) 9 on nonnacelle thermoplastic structures like fuselage

manufacturing, reducing the industrialization footprint and capital investment. “These new materials have also shown improved time on wing and better resistance to harsh operating environments, making them promising for future applications,” she says.

François Fermat, sales and business development manager for Vallair’s aerostructures and engines divisions, predicts that modern nacelles will increasingly rely on thermoplastic composites, as well as ceramic matrix components and carbon-fiber-reinforced polymers.

“Early service data has been encouraging across all fronts,” Fermat says. “These materials offer durable performance, reduced weight and reliability under harsh environments.

Vallair expects next-gen nacelles to rely more on thermoplastic composites, ceramic matrix components and carbon-fiber-reinforced polymers.



VALLAIR

Thermoset and thermoplastic composites continue to displace metal for nacelle fabrication, says Joanne Brabon, executive director of engineering for aerostructures at Collins Aerospace. She says that both thermoset and thermoplastic composites offer a 20-30% weight savings compared with metallic nacelle structures. Current applications include

brackets and clips, which are now flying on the A350 and 787. Now we are ramping up production of the first stamp-formed parts for nacelles.” TRL 9 is the highest level of technical maturity, indicating that a product has been developed and validated for commercial deployment.

Brabon adds that thermoplastics also enable high-rate, repeatable

However, the biggest lessons learned revolve around managing fatigue crack growth, oxidation and proper attachment interfaces. So far, Vallair observes, operational experience supports their longer-term viability by reducing maintenance requests.”

Jim Berberet, AAR Corp.’s senior vice president of component services, reports that new-generation nacelles

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are using more one piece-type composite construction in fan reverser fabrication, to cite one example. “But those composite assemblies continue to be dependent on proper internal cooling and clearances within the engine areas to prevent over temperature exposure,” he cautions.

Ceramics is another material of interest for application to nacelles and other metallic structures. In the case of nacelles, that is not likely to happen in the near term, Brabon says. Yet they may have some nacelle application in the long term.

“There is currently no plan to implement them on nacelles, due to their cost and limited rate-capable production process for large structures,” she says. “It’s difficult to beat the light-

reverser, for improved aerodynamic and reliable nacelles.

“Switching from pneumatic to electric anti-ice heating reduces mechanical failure points and safety risks while allowing for a lighter design,” she says. “Electric actuation in thrust reversers also removes the need for hydraulic fluids, pumps and valves, enhancing reliability and aircraft availability.”

Brabon also cites Collins’ electric thrust reverser actuation system (elecTRAS) as a new nacelle development. She explains that, unlike traditional hydraulic or pneumatic systems, the electrically operated elecTRAS reduces the need for ducts, tubes and fluids. This, she says, cuts system part complexity and weight 15-20% and simplifies maintenance.

coque structures to reduce fasteners and joints. “Combined with streamlined designs, part count minimization and simplified control systems, Vallair sees the industry is on track to continue reducing nacelle weight—thereby enhancing fuel efficiency, lowering emissions and reducing the cost of production,” he says.

Berberet at AAR Corp. notes that nacelles are increasing in size to support widebody aircraft engine diameters. “Lighter-weight composite bondments using one-piece designs eliminate fastener rows, and brackets allow for weight reduction,” he says. “Redesign of cascade vanes with lightweight metal and composite have provided for weight reduction of structure.”

NOISE CONTROL

Engine noise suppression measures account for several promising nacelle design developments, according to Fermat. Two he cites are the introduction of chevrons for the exhaust nozzle, coupled with advanced acoustic liners for the thrust reverser. The OEMs, he says, are already integrating many of these innovations into next-generation commercial and business jet platforms.

“The size and shape of the new-generation nacelles have been redesigned to accommodate noise suppression,” Berberet says. “The units are larger, and translating cowl lengths have been extended to address the flow of engine fan exhaust air.” He adds that the contours and length of the exhaust nozzle/plug also have been changed to address flow of air exhausting the engine core and fan.

Brabon reports that Collins is “advancing solutions that move the use of traditional perforated honeycomb core sandwich structures to more advanced perforation methods and core technologies that together offer attenuation of a broader range of engine noise and drag reduction.” She notes that Collins is also “evaluating changes” to the inlet geometry and thrust reverser mechanism design to allow for adequate packaging of higher-performing attenuating cores.

ARCHITECTURAL CHANGE

Fermat says nacelle architecture is likely to be considerably transformed by emerging propulsion concepts, such as unducted fans (open rotors), hydrogen combustion and electric

AAR CORP.



AAR says nacelle redesigns are prioritizing noise suppression.

weight and high-strength properties of titanium alloys used in exhaust structures. Still, ceramics for nacelle structures is a technology that will remain under evaluation as part of our longer-term technology road maps and for applications where exhaust temperatures surpass the capability of titanium.”

TARGETING PARTS

In tandem with advancements in nonmetallic materials, nacelles are incorporating lighter-weight materials and fewer parts. In that regard, Brabon says Collins is using more electric components, specifically with application to the inlet and the thrust

She reports that, to date, Collins has implemented elecTRAS on more than 600 A350 aircraft, accumulating close to 11 million operating miles.

“The next generation of actuation builds on [what we have learned] to produce a more robust and compact electric actuation system,” Brabon says, adding that the OEM announced the opening of an elecTRAS center of excellence in Wolverhampton, England, in June.

Reduced parts counts are playing into weight reduction strategies, which, as Vallair’s Fermat points out, is “now core to nacelle development.” Along with thermoplastics, he says, nacelle OEMs are pushing mono-



propulsion systems. “Each of these technologies is reshaping traditional nacelle design so that in the future, nacelles will be system enablers, not just engine housings,” he adds.

Brabon says Collins is working on the next-generation nacelle architec-

ture, with the belief that a high bypass ratio, ducted architecture is the best engine solution going forward. “It offers greater reliability and poses fewer risks compared to open rotor designs,” she explains. “The higher bypass ratios and more aerodynami-

cally optimized nacelle architectures are showing fuel burn improvements that are competitive and that provide unmatched noise attenuation and blade containment capability.”

Collins Aerospace is using more electric components for improved aerodynamics and reliability.

More robust designs of actuation systems and blocker doors have improved on-wing reliability; heat blankets and improved adhesives of bonded components also have contributed to longer life on wing, Berberet says. He adds that nacelle on-wing life will always be driven by engine build-up installation, as it relates to internal cooling, accessory locations and exposure to the elements.

“Actuation system design advancements, along with improved adhesives of the bonded components, have improved durability,” he says. “Elimination of wire mesh in some of the new-generation nacelle designs has reduced early removals and need for on-wing repairs.”

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Lighting Innovations

LINDSAY BJERREGAARD CHICAGO

1. LED Portfolio

COMPANY: Honeywell Aerospace

Product: Honeywell Aerospace has been designing and developing lighting systems for commercial and military aircraft since 1933. Its five active lighting product lines serve most helicopter and fixed-wing aircraft platforms in all market segments. One of Honeywell's most recent lighting products is its LED Searchlight, which incorporates multiple functions in one product to reduce pilot workload. Honeywell says its LED lighting features enhanced optical design, environmental protection, and power and thermal management, which reduces operating costs and weight.

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IFE PRODUCTS

2. PMA Lamps

COMPANY: IFE Products

Product: IFE Products provides plug-and-play LED lamps that replace incandescent and halogen lamps in aircraft exterior applications, such as parabolic aluminized reflector lamps for landing and taxi lights and specialty lamps that replace those in navigation, position and logo light fixtures. The company has FAA parts manufacturer approval (PMA) for LED navigation lamps on several Airbus and Boeing platforms, and it just received FAA approval for an LED navigation light to replace the Boeing 747 lamp 1970X. IFE Products says its lights operate with less power and heat for improved performance reliability.

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OXLEY



STG AEROSPACE

3. Smart Lighting

COMPANY: Oxley

Product: Oxley's LED aircraft lighting portfolio includes a wide range of products for the interior and exterior of aircraft. The company says its lights have an average mean time before failure of 27,000-30,000 hr., and their low power consumption provides more than 70% power savings over traditional halogen lighting products. Oxley recently integrated smart technology into its lighting assemblies to enable predictive maintenance and discrete end-of-life feed-



THALES

back. Korea Aerospace Industries has selected Oxley to develop the complete exterior lighting system for the KF-21. marketplace.aviationweek.com/suppliers/oxley-inc/

4. Retrofit Options

COMPANY: STG Aerospace

Product: A subsidiary of Heads Up Technologies, STG Aerospace designs and manufactures cabin lighting and emergency exit marking systems for commercial aerospace. The company provides retrofit lighting products for more than 300 global airlines, operators and MROs, including its latest product, the Curve LED flexible light. The light can be used for animated effects to adjust light washes that are consistent around curved geometry, such as in galleys, monuments and business-class seats. STG Aerospace says its liTeMood retrofit cabin lighting system is popular for its ability to enable airlines to introduce dynamic lighting effects that match their line-fit color choices. The company says the system can be installed on an Airbus A320 in as little as 6 hr.

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5. Expansive Product Line

COMPANY: Thales

Product: Thales supplies various interior and external lighting products for a wide range of platforms, including helicopters and commercial, regional, business, training, missionized and fighter aircraft. Thales recently upgraded its offering for legacy product lines by introducing LED lighting technologies and improvements to performance and power consumption. The company also recently developed a new generation of helicopter search and landing lights that feature enhanced maneuvering capabilities and what it says is unrivaled lighting performance, weight and dimensions. Thales operates a lighting repair station in Dourdan, France, and offers spare parts from its service center in Montreal. marketplace.aviationweek.com/suppliers/thales/

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Difficult Decisions

Spare engine parts shortages are creating conundrums for engine MROs

ALTON AVIATION



Jonathan M. Berger is a founding partner and managing director at Alton Aviation Consultancy, a global aviation and aerospace advisory firm.

BY JONATHAN M. BERGER

Drive by any engine MRO facility, and you might notice something peculiar: There are just as many commercial jet engines as employee cars sitting in the parking lot. Because of the ongoing global shortage of new and used serviceable engine parts, engine MRO suppliers are loath to begin overhaul until 100% of the planned bill of material has been secured. Otherwise, they risk tying up valuable shop-visit slot capacity with partially disassembled engines.

Parking lots full of unserviceable engines can mean only one thing: grounded aircraft awaiting serviceable engines (called “gliders”). At last count, we at Alton Aviation Consultancy estimate that about 850 commercial aircraft are grounded—amounting to more than \$60 billion in aviation assets sitting idle and not generating revenue.

THE GOLDEN BOLT

Thus far, not even the omnipotent wonders of artificial intelligence can predict every spare part needed during an engine overhaul. In fact, among engine MRO insiders, the critical shortage of spare engine parts has spawned a new MRO industry term: “the golden bolt”—the one unplanned, nearly impossible-to-forecast part failure discovered mid-overhaul that is inevitably on back order (but was historically easy to procure).

No single cause explains the challenges facing the engine MRO industry, but two key drivers are noteworthy:

① New-generation engines are experiencing what engine OEMs diplomatically call “teething pains” in reliability and durability. But for airline operators, the impact of soaring rates of premature, unplanned engine failures feels more like a root canal. Although the arm-waving engine OEMs often emphasize that these so-called teething pains are not unlike those for previous-generation engines (which is factually correct), a key difference exists. The proportion of new-generation engines delivered relative to the

total in-service fleet is dramatically higher, making today’s operational and financial industry pain considerably worse.

② Contrary to the cliché “it isn’t rocket science,” one could assert that the engine MRO industry is, indeed,

Far too many of our invaluable rocket scientists either retired or pursued careers in more stable industries, and it will take a generation to rebuild that expertise.

rocket science. The advanced engineering skills, high-tech manufacturing craftsmanship and use of exotic superalloys that achieve the design tolerances, thrust and fuel burn requirements all require decades of experience and expertise to master. During the COVID-19 pandemic, in a well-intentioned effort to avoid involuntary layoffs, the industry offered generous retirement packages that had a high acceptance rate. The unintended consequence was the biggest loss of institutional knowledge in aviation history. Far too many of our invaluable rocket scientists either retired or pursued careers in more stable industries, and it will take a generation to rebuild that expertise.

Additional drivers of engine shortages include:

- Fewer aircraft retirements that are causing a shortage of used serviceable material while increasing demand for older-generation engine shop visits.
- Extended engine shop-visit turn-around times (TAT) that are creating a severe shortage of spare engines.

IMPOSSIBLE CHOICE

Today’s engine MRO leaders face a difficult decision with no clear winner: rationing scarce engine parts and deciding which customers they will disappoint the most—or the least.

■ Engine OEMs must choose between allocating new engine parts for: (a) new-build engines to support aircraft OEM delivery schedules (e.g., Airbus recently announced it has 60 gliders awaiting engines); (b) MRO shops (see above—parking lots full of engines awaiting induction); or (c) new-build spare engines (see above—airlines with parked aircraft gliders).

■ Engine MRO suppliers must choose which customer engines to prioritize inducting first, despite TAT guarantees.

■ Engine piece-part manufacturers must choose among: (a) which engine model to produce parts for (new-gen, mid-gen or old-gen); (b) which engine OEM; and (c) which MRO supplier.

Every day, engine MRO industry leadership teams must choose the “least worst option” and do their best to limit the operational and financial fallout for their customers and themselves. Until such time as the engine MRO supply chain further stabilizes and institutional knowledge is rebuilt, there is no choice but to continue making thoughtful trade-offs, choosing the least worst option guided by experience, transparency and, perhaps most important, trust. It will not be easy, but it is manageable, provided we all stay calm, maintain a positive attitude and demonstrate a little empathy for our respective industry colleagues. ☛

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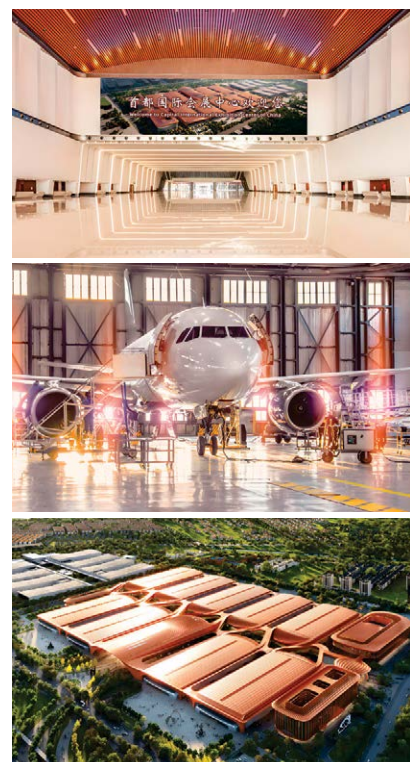
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Portugal Makes Another Attempt To Develop an Aircraft on Its Own

➤ LUS-222 FIRST FLIGHT IS TARGETED FOR LATE 2027 OR EARLY 2028

➤ BRAZIL'S AKAER WILL SUPPLY AEROSTRUCTURES

Tony Osborne Paris

Portugal's first indigenous aircraft is beginning to take shape, and the country's air force has assumed a key role in defining its capabilities and helping bring it to market.

The LUS-222, a twin-turboprop light regional aircraft, is set to enter a packed market. Its competition includes Cessna's 408 SkyCourier, Indonesian Aerospace's N-219, De Havilland Canada's DHC-6 Twin Otter and China's Harbin Y-12. Despite this, the Portuguese companies involved are confident that the LUS-222 can make an impact in both regional and military aircraft markets.

Targeting a first flight in late 2027 or early 2028, the high-wing, fixed-landing-gear LUS-222 has gone through preliminary design review, and its manufacturer, EEA Aircraft and Maintenance, has begun selecting suppliers. Brazil's Akaer is slated to produce aerostructures, including the complete wing, horizontal and vertical stabilizers and all control surfaces, while Pratt & Whitney Canada is to supply PT6 turboprop engines. Several other suppliers remain to be announced; at least three are shortlisted to provide the avionics suite.

EEA is seeking European Union Aviation Safety Agency (EASA) Part 23 standards for commuter aircraft. The manufacturer is designing the LUS-222 to carry 19 passengers or a 2.5-metric-ton (5,500-lb.) payload and fly distances of up to 2,000 km (1,200 mi.).

The airframer is taking lessons from Embraer's C-390 development program, EEA Chairman Miguel Braga told Aviation Week at the Paris Air Show. EEA was formed out of aerospace engineering services company CEiiA, where Braga had served as head of aeronautics and defense. Other organizations in the project include Aero.Next Portugal, an innovation partnership between Portuguese aerospace companies. The LUS-222 is one of Aero.Next Portugal's work packages established to strengthen the country's industrial capabilities.

"The C-390 is a success in the mar-

ket because it has been defined by pilots and developed by engineers, so we are trying to do the same," Braga said.

The Portuguese Air Force joined the project in November as a co-developer, co-promoter and potential end user, Braga said. The service also plans to lead in flight-testing the aircraft, using its experience from developing the NATO variant of the C-390.

The LUS-222 is intended to provide a European answer to Cessna's SkyCourier and other small twin-turboprop airlifters.



Braga noted that the service has a need for smaller transport aircraft, since it retired its CASA (now Airbus) C-212 light turboprops in 2011 and replaced them with the larger Airbus C-295s. The Portuguese Air Force flies many missions with larger, more expensive aircraft than necessary, he said, and other air forces in Europe and Latin America face similar issues.

These will be the key markets addressed by the LUS-222, he said, and with EASA certification, its only true competitor in those markets will be the Cessna SkyCourier, as the Indonesian N-219 and Chinese Y-12 are unlikely to secure EASA or FAA certification. The main difference between the LUS-222 and the SkyCourier—and likely a crucial LUS-222 selling point—will be the Portuguese aircraft's rear cargo ramp, which will appeal particularly to military customers, Braga

said. The SkyCourier has a large cargo door on its port side behind the wing.

Incorporating the rear cargo ramp was challenging, Braga said, because it required a significant change in design that would nonetheless meet the basic parameters of range and payload performance.

"We took a step back to take the aircraft two steps forward. . . . Today we can offer the same range and same cargo load of the SkyCourier, but with the ramp," he explained.

EEA plans to produce the LUS-222 on an assembly line in Ponte de Sor in central Portugal, initially aiming to build 20 aircraft per year.

In addition to developing an aircraft, the program is introducing an entirely new Portuguese industrial capability.

"We are planning to join the list of aircraft manufacturing nations," Braga said. "This is a big step for the country, building the competencies that those countries have."

That process has not been easy. Portuguese industry has sought engineers from across the globe, including many from Brazil, which has helped "accelerate the process and at the same time transfer competencies and knowledge," Braga said.

The LUS-222 is the country's second attempt to produce a homegrown aircraft. Portuguese industry previously teamed with Brazil's Desaer to develop the twin-turboprop ATL-100 airlifter, but the partnership ended in 2021, leading to work on a clean-sheet design that became the LUS-222 (AW&ST Jan. 25-Feb. 7, 2021, p. 22). Desaer is now pursuing development of the ATL-100 on its own. 🇵🇹

EEA AIRCRAFT AND MAINTENANCE

Narrowbody Fleet Renewal in Australasia Gains Momentum

➤ NEW NARROWBODIES EXPAND MAIN PLAYERS' NETWORK OPTIONS

➤ WIDEBODY FLEET GROWTH IS SET TO RESUME NEXT YEAR FOR QANTAS AND AIR NEW ZEALAND

Adrian Schofield Cairns, Australia

Australasian airlines are focused on upgrading their narrowbody fleets this year to tap into strong domestic and international short-haul demand, while widebody additions further ahead will bring major changes to long-haul services.

2019. This reflects the quicker rebound in domestic and close-range international markets versus long-haul travel.

Data from CAPA – Center for Aviation shows that Australia's major airlines—Qantas, Jetstar and the Virgin Australia group—have 261 narrowbod-



Qantas expects to have three A321XLRs by year-end.

Qantas has begun taking delivery of its first Airbus A321XLRs, which will form the backbone of its domestic narrowbody fleet and also offer new international opportunities. Meanwhile, Virgin Australia is set to receive several more Boeing 737 MAXs, and Air New Zealand has boosted its short-haul operations with new A321neos. In neighboring Papua New Guinea, Air Niugini is slated to begin taking delivery of Airbus A220s.

Although these airlines have no widebodies scheduled for delivery this year, both Air New Zealand and Qantas have aircraft due to arrive in 2026 that will enable new long-range flights and cabin products.

Carriers in this region have expanded their narrowbody fleets beyond pre-pandemic totals, but their widebody fleets are still smaller than in

ies in service (see chart). This compares with 234 before the pandemic, including 15 operated by Tigerair Australia prior to its termination in 2020. The major gains in narrowbodies over the past five years have come from Virgin Australia and Jetstar.

The trend has been the opposite for widebodies, with the Australian major carriers now operating 61, versus 79 in early 2020. Virgin Australia cut its widebodies entirely during the pandemic, and Qantas has reduced its widebody fleet slightly.

Air New Zealand, meanwhile, has about the same number of narrowbodies and fewer widebodies compared with early 2020, and some of these are grounded due to lack of engine availability.

Narrowbody numbers in Australia are set to increase further this year,

thanks to new deliveries for all of the main carriers.

"After several years of delays in the delivery of aircraft and global supply chain issues, both the Qantas Group and Virgin Australia are expected to receive new aircraft in the second half of 2025," the Australian Competition and Consumer Commission noted in an August domestic market report. However, the carriers have said their deliveries and redeployed aircraft "will be used to replace leased and older aircraft in the first instance, before considering significant expansions in [domestic] capacity," the commission report stated.

Qantas took delivery of its first A321XLR in June and a second in August. A third is expected in October, Qantas Domestic CEO Markus Svensson said during the CAPA Australia Pacific Airline Leader Summit here on Aug. 1. The airline is due to take delivery of a total of seven of the aircraft type by June 2026.

Qantas has 48 A321XLRs on firm order after exercising more options in August. The group's low-cost subsidiary Jetstar also has XLRs on order, which are due to begin arriving in 2027.

The Qantas full-service carrier will use its XLRs to replace Boeing 737-800s. The aircraft "will definitely be a game changer for domestic and short-haul international" flights, Svensson said.

The XLRs are being deployed initially on domestic routes, but Qantas plans to take advantage of their greater range for international services at some point. No decisions have been made about which international routes will feature this aircraft, but they will be particularly useful on routes where 737-800s have payload restrictions due to range, Svensson said. They can also be used to open new routes.

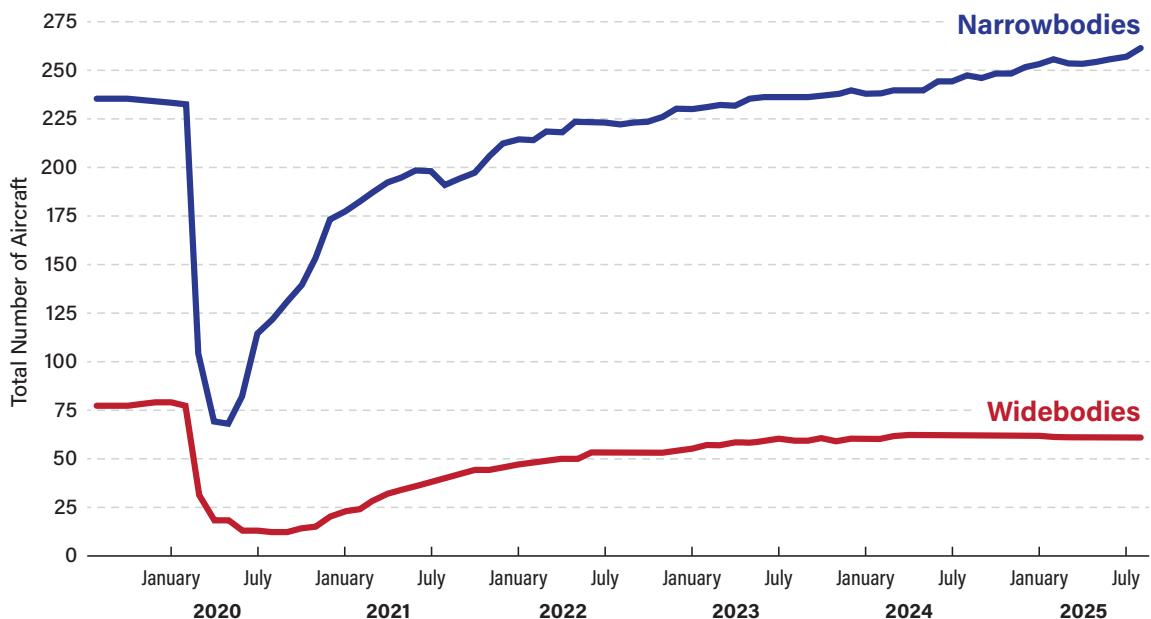
Replacement of the 737-800s will occur over about a decade. In the meantime, Qantas intends to undertake cabin refits on 42 of its 75 passenger 737s.

Like many airlines, Qantas has been forced to adjust its fleet plans due to delivery delays. The carrier has had to keep some older aircraft longer than expected, and plans to lease four more 737s this year to cover for delays to XLR deliveries, Svensson said.

The Qantas Group's fleet will also receive a boost following its decision to close its Singapore-based joint venture

AIRBUS

Aircraft in Service With Australian Major Airlines



Note: Includes Qantas, Jetstar and Virgin Australia Group carriers

Source: CAPA Fleet Database

Jetstar Asia, resulting in the redeployment of 13 Airbus narrowbodies to its Australia and New Zealand operations.

New narrowbodies are also coming into the group's regional business. Qantas ordered 29 A220s for its QantasLink subsidiary, and seven have been delivered so far.

Like its major rival, Virgin Australia is continuing to add narrowbodies and regional jets to its fleet. The carrier is due to receive 16 aircraft in the fiscal year that began July 1, CEO Dave Emerson said at the CAPA conference. These will include 12 737 MAXs, and the remainder will be Embraer 190s to replace Fokker 100s in its regional fleet.

Delivery delays have required the airline to "stretch out its fleet renewal" by extending leases and wet-leasing domestic aircraft, Emerson said.

Virgin has so far received 10 737-8s, which are operating alongside its more than 80 older 737-800s and -700s. The carrier has 29 737 MAX aircraft remaining on order, comprising 18 737-8s, one 737-9 and 10 of the -10 variant.

Virgin conducted an initial public offering (IPO) in June, which reduced majority owner Bain Capital's share of the airline to 40%. Emerson stressed that the IPO was not aimed at raising capital to buy aircraft, because the carrier is doing well financially and is generating enough money to fund its growth and fleet renewal plans. Rather, the IPO was intended to set up

a new ownership structure for the next phase of Virgin's development, he said.

The airline accounts for about a third of the Australian domestic market and will seek to maintain that share level, according to Emerson. Virgin has a much smaller international network than before the pandemic and only operates to a handful of international destinations in Southeast Asia and New Zealand that it can reach with its narrowbodies.

One change coming up for Virgin's narrowbody fleet will be that passengers will soon be able to bring small pets in carriers into the cabin. While this is common in Europe and North America, it will be new for Australia. Virgin has been working through the regulatory requirements and plans to allow pets before year-end, Emerson said.

Air New Zealand has taken delivery of two new A321neos in recent months, one in June and the second on Aug. 13. These are configured for short-haul international flights rather than domestic operations.

The two aircraft will help mitigate a fleet availability shortage caused by global heavy maintenance backlogs on Pratt & Whitney geared turbofan engines. Air New Zealand has five Airbus narrowbodies grounded for this reason, and four of its Boeing 787s are parked due to maintenance bottlenecks for Rolls-Royce Trent 1000 engines.

The narrowbody engine shortage has frustrated Air New Zealand's fleet

and network plans for the past several months, but the arrival of the two A321neos will help the carrier resume growth on its Australian and Pacific Island networks, Chief Commercial Officer Jeremy O'Brien said during the CAPA event. The carrier has also managed to lease and buy some extra engines for its narrowbodies.

Air New Zealand is launching a major push in the Australian market for the upcoming summer season, and its capacity is projected to be up 10% year over year for that peak period, O'Brien said. A new route between Christchurch, New Zealand, and Adelaide, Australia, is due to be launched in October.

Qantas is also making a push in the Australia-New Zealand market. O'Brien noted that demand remains strong there despite intense competition, and capacity between the two countries is still at 91% of pre-pandemic levels, so there is room for growth.

Air Niugini is adding a new narrowbody type: The first of its 11 A220s on order is due in September; CEO Gary Seddon said during the CAPA summit. A second is scheduled to arrive in November and a third in December. The remaining eight aircraft are due by 2028.

The A220s are intended to replace the carrier's Fokker 70 and 100 regional jets. It has nine of these in its fleet, seven of which are in service, according to the CAPA fleet database.

Replacing the Fokkers will allow Air

Niugini to expand its network and increase frequencies, Seddon said. For example, the carrier will be able to operate A220s on some of its international routes alongside its widebodies, such as between Singapore and Port Moresby, Papua New Guinea.

While the short-term focus is on narrowbody additions for Australasian carriers, widebody deliveries will take more of the spotlight in 2026.

These will start with Air New Zealand's next two 787-9s, which are due to arrive in February and March. The aircraft will be the carrier's first to be equipped with GEnx engines, instead of the Trent 1000s powering its current 787 fleet, and they will also have a higher premium seat mix.

The engine and cabin configuration changes will effectively give these 787s greater range, and Air New Zealand intends to use them on its longest route between Auckland and New York. They will have fewer payload restrictions than those required for the carrier's current 787s on the New York route. It will "really change the

commercial dynamics to have fit-for-mission aircraft" operating these flights, O'Brien said.

Another notable feature being introduced on the new 787s will be Air New Zealand's Skynest product, comprising six bunk beds that can be booked for 4-hr. periods by economy passengers. The carrier has yet to divulge pricing, but it will likely be NZ\$400-600 (\$240-350) per sleep period.

Qantas is on track to take delivery of its first Airbus A350-1000s in late 2026, Svensson said. These aircraft have been modified to extend their range, and they will be used to operate the airline's proposed record-setting ultra-long-haul flights between Sydney and both London and New York starting in early 2027 under its Project Sunrise initiative.

The first of these are already in production, Svensson said. Qantas has 12 of the modified A350-1000s on order and has also ordered 12 of the standard version of the -1000 which are due to be delivered beginning in fiscal 2028.

Virgin Australia has not ordered

any widebodies, but it will consider doing so, Emerson said. The carrier began wet-leasing Boeing 777s from Qatar Airways in June, which could be a step toward ordering its own twin-aisle jets.

The 777s allow Virgin Australia to offer flights from Australian destinations to Doha, in partnership with Qatar Airways. This means Virgin can test the long-haul market without having to spend many millions on buying widebodies, Emerson said.

"We will monitor the performance of these flights and see what the economics look like," he said. This will give the carrier an understanding of whether "we have an investment case to put our own capital into long-haul [aircraft]," he added.

Virgin will probably take a couple of years to assess the results from the wet-lease flying, Emerson said. He noted that the arrangement with Qatar Airways has been authorized for five years. The partners will also consider transitioning the wet leases to dry leases. 

Frankfurt Airport Expansion Creates Opportunities for Lufthansa

- A THIRD TERMINAL IS SLATED TO OPEN IN 2026
- LEGACY FACILITIES WILL UNDERGO EXTENSIVE UPGRADES TO MAXIMIZE HUB FUNCTIONS

Jens Flottau Frankfurt

Approaching the new terminal, passengers might imagine that they could easily show up the next day to go to their gates, board their flights and fly away. The access roads and the big parking garage are essentially finished, and shuttle trains connecting the south terminal with the rest of the airport north of the main parallel runways are performing test runs.

The impression is half correct. Although construction of Frankfurt's Terminal 3 is far advanced, the soft opening of the terminal will not happen for another nine months or so, sometime next spring. But when it does open, the terminal will not only add much-needed capacity to one of the busiest and most constrained European hubs but also launch a multi-

year transformation that will include a fundamental revamp of Terminal 2 and its future integration with Terminal 1, Lufthansa's main base.

Frankfurt Airport handled 61 million passengers in 2024, down from its record year in 2019, when more than 70 million passengers passed through the facility just before the COVID-19 pandemic reduced traffic to just 18 million a year later. The crisis led airport operator Fraport to delay the opening of the long-planned Terminal 3 by several years. But now the company believes the timing is right to open the facility.

Terminal 3 will add capacity for about 19 million passengers in its first stage. Fraport can expand capacity to around 24 million later if needed. Frankfurt will therefore soon become one of

the few major European hub airports with ample room for growth. The airport is, however, limited by its complex layout, utilization patterns of its four runways, a strict curfew and constraints in air traffic control (ATC) capacity.

The new terminal operates fully independently from the rest of the field as if it were a separate airport, except that it uses the same runways. It will initially serve airlines that are currently based in Terminal 2. These are mainly non-Star Alliance carriers that have few connecting flows with Lufthansa and the alliance. The group includes Emirates, Etihad and Qatar Airways but also Air France, American Airlines, British Airways, Iberia, Japan Airlines and KLM. These carriers will have not only much more space than in Terminal 2, which was designed for about 9 million passengers annually, but also better connecting opportunities and more space for lounges and retail sites.

The new terminal has three piers. Gates on the G and H piers are for borderless Schengen Area traffic, with positions mainly designed to accommodate narrowbody aircraft. The J pier will serve non-Schengen flights and is therefore planned for widebody air-



Doug Anderson
Leader in Supply Chain
and Operations Practice
- Industrial Products
Sector at PwC



Ozzie Ortiz
Senior Manager -
Aerospace and Defense
at PwC

How Commercial Procurement is Reshaping A&D Supply Chains

With defense prime contractors facing mounting pressure from fixed-price contracts and supply chain disruptions, the shift toward commercial procurement has become critical for maintaining profitability and resilience. Aviation Week spoke with Doug Anderson and Ozzie Ortiz of PwC to learn how this transformation is balancing affordability with mission-critical requirements.

Q Aviation Week: Why are defense contractors shifting toward commercial procurement, and what does this transition entail?

A Doug Anderson: Commercial procurement means acquiring goods and services from the commercial market rather than through government contracts or with specialized procurement requirements. It's becoming the norm as more of the defense acquisition process also moves from cost-plus to fixed-price contracting.

An executive order issued in April is aimed at modernizing the defense acquisition process and emphasizes commercial acquisition. This breaks down barriers for prime contractors to acquire goods and services more efficiently—but it also requires them to rethink how they design, build, test—and produce products by incorporating commercially available parts and components.

A Ozzie Ortiz: Defense primes are making public statements about fixed-price contracts—they're underwater and are shifting the focus from top-line revenue to profitable growth, which requires a deeper understanding of cost and predictability. The COVID supply chain shock turned multi-week lead times into year-plus waits and was further

disrupted with the spike in aerospace and defense demand. Companies are being forced to think differently. You can no longer do business as usual because legacy supply simply isn't available.

Q AW: What are the benefits of transitioning toward commercial procurement?

A DA: The biggest benefit is cost. When you access suppliers producing hundreds of thousands of parts instead of tens or hundreds, their cost structure is much better. We often see 1/10th the cost by switching to commercially available, automotive-grade parts using industry standards like SAE, ANSI, and ASTM.

Second is flexibility and resilience. Instead of relying on one, maybe two suppliers, you have multiple suppliers producing parts. And lead times shrink dramatically—from one to two years to six to 20 weeks—when markets are bigger and production volumes are higher.

A OO: Innovation timelines shorten significantly, too. An example is the eastern EV market which is innovating on two-year product timelines versus the four-years from western OEMs. This speed advantage lets you get products to market quickly and adapt to what the market is buying and out-innovate competitors.



craft. A fourth K pier could be added, should demand justify the extension.

Fraport is negotiating the move of airlines to Terminal 3, including the exact timing. The airport wants carriers to transfer in several groups so that operations can ramp up more slowly in several steps.

One of the more interesting open questions is where Frankfurt's fast-growing second hub carrier, Condor, will operate in the future. The airline is currently in Terminal 1 along with Lufthansa, which has historically provided short-haul feed. But since the two carriers are seemingly parting ways (subject to some legal challenges) and Condor is building its own connecting network, Terminal 3 could be a much more high-quality option for the airline. Although the two terminals are connected by the airport train, depending on the flight combination, some passengers might have to pass through local security again.

The opening of Terminal 3 will kick off the transformation of the existing

Frankfurt's Terminal 3 will have three piers and initial capacity for 19 million passengers.



FRAPORT PHOTOS

therefore provide Lufthansa and the Star Alliance partners a lot of room to expand. Terminal 2 is not designed for connecting traffic now nor does it provide any significant retail space.

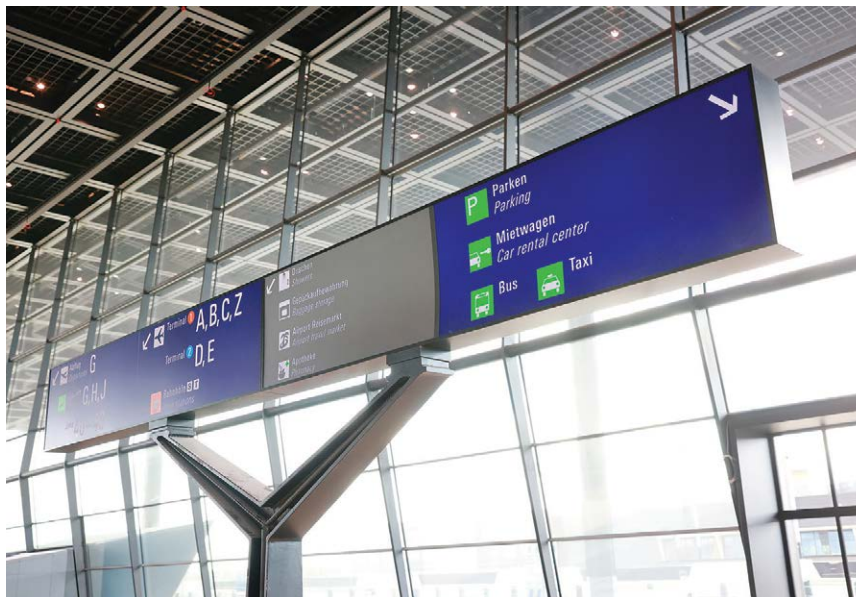
Once the two buildings are integrated, Frankfurt could strengthen its competitive position vis-a-vis

remaining Airbus A380s in Munich along with most of its A350s, which were the first to be equipped with the long-overdue upgraded Allegris cabins. The airline's Frankfurt-based long-haul fleet, meanwhile, is aging and still includes Boeing 747-400s and Airbus A340s. Lufthansa's investment in new subsidiaries outside of Germany—the latest being ITA Airways—also lessens its dependence on Frankfurt.

Airlines that are not part of the Star Alliance will move to the new facility, creating more space in Terminals 1 and 2.

Of course, Terminal 1 is in need of some serious redesign before it can compete with more modern airports. A top Lufthansa priority is relocating security checks further outward to create more space airside for easier movement between A and B gates and to create more retail space. Now that online check-in is amply available and self-drop baggage facilities are abundant, less space is needed for the processing of local as opposed to connecting passengers, Lufthansa argues.

Fraport CEO Stefan Schulte, however, has temporarily stopped the project, arguing that it would be too disruptive for the time being. Sources at the airline say the airport is simply reluctant to fund additional costly construction while it is still completing Terminal 3 and preparing for Terminal 2 upgrades. 🛫



airport in the north, the location for all current facilities except some maintenance hangars and the general aviation base. Terminal 2 will be closed temporarily, renovated and refurbished. While the exact timeline is not clear and the project will likely take several years, the idea is to integrate Terminal 2 more effectively with Terminal 1 and

other European hubs, including the only other German airport following a similar business model, Munich Airport. Lufthansa's second-largest base has greatly benefited from Frankfurt's constraints, including a rocky relationship between the airline and airport operator Fraport. Lufthansa, for example, has based all eight of its

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Christine Boynton Boston

After voicing substantial doubt about its ability to continue as a going concern for another 12 months, Spirit Airlines is pulling out all the stops in a bid to steer the business back to profitability.

by Spirit restructuring its network.”

Rival budget carrier Frontier Airlines is one of those keeping watch, boasting to investors that it will soon have “a lot less low-cost capacity” to compete against. “We are going to be

carrier (ULCC) in 2006 as the model’s pioneer in the U.S.

Today “we kind of think of ourselves as a low-cost value carrier,” John Kirby, Spirit’s vice president of network planning, told Aviation Week in early August. “Our cost structure, while it’s been impacted by the pandemic and some other factors, is still significantly lower than most carriers.”

Burdened by debt, shifting demand and rising costs in the post-COVID-19-pandemic years, what Kirby calls “significant macroeconomic and industry-specific headwinds” pressured the business and precipitated failed merger attempts with Frontier and JetBlue Airways before Spirit’s more recent Chapter 11 restructuring.

“I don’t have an estimate as to when we intend to return to profitability,” then-Spirit CEO Ted Christie told a judge in late 2023, while arguing the merits of a combination with JetBlue, which was ultimately blocked on anti-trust grounds. Spirit began evaluating potential merger partners in 2016, he detailed, concerned that independent growth would be insufficient to compete effectively (*AW&ST* Nov. 13-26, 2023, p. 28).

Its move to file for bankruptcy in November 2024 followed nearly a dozen loss-making quarters, a far cry from the 23.4% adjusted pretax margin Spirit posted for 2015 (*AW&ST* Nov. 25-Dec. 8, 2024, p. 18). But as it faced its future solo, the ULCC estimated it could earn 13% more revenue per passenger if it were “able to successfully rebrand as a higher-value carrier in its current markets,” under a business model pivot dubbed Project Bravo.

Spirit emerged from the restructuring process in March, more focused and with less debt, determined to continue its transformation and position itself for long-term success. Less than six months after that milestone, Spirit is reportedly exploring a repeat restructuring, according to *The Wall Street Journal*. Declining to comment “on market rumors and speculation,” the carrier says it remains “hard at work on many initiatives to protect our business,” focused “on making the necessary changes to better position the company and build a stronger airline.”

But does it have enough runway left?

While reporting its summer-quarter results, Spirit disclosed that minimum liquidity covenants in the company’s debt obligations and credit card pro-



Spirit Airlines, taking steps to cut costs and find new streams of revenue, is working through a network optimization and “leaning very heavily” into where it does well. Meanwhile, its cash burn is being watched closely.

Spirit’s challenges are steep. Overcapacity in domestic leisure markets has put pressure on its ability to fill seats and turn a profit. And aircraft groundings due to Pratt & Whitney geared turbofan (GTF) engine issues continue to plague its all-Airbus fleet. Analysts are eyeing its cash burn with concern as well, and in a crowded domestic leisure market, there is little breathing room as other carriers look to jump on any opportunity.

“The U.S. airline industry seems on the cusp of revolutionary competitive changes with the potential demise of Spirit Airlines,” TD Cowen analyst Tom Fitzgerald wrote in an Aug. 16 report. Noting a material overlap of the carrier’s domestic network with several others, he added: “Airlines are looking to quickly fill any vacuum created

last man standing in the low-cost space when you get to next year,” Frontier CEO Barry Biffle said during the company’s second-quarter earnings call in early August. A few weeks later, Frontier dialed up the pressure by announcing 20 new routes, many into Spirit-focused markets including Detroit, Houston and Fort Lauderdale, Florida.

“As industry capacity adjusts, we want to ensure consumers in those markets continue to have affordable flight options,” Biffle said.

Meanwhile, Spirit has been working to improve its bottom line through initiatives including network shifts and new product offerings. If successful, it will not be the first time the company has evolved to survive, having redefined itself as an ultra-low-cost

cessing agreement would require financial results to improve at a faster rate. If it fails to generate enough cash to comply with the covenants, there will be “substantial doubt as to the company’s ability to continue as a going concern within 12 months,” the company stated in an Aug. 11 filing. The disclosure generated concern, including from its pilot and flight attendant unions, which advised members to examine their options and prepare for all possible scenarios.

The warning was one “required by our outside auditors to convey that there is risk if we do not make changes,” new Spirit CEO Dave Davis later clarified. “But we are.”

The plan, he noted, leans into the carrier’s strengths and away from underperforming elements.

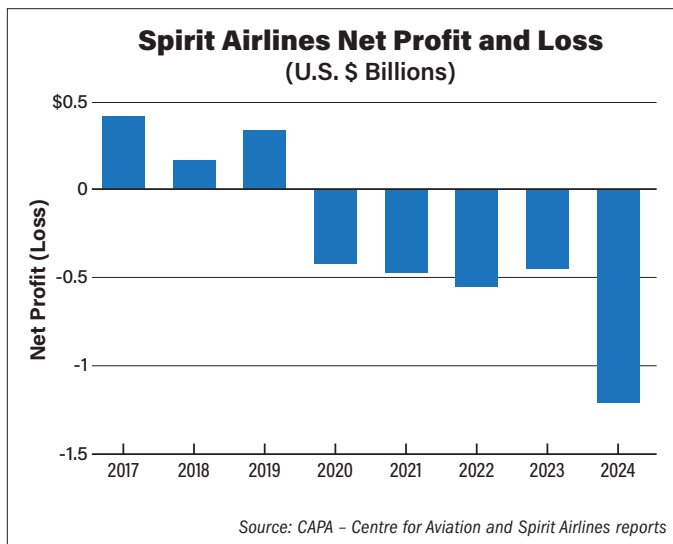
“The team and I are confident that we can build a Spirit that will continue to provide consumers the unmatched value they have come to expect for many years to come,” Davis said, citing improvements to Spirit’s revenue management system and an ongoing network optimization effort to grow into stronger markets such as Detroit, Fort Lauderdale and Orlando, Florida.

The carrier has also re-evaluated less profitable routes and scaled back. Its domestic capacity was 30.6% lower in August 2025 than the same period a year ago, according to OAG Schedules Analyzer. As flight volumes have decreased, the carrier has trimmed its workforce. It announced its most recent round of pilot furloughs in July.

“Those furloughs could be a triggering event,” the Swelbar-Zhong Consultancy states, since they come as other airlines are starting to ramp up their own hiring. Should a volume of pilots choose to leave, “then the demise of Spirit’s network gets accelerated—just like when the network airlines were ‘captain-grabbing’ from the regionals and the ULCCs in 2022,” says William Swelbar, chief industry analyst of the consultancy. “Losing captains ensures an accelerated shrinkage and likely greater than what is planned. . . . If I am a competitor and am hiring pilots, I smell blood.”

Spirit exited the busy summer travel period with a second-quarter operating margin of -18.1%, widened from the operating margin of -11.9% in the same period a year ago, while its operating revenues dropped 20.4% to \$1.02 billion on a 23.9% decrease in capacity. While the ULCC’s total revenue per passenger flight segment increased 7% year over year during the quarter, driven by a 9.6% increase in average yield, its unit costs excluding fuel jumped 19.2% to 8.77 cents per available seat mile on higher salaries and expenses.

The company generated a net loss of \$245.8 million for the three months that ended June 30. In December, Spirit had projected a net income of \$252 million for the full year ahead, according to bankruptcy court filings.



Coming into the second half of the year, Spirit plans to take additional liquidity-enhancing measures, which could include the sale of aircraft, real estate or excess airport gate capacity. It expects new premium offerings to help move the needle, including extra-legroom seats recently installed on about 160 of its aircraft—slightly more than the carrier has in service, accounting for GTF-related groundings and aircraft held for sale. Alongside continued realignments to its network, new offerings “are expected to support pricing premiums and generate higher per-seat revenues,” the company said.

At the end of the second quarter, the ULCC had \$682.5 million in liquidity, including \$407.5 million in cash and equivalents and \$275 million available under a Revolving Credit Facility,

an amount it has since borrowed.

The financing “provides us with additional cash as we work to return to profitability,” Davis told staff in an Aug. 21 email. The cash also supports terms of a new agreement with credit card processor Elavon, a U.S. Bank subsidiary, which had requested additional collateral in order to renew the agreement that is set to expire Dec. 31.

A resulting two-year extension gives Spirit “long-term certainty,” Davis told employees. “This agreement reaffirms support from a key financial partner in our plan to move the airline forward.”

While the latest two moves to borrow cash and renew its credit card processing agreement might buy the carrier some time, the company’s cash burn is being watched closely. Citing the difficult operating environment,

Moody’s Ratings forecasts Spirit “will burn more than \$500 million of cash in 2025,” which could “result in the company violating its minimum liquidity covenant of \$450 million as early as the end of 2025, barring any liquidity raises.”

The ULCC “needs further assets sales (or partner concessions) to sustain beyond early December,” Raymond James analyst Savanthy Syth writes. “Importantly, we believe lessors are highly incentivized to work with Spirit given the large size of the leased-aircraft fleet.”

Roughly 75% of its fleet is leased, the Aviation Week Network’s Fleet Discovery database shows.

Looking ahead, Spirit still sees room for growth in the crowded domestic marketplace—although perhaps more niche than obvious. And it believes low fares still stimulate demand—but perhaps not to the level they once did. It intends to capitalize on opportunities that might arise as it closely monitors market dynamics.

“We’re continuing to make changes to strengthen our airline,” Davis told employees while announcing Spirit’s latest steps. “When we have more news to share, you’ll hear it directly from our leadership team. Let’s keep running a safe operation and taking care of each other and our guests.”

—With Lori Ranson in Washington

Blue Sky Thinking

> CALLS TO ACTION ON CUTTING CONTRAILS GROW

> MITIGATION PLAN PROPOSED TO UK GOVERNMENT

Guy Norris Colorado Springs



AVIATION STILL HAS an opportunity to mitigate the impact of contrails on atmospheric warming—but the clock is ticking and time is running out, an international research study warns.

While there remains some uncertainty about the global effect of contrails—the clouds formed by high-flying aircraft—the use of sophisticated atmospheric modeling indicates that “the contrail formation of aviation is either a big problem or a very big problem,” says Robert Miller, director of the University of Cambridge’s Whittle Laboratory in Cambridge, England.

For the study, researchers in the UK, U.S. and South Africa evaluated global temperature changes associated with contrail avoidance projected until 2050 using the Aviation Climate

and Air Quality Impacts model. This tool, which is used by the Whittle Laboratory’s Aviation Impact Accelerator (AIA) project at Cambridge University, among others, quantifies the temperature impacts of aviation, including contrail warming effects and CO₂.

“If no avoidance is adopted, aviation is projected to contribute 0.1K [0.1C/1.8 F] of warming by 2050: 0.04K from CO₂ and 0.06K from contrails,” states the study, which Cambridge University produced with a team from Kirkland, Washington-based Breakthrough Energy; the Cambridge Institute for Sustainability Leadership; Imperial College London; the Washington-based International Council on Clean Transportation; and the University of Pretoria in South Africa.

Although previous research has focused on the climate effect of contrails

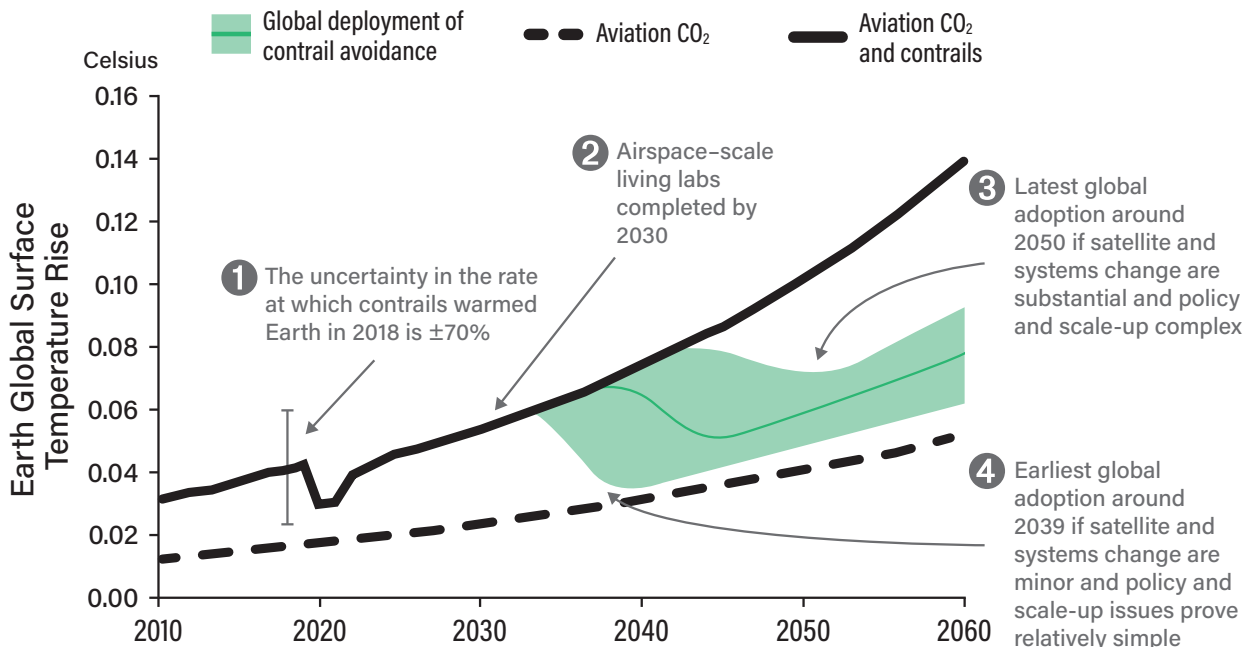
or the effectiveness of contrail mitigation measures, this appears to be the first study to look at the impact of navigational contrail avoidance in terms of global surface temperature rise.

Every year of inaction raises the likelihood of a “significant climate risk,” states the paper, which found that the projected temperature rise if no steps are taken represents 20% of the difference between current temperatures and the 2C limit above pre-industrial levels. This is around “20% of our remaining temperature budget,” it adds, referencing the global surface temperature rise limits targeted by the 2015 Paris Agreement.

Cutting contrails could present a chance to harvest low-hanging fruit in terms of atmospheric warming, but the benefit will be meaningful only if action is taken quickly, the paper adds. “An avoidance strategy phased in over 2035-2045 may recover 10% of this budget, but a 10-year delay may reduce this to 2%,” the authors write.

“When the additional CO₂ emitted during avoidance is accounted for, there is less than a 0.01% chance of a net warming,” the paper also notes. “For every year of delay, the world will be on average 0.004K hotter in 2050.

Operation Blue Skies Proposed Contrail Avoidance Plan



Source: Aviation Impact Accelerator

The most significant climate risk associated with contrail avoidance is therefore inaction.”

The AIA, which develops tools to help policymakers and the industry move toward sustainable aviation more quickly, is meanwhile advocating for a five-year international plan dubbed Operation Blue Skies to kick-start contrail mitigation. The plan involves establishing large-scale airspace blocks, or “living labs,” around the world in which contrail mitigation procedures could be tested and results verified. The labs would be strategically located to represent diverse climate conditions, varying degrees of airspace congestion and different regulatory environments.

Each lab would be large enough to represent real-world networks, air traffic control and aircraft proximity accurately. Unlike preliminary contrail avoidance trials in Europe and the U.S., the Blue Skies labs would be targeted at operations that ensure statistical significance, independent verification and the use of control aircraft. Data from the trials would be transparently shared, reviewed and overseen by an independent nongovernment organization.

“This gets us on the right path to make this a reality,” Miller says. “We need to learn by doing. This is a problem [with] multiple forms of uncertainty. So imagine this a bit like a medical trial, where you go through stages,

where you start the process and you must systematically learn exactly what you need to do through the process.

“We hope that the first one of these will be launched in the UK, and we are encouraging the UK government to go ahead with this,” Miller continues. “There’s hope that maybe next year we could start something. We believe over five years, starting immediately, we need to launch three [or] four of these wide, airspace-scale living labs, and if they can report by 2030 or before, then we could start a global deployment system.”

The estimated speed of deployment varies significantly depending on the extent of changes that will be needed in air traffic management and operational systems, as well as policy. Scaling up operations will also take time, the AIA says. Other key factors affecting the timescale include technological aspects, such as the potential deployment of airspace monitoring satellites to view contrails or aid in forecasting areas of persistent trail formation. In a best-case scenario, the AIA predicts global adoption could be as early as 2039, while longer policy and scale-up changes could delay implementation to 2050.

Deployment could reduce the temperature of the planet even marginally, Miller says. “There are only two ways of dropping the temperature of the planet: One is to take carbon dioxide out of the atmosphere and put it under-

ground, and the other one is to turn off contrails,” he explains.

The AIA plan also recognizes several severe challenges. “There are thousands of people from all different parts of the aviation sector who are going to have to change their behavior, and how you do that is partly a psychology game,” Miller says.

“Some pilots will be very enthusiastic,” he adds. “Others will just find it an annoyance. There will be the ones that are flying over the UK, that have come from over Russia and from the Far East—what are they going to care about what you’re doing? So we need ways you can encourage that.”

Congested skies, incentivizing operators, operational changes and determining whether a contrail would have formed if no avoidance had been taken are all seen as key focus areas for action to help accelerate implementation.

The plan also seeks to dispel several myths, including the assertion that the warming impact of burning the extra fuel required to avoid contrails by flying higher, lower or further will outweigh any benefits.

“The highest warming impact of extra fuel burn from moving planes is between 100 and 1,000 times smaller than making the contrail maneuver—it’s totally irrelevant,” Miller asserts. The plan does, however, acknowledge that added fuel burn and other factors will likely result in an increase in ticket costs of about 1%. ☼

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JASON WELLER

The Vulcan Launch Vehicle Joins U.S. National Security Space Fleet

> THE SPACE FORCE REGAINS ACCESS TO TWO ROCKETS FOR NATIONAL SECURITY MISSIONS

> WORK IS UNDERWAY TO CERTIFY THE HEAVY-LIFT VULCAN VARIANT

Vivienne Machi Los Angeles and **Irene Klotz** Cape Canaveral

Faced with competition from SpaceX and a ban on buying Russian rocket engines, United Launch Alliance staked its future more than a decade ago on a new launch vehicle to serve U.S. national security agencies—its primary customers at the time.

For the U.S. Space Force, that was a turning point. “We officially end our reliance on Russian-made main engines with this launch,” Col. James Horne, Space Launch Delta 30 commander and USSF-106 mission director, told reporters during a prelaunch press conference.

nated in a different geopolitical era. In the 1990s, the Pentagon sought to modernize its space launch capabilities through a new expendable launch vehicle program, leveraging innovations from both industry and foreign partners.

Trade agreements encouraging U.S.-Russia space coordination led to Pratt & Whitney securing exclusive rights in 1997 to sell and produce NPO Energomash's RD-180 through a joint venture, RD Amross, and to establish a U.S. production line by 1998. But the domestic production line never materialized due to cost concerns and schedule delays.

Lockheed Martin used the engine to develop the Atlas V under the military's Evolved Expendable Launch Vehicle program. While the Atlas V and ULA's Delta IV family of vehicles became workhorses for U.S. military launches, RD-180 dependence eventually became a liability the U.S. could not afford.

When Russia launched its full-scale invasion of Ukraine in 2022, importing Russian rocket engines became unacceptable for both U.S. military and commercial launchers. ULA had already revamped its entire business to address the ban and reduce costs, helping it compete better with SpaceX and other launch providers.

Toward that goal, ULA retired its exquisite but expensive Delta IV booster, which did not use Russian engines. The company has 13 Atlas V rockets remaining: six were

purchased by Amazon for Kuiper satellite launches, six by Boeing for Starliner missions to the International Space Station (ISS) and one by ViaSat.

ULA now buys U.S.-made engines for the Vulcan from Blue Origin. The 2022 ban sidelined Northrop Grumman's use of Russian RD-181 engines for its Antares rocket, which is used to launch Cygnus cargo ships to the ISS for NASA. Northrop turned to U.S. startup Firefly Aerospace for a new Antares engine.

Eleven years after Congress first moved to eliminate the RD-180, the Space Force can now call on both the Vulcan and SpaceX's Falcon rockets for NSSL missions. A third offering,

ULA designed the Vulcan with national security space missions like USSF-106 in mind.



The new rocket, named the Vulcan, debuted in January 2024, but it took another 19 months of work and a second flight before United Launch Alliance (ULA) was cleared to launch a national security space mission. ULA, a joint venture of Lockheed Martin and Boeing, fulfilled its longtime goal on Aug. 12, opening a new chapter in U.S. space access.

Built to replace ULA's Atlas V and Delta IV rockets, the Vulcan was designed to launch the Defense Department's most challenging missions, including deploying payloads directly into geosynchronous Earth (GEO) orbit, as was demonstrated during the recent USSF-106 mission.

Congress banned Russian-made rocket engines for U.S. military missions as part of trade sanctions enacted following Russia's invasion of Ukraine's Crimean Peninsula in 2014. The ban directly affected ULA's workhorse Atlas V, which uses a first stage powered by the Russian NPO Energomash RD-180 engine. Congress capped the number of engines ULA could import to complete its U.S. military launch manifest. The last Atlas V to launch a national security mission lifted off on July 30, 2024, leaving SpaceX as the military's sole National Security Space Launch (NSSL) provider for more than a year.

U.S. reliance on the RD-180 origi-

Blue Origin's New Glenn heavy-launch vehicle, is undergoing certification. Its second demonstration launch is planned for Sept. 29.

For its first NSSL mission, ULA's Vulcan lifted off at 8:56 p.m. EDT on Aug. 12 from Space Launch Complex 41 at Cape Canaveral SFS. The multi-manifest mission included a satellite experiment developed by the U.S. Air Force Research Laboratory and L3Harris Technologies as well as an undisclosed payload. With a direct injection to GEO, it showcased the very purpose of the Vulcan: supporting "exotic orbits" primarily used by the U.S. government, ULA President and CEO Tory Bruno told reporters Aug. 7.

The first stage is designed to boost payloads up to two or three times the altitude and velocity of comparable rockets and precisely deliver the upper stage to its desired orbit "already in space and still full of propellant," Bruno noted.

It also marked the first Vulcan launch using four strap-on solid rocket boosters instead of two, the configuration flown during two certification flights on Jan. 8 and Oct. 4, 2024. During the second flight, a nozzle on one of the solid rocket boosters detached, causing a loss of thrust and a slight reduction in total impulse. Despite the anomaly, the Vulcan nailed its target orbit, but the incident and a subsequent investigation delayed its NSSL certification until March 26, 2025.

ULA anticipates at least nine more

National Security Space Launches

Since 2020

Awarded under NSSL Phase 2 Awarded under NSSL Phase 3 Lanes 1 and 2

ORDER YEAR	ULA	SPACEX	LAUNCHED TO DATE
2020	2	1	3
2021	2	2	2
2022	4	4	3
2023	18	16	1
2024	0	2	1
2025	2	7	0
TOTAL AWARDED	28	32	10
REMAINING TO LAUNCH	26	24	50*

*40 Phase 2 launches and 10 Phase 3 launches

Note: Blue Origin has been assigned seven missions under NSSL Phase 3 Lane 2, to be assigned in fiscal 2026, pending full certification of its New Glenn launch vehicle.

Data up to date as of Aug. 28, 2025

Source: U.S. Space Force

missions this year using both Vulcan and Atlas vehicles, pending unforeseen schedule changes, Bruno said. It had earlier forecast more 2025 missions, but delays in the Vulcan's NSSL certification pushed its start later into this year. At least two Space Force missions for GPS III satellites, initially slated for the Vulcan, were ultimately launched by SpaceX.

The company plans to ramp up to two launches per month by year-end and sustain that tempo through 2027.

Bruno said the company is targeting 25 or 26 missions annually in the next two years, with a 60-40 split between commercial and government customers.

The six-booster Vulcan variant remains to be certified. It will debut carrying 45 satellites for Amazon's Kuiper constellation to low Earth orbit, which is expected by late 2025, Bruno said. That launch will count toward the "Heavy" version's certification, but further Space Force analysis and review will be required, Horne said. 🌐



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AVIATION WEEK
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Golden Dome's Rapid Timeline Collides with Industry Funding Fears

- > SPACE FORCE TO ISSUE SBI PROTOTYPE SOLICITATIONS
- > INDUSTRY SEEKS CLARITY ON ACQUISITION STRATEGY BEFORE MAKING A MOVE

Vivienne Machi Los Angeles and Huntsville, Alabama

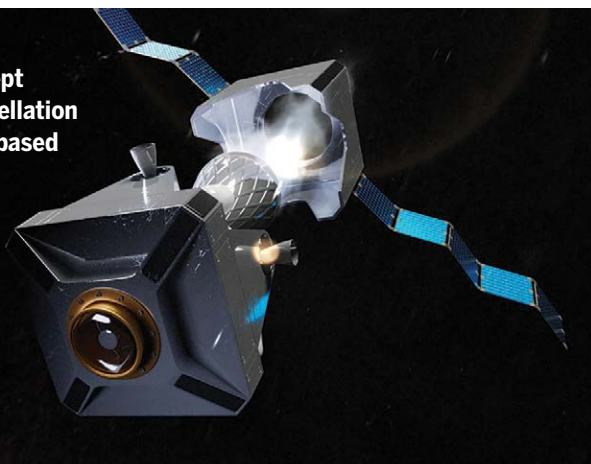
In a race to meet the White House's aggressive deadlines for an operational Golden Dome system, the Defense Department is mulling an unconventional acquisition strategy to field space-based interceptors.

As the most ambitious part of the layered missile defense architecture, a fleet of space-based interceptors (SBI)

or demonstrations, along the way.

The office is seeking industry feedback before finalizing an acquisition strategy, the representatives tell Aviation Week. Such a proposal is a tough sell, particularly for smaller companies with promising but still emerging technologies or for those that must justify their investments to shareholders.

Booz Allen Hamilton's Brilliant Swarm concept would include a constellation of up to 2,000 space-based interceptors.



BOOZ ALLEN HAMILTON

capable of shooting down adversary missiles in their boost or midcourse phases could redefine how the U.S. defends itself against emerging ballistic and hypersonic threats.

The U.S. Space Force plans to solicit prototype designs in early September and to award multiple fixed-price, Other Transaction Authority prototype contracts by October leading to on-orbit demonstrations anticipated as early as 2028.

The core of the proposed strategy—requiring prospective partners to self-fund their SB prototypes for several years ahead of the on-orbit demonstration—has generated apprehension among industry players, according to representatives from four companies that attended an industry day hosted by the Space Force's Space Systems Command in Los Angeles on July 31. Participants may have limited opportunities to recoup funding via prizes awarded for completing certain gates,

ers. Meanwhile, companies with deep, venture-capital-backed pockets could have a sizable advantage, they say.

The Defense Department issued a memo in April directing acquisition leaders to buy commercially available products to the "maximum extent possible." The Pentagon has historically practiced cost-sharing with industry for dual-use capabilities that could offer a commercial return on investment.

But the Golden Dome SBI program has only one buyer and one mission, limiting ways for companies to recoup substantial upfront costs, Chris Bogdan, executive vice president at Booz Allen Hamilton, tells Aviation Week.

The proposed strategy as described at the SBI industry day is "puzzling," says Bogdan, a retired Air Force lieutenant general who oversaw the Lockheed Martin F-35 Joint Strike Fighter program and attended the event. Interested vendors understood that some cost-sharing would be necessary,

but "we didn't expect we were going to have to foot the whole bill," he says.

If companies fully fund early-stage development, the government may not own the technology outright, another industry executive eyeing the SBI program notes. Concerns about control of intellectual property were highlighted recently when SpaceX CEO Elon Musk threatened to decommission his company's Dragon spacecraft—used to resupply the International Space Station—amid a spat with President Donald Trump that played out on social media.

A Defense Department spokesperson declined to comment on the discussions held at the industry day. The Pentagon has sought to keep a tight lid on predecisional discussions about the missile defense program, even going so far as to restrict U.S. military leaders from uttering the words "Golden Dome" at the Space and Missile Defense Symposium held Aug. 5-7 in Huntsville, Alabama.

"As we continue gathering information from industry, academia, national labs and other government agencies for support to Golden Dome for America, it would be imprudent for the department to release further information on this program during these early stages, keeping operational security of this endeavor top of mind," the spokesperson said Aug. 26.

Booz Allen is among the companies racing to meet the anticipated call for SBI solutions once a strategy is finalized. In March, it unveiled its "Brilliant Swarm" concept, which envisions up to 2,000 small, networked systems, each acting as both a missile tracking sensor and a hit-to-kill interceptor.

Since then, the company has refined the digital design to be more mission-ready. Originally sized at 40-80 kg (88-176 lb.), the proposed satellites have grown to 300-400 kg, Bogdan says. These larger spacecraft would be maneuverable and fast enough to engage missiles during their boost phase, one of the most vulnerable stages of flight, he adds.

One company that is taking a different approach is LAU Superconductors. It is opening a lab in Huntsville and has designed a space-optimized interceptor launcher based on superconducting magnetic propulsion, a technology that would be well-suited to space ambient temperatures.

The LAU Coilgun could sit atop an

orbital platform and fire kinetic-kill vehicles without the need for traditional rocket propulsion, founder and CEO Wayne Lau says.

The company and its partner, T2S Solutions, have crafted an SBI proposal with plans to deliver two space-capable prototype coilguns by the end of 2026 and launch operational units on dedicated microsatellites or as hosted payloads by 2028. Lau envisions a model of continual upgrades, delivering 2-4 improved units every two years while producing a larger number of current-generation systems. By the end of 2030, he wants to deliver coilguns that can be fitted with any existing kinetic-kill vehicle technology.

However, U.S. superconductor production lags the rest of the world's, as its use cases are limited to magnetic resonance imaging machines, Lau notes. He says the Golden Dome could serve as "a long-awaited catalyst" to scale up U.S. superconductor manufacturing.

Prospective primes are holding their cards close ahead of what will

likely be fierce competition for an SBI contract. Lockheed Martin plans to demonstrate an SBI on orbit by 2028, says Amanda Pound, director of mission strategy and advanced capabilities. Lockheed did not disclose details of its concept.

Northrop Grumman is already testing SBI capabilities, Raymond Sharp, the company's Golden Dome enterprise lead, said during an industry panel at the Space and Missile Defense Symposium, without elaborating on specifics.

Major defense contractors are expressing caution about fixed-price development contracts, especially for unproven technologies, due to the technical risk and potential for cost overruns.

Eric DeMarco, president and CEO of Kratos Defense and Security Solutions, stated in a February earnings call that his company is "not comfortable one bit" with fixed-price development contracts for "bleeding-edge stuff, including stuff that's never been done before," adding, "other companies

do this, and they blow their brains out."

Still, the financial incentives to work on SBI are considerable. The budget reconciliation bill passed by Congress in July included \$15.7 billion for space-focused Golden Dome systems, with \$5.6 billion specifically allocated to SBIs.

For all the uncertainty, the Pentagon's tight timelines also show its determination. The Defense Department views the Golden Dome as a "strategic imperative," the spokesperson said.

Space Force Gen. Michael Guetlein, who was confirmed in July to oversee the Golden Dome for America program, has acknowledged the challenges to fielding SBIs but also expressed optimism that it can be done.

"That technology exists," Guetlein said at the Space Foundation's Innovative Space conference in Arlington, Virginia, on July 22. "I believe we have proven every element of the physics that we can [to] make it work. What we have not proven is, first: Can I do it economically? And then second: Can I do it at scale?" 🗨️

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NASA's Smallsat Mars Mission Gets Another Shot at Launch

> THE AGENCY IS STICKING WITH BLUE ORIGIN FOR LAUNCH

> THE SATELLITES CAN LINGER FOR A YEAR IN L2 ORBIT

Irene Klotz Salt Lake City

When a team headed by the University of California at Berkeley won a NASA contract in 2019 to build and fly a small-satellite planetary science mission, it expected to be off the ground and on its way to Mars in three years.

Collapsing the time between contract and launch was one of the principles of the Small Innovative Missions for Planetary Exploration (Simplex) program, which funded the Mars-bound Escapade mission as well as

for its ride. Launch provider Blue Origin is targeting Sept. 29, but the requirement to meet a planetary launch window—which is what bumped Escapade from its last flight—has been lifted.

After 25 trajectory redesigns, Escapade can launch any time between now and November 2026, an option spawned by that mother of invention, necessity. “It’s been quite the saga,” Escapade Principal Investigator Robert Lillis said on Aug. 11 at the annual SmallSat Conference here.

Officially known as the Escape and Plasma Acceleration and Dynamics Explorers (Escapade), the spacecraft are nicknamed Blue and Gold—Berkeley’s school colors. They are designed to work in tandem, allowing one to be in the solar wind while the other senses what is happening inside the Martian atmosphere.

From highly elliptical 124-4,350-mi.-high orbits, the satellites will make simultaneous measurements of Mars’ magnetic field strength and topology; the distribution of light and heavy ions in the planet’s tenuous atmosphere and surrounding space environment; suprathermal electron flows; and thermal electron and ion densities.

“Having two spacecraft passing through all the different complex plasma regions will enable us to distinguish between spatial and temporal cases,” said Lillis, who also serves as associate director for planetary science at Berkeley’s Space Sciences Laboratory. “If you see something change your data and you only have one spacecraft, you have no idea whether you’ve seen a global change or you just entered a new region. If you have two spacecraft, you can be upstream and downstream at the same time to see the cause and the effect in real time of space weather on Mars.”

In February 2020, just ahead of the COVID-19 pandemic, Escapade got its first launch assignment: a rideshare with NASA’s Psyche asteroid probe on a SpaceX Falcon Heavy. But as soon as NASA named the launch vehicle, the Psyche team realized the Falcon Heavy could be used to shave a year off Psyche’s travel time by launching in a different direction.

“Their launch targets completely changed and totally screwed over Escapade. It was no one’s fault,” Lillis said. “It’s their mission, and we were the rideshare.”

“A major lesson learned is if you are doing an interplanetary rideshare, make sure everyone onboard is going to the same—or at least very close to the same—destination in the Solar System,” he added.

Psyche ended up launching on Oct. 13, 2023, and is en route to a metal asteroid, also named Psyche, located in the Main Asteroid Belt between Mars and Jupiter.

NASA offered the Escapade team an extra \$1.8 million and nine more months to prepare a more flexible mis-

ROCKET LAB



The twin Escapade satellites are being prepared for shipment to Florida for another launch attempt.

the Janus asteroid probe and Lunar Flashlight, only the last of which has flown. The Simplex program has two more lofty goals: world-class science and a budget of \$55 million per mission, not including launch.

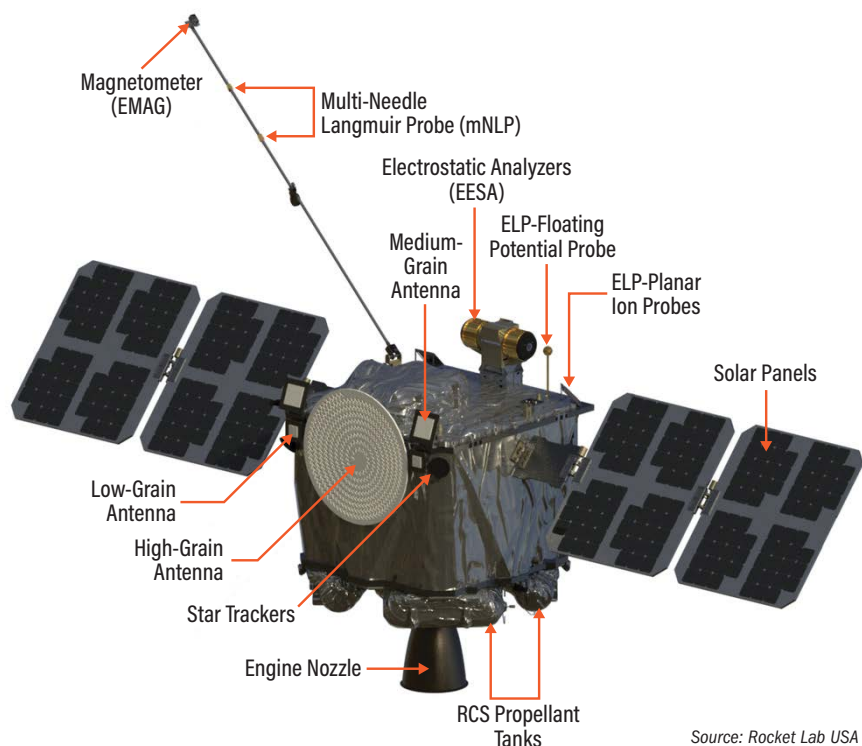
Given all the existing and emerging launch service options, NASA figured it would provide the rides while reaping the scientific bounty and but-tress—and learning—from the U.S. commercial space industry.

Six years and two unfulfilled flight bookings later, Escapade is still waiting

When Escapade started off in 2019, it was intended to fly with NASA’s Psyche asteroid probe in August 2022 and then use its solar electric propulsion system for a long, low-power cruise to Mars.

After capture by the planet’s gravity, the twin Escapade spacecraft would spiral down for a two-part, yearlong science campaign to study how the solar wind interacts with the upper atmosphere of Mars, how those winds drive atmospheric escape and how the planet’s upper atmosphere responds to space weather. Solar wind arriving at Mars encounters the environment very differently than what happens around Earth.

Anatomy of Escapade



Escapade is outfitted with three science instruments to study how the solar wind interacts with and affects the complex environment around Mars.

sion, though the agency did not immediately commit to a new ride. Escapade program managers decided to drop the spacecraft's low-thrust solar electric propulsion system for a chemical system and hire a new company to provide the satellites.

The only viable proposal came from Rocket Lab, which proposed its Photon platform for the mission. "They were the only bus provider that stepped up and said, 'Sure, we can build you two spacecraft for'—I won't give the exact number—but it was a spacecraft-size fraction of the \$55 million," Lillis said. "Ball [Aerospace], Lockheed Martin and others just couldn't do it for that cost."

The original spacecraft provider for Escapade was Terran Orbital, now owned by Lockheed.

"When we redesigned the mission, we didn't have a ride so we had to build this spacecraft to support any number of launches," said Jeffrey Parker, chief technology officer at Advanced Space, an Escapade partner.

Working with NASA, the team considered a host of alternatives to reach

Mars, including flying on a SpaceX Falcon 9 rideshare to sun-synchronous orbit and then going from there to Mars. That would require far more fuel than would be available, but it was an exercise in flexibility and resilience, Parker said.

In February 2023, Escapade was assigned to fly on the debut mission of Blue Origin's New Glenn launch vehicle; liftoff was targeted for September-October 2024. Since it was a new vehicle, it was no surprise that the rocket was not ready to support Escapade's planetary launch window, prompting the team to think even more out of the box.

New Glenn ended up launching for the first time Jan. 16, 2025, with a company-owned technology demonstration onboard. In mid-July, NASA confirmed Escapade's ride for New Glenn's second flight.

The Escapade team can accommodate launch anytime between now and November 2026, when Earth and Mars will next align for the most direct interplanetary flight. "I don't think any mission has ever launched

to Mars when the planets are not aligned," Parker said. "Escapade is proving that you can."

The plan, which the team refers to as "launch and loiter," is intended to first and foremost get the satellites launched. "There are a lot of different pathways we can take to go from Earth to Mars in a launch-and-loiter strategy, but many of them are unavailable for this mission," Parker said.

The current plan is to launch Escapade with just enough force to stay on the cusp of an Earth orbit, with the satellites cycling in a gravitationally stable halo orbit around Lagrange Point 2. L2, as it is known, is a region of space where the gravitational pulls of the Sun and the Moon naturally balance the orbit of a third, smaller object. L2 is located about 1 million mi. from Earth.

"There's a whole family of these orbits, so we have built trajectories to launch from Aug. 11-Dec. 31," Parker noted. "There's a tremendous number of launch opportunities, and it's very flexible."

Escapade's launch opportunities extend beyond Dec. 31, but that is as far as the team has taken the analysis at this point, Parker added during an interview on the conference sidelines.

Rather than an instantaneous launch window dictated by orbital mechanics, New Glenn can lift off with Escapade any time within the same 90-min. window. "The rocket is doing the exact same thing every launch opportunity," Parker said. "We use our fuel to make it easy for the launch vehicle. Given it's a brand-new launch vehicle, we think this is a good way to reduce risk."

The launch-and-loiter strategy also allows Escapade flight controllers to put some time between when each spacecraft conducts critical events, such as the engine burn to begin the interplanetary cruise phase.

"Because we have two spacecraft, we want to spread them out so that one of them passes by the Earth and heads on out to Mars, and then the second one flies by the Earth two days later," Parker said. "When we get to Mars, the spacecraft will arrive two days apart, so one operations team and one navigation team can focus on that particular event."

Beyond Escapade, the launch strategy demonstrates how fleets of spacecraft could set off every few weeks from the same launchpad and fly into

L2 holding orbits. “They could loiter out in space, fly by the Earth when the planets are perfectly aligned . . . and then head off to Mars on the right day,” Parker said. “You can get a whole fleet to follow, and a string of pearls would fly off to Mars.”

From their L2 halo orbits, the Escapade twins would begin their journeys to Mars with a powered flyby of Earth to pick up speed to reach Mars. If the spacecraft can depart L2 for the fall 2026 planetary window, they would be expected to arrive in September 2027. “There are other ways to launch and loiter that don’t use the L2 orbit, and the spacecraft doesn’t have to carry as much fuel,” Parker said. “The Blue Origin solution wasn’t going to work for those, but going into heliocentric orbit and doing a passive Earth gravity-assist is another option.”

With the switch to chemical propulsion and other changes, the Escapade satellites grew to about 1,173 lb. apiece from 265 lb. “They’re not small spacecraft by Earth standards, but they’re the smallest thing we’ve ever tried to

put into orbit around Mars by a long shot,” Parker said.

“By allowing the mass to grow, the cost went down, and part of that was because we got to work with NASA on how to launch this mission,” Parker said. “That’s another lesson learned:

“Escapade is part of an experiment to see if we can do something for about one 10th

of what it would have cost in the past and what success probability we are going to get.”

If you’re a small payload on a rideshare, . . . you don’t have to be as small [in] mass. Just keep it low on the cost.”

Escapade started with a cost cap of \$55 million, which is about a 10th of the starting price of a traditional mission to Mars. “At \$55 million, if we could fly six Escapade missions and if one of

them worked, it would save taxpayer dollars right there,” Parker said.

Launch delays have since added about another \$30 million to Escapade’s cost.

The verdict is still out on whether NASA’s cut-rate Simplex science initiative will be successful. “Escapade is part of an experiment to see if we can do something for about one 10th of what it would have cost in the past and what success probability we are going to get,” Lillis said.

NASA’s first Simplex mission, Lunar Flashlight, launched Dec. 11, 2022, as a rideshare on a Falcon 9. The 6U spacecraft had a propulsion system failure that prevented it from reaching the Moon, where it was supposed to scout and study water ice deposits inside permanently shadowed regions of the lunar south pole.

Another Simplex test case is the asteroid probe Janus, which was originally manifested to fly with Escapade as a secondary payload on Psyche’s Falcon Heavy. Janus is still waiting for a new launch assignment. ☒

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Irene Klotz Cape Canaveral

Iteration in action is sometimes hard to witness. Three times this year, SpaceX tried to test changes to its Starship-Super Heavy launch system, only to uncover other, more pressing issues that needed to be resolved first.

Nine months and four lost Starships later, SpaceX finally collected key flight-test data needed to help bring the planned reusable, refuelable and high-tempo launch system into operational service.

The U.S. space program is banking on a variant of the Starship to land astronauts on the Moon, presumably in 2027 and hopefully ahead of China, a key tenet of the Trump administration's marching orders for NASA.

For that mission, SpaceX needs not only to repeatedly demonstrate Starship orbital flight—which has not yet occurred—but also to develop and perfect large-scale in-space refueling, another first. The Starship-Super Heavy system is designed to carry 110-165 tons into low Earth orbit, then be refueled with liquid oxygen and methane for travel to the Moon, Mars and other destinations.

From a new factory in Starbase, Texas, located near the southernmost tip of the state on the U.S. Gulf Coast, SpaceX plans to manufacture thousands of Starships per year eventually to fulfill founder, CEO and Chief Engineer Elon Musk's goal of establishing a self-sustaining city on Mars.

Being hardware-rich is how SpaceX managed to try four times this year to put a Version 2 Starship through a full-duration suborbital flight test, ending with a controlled splashdown in the Indian Ocean. After three failed attempts—plus a ground accident that claimed a fourth ship—SpaceX finally pulled that off on Aug. 26.

Running two days late due to a ground system leak and then poor weather, the Starship-Super Heavy first stage, powered by 33 methane-fed Raptor 2 engines, ignited at 7:30 p.m. EDT (6:30 p.m. local time), kicking off the program's 10th integrated flight test.

Generating more than 16.5 million lb. of thrust—more than twice the power of NASA's Space Launch System or the legendary Apollo-era Saturn V

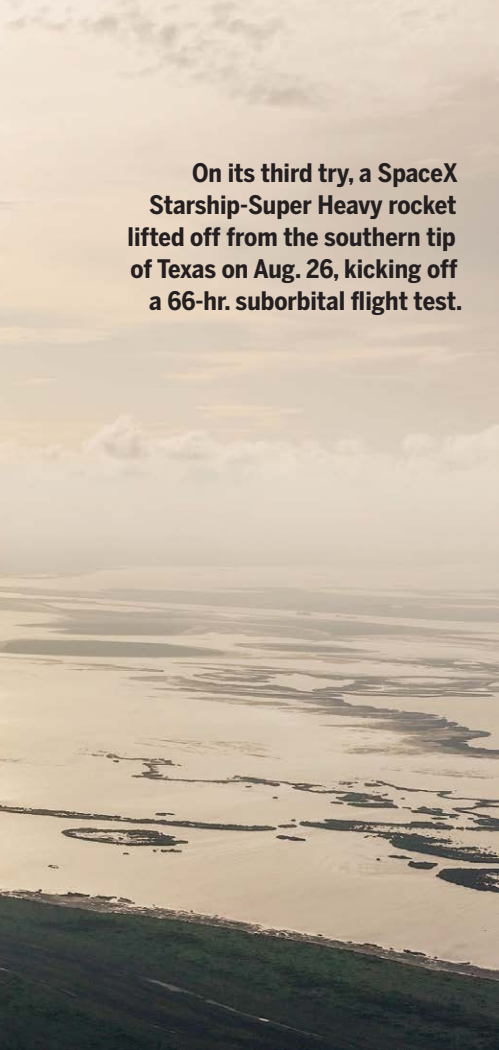
rocket—the 403-ft.-tall Starship-Super Heavy headed toward a suborbital trajectory to begin a 66-min. flight. One engine shut down during ascent, with no discernible impact on the mission.

Two minutes and 36 sec. after liftoff, all but three of the Super Heavy engines shut down, while the six Raptors on the Starship upper stage ignited to push itself off the booster, a technique known as hot-staging.

As the Starship headed to its intended near-orbital trajectory, the Super Heavy completed a controlled flip and then conducted a 12-engine boostback burn to return toward the launch site. The flip maneuver, demonstrated for the first time on Flight 9 in May, requires less propellant to be held in reserve, allowing more lift capacity for payloads.

Three previous Super Heavy rockets returned to the launchpad and were captured in midair by a pair of giant mechanical arms on the tower. SpaceX passed on the gantry landing for Flight 10 so it could test the booster's performance during a simulated engine failure during the critical landing burn.

On its third try, a SpaceX Starship-Super Heavy rocket lifted off from the southern tip of Texas on Aug. 26, kicking off a 66-hr. suborbital flight test.



SPACEX

One of the booster's three center engines was intentionally disabled to test a scenario in which a middle-ring engine would fire up to compensate for the lost thrust. The test ended with just two center engines burning, leaving the Super Heavy to hover for a few seconds over the ocean. When the engines cut off, the booster dropped into the Gulf of Mexico and exploded as expected, bringing its part of the mission to an end.

The Starship meanwhile completed a 6-min. 19-sec. burn of its six Raptor engines to reach near-orbital velocity and an altitude of about 120 mi. The primary object of Flight 10 was to collect data during atmospheric reentry that will enable future Starships to return to the launch site for reflight.

"There are thousands of engineering challenges that remain for both the ship and the booster, but maybe the single biggest one is the reusable heat shield," Musk said during SpaceX's Aug. 25 Flight 10 webcast. "We are confident in making a fully reusable heat shield, but it will require many flights, many iterations to figure

out where the weak points are in the heat shield, where we need to change the design by either strengthening the tile, or changing how big the gap is between tiles, or changing what's underneath the tile.

"There are 100 different variables we could tweak, . . . but the only way to know exactly what we should be adjusting is to fly repeatedly and be able to examine the ship upon landing," Musk said.

The goals of Flight 10, which remained largely unchanged from Flights 7, 8 and 9, focused on the performance of the Starship's heat shield during and after reentry. Ahead of that, the Starship demonstrated a payload-dispenser system that is designed to deploy SpaceX's large, next-generation Starlink satellites.

About 18.5 min. after liftoff, the Starship's payload bay door slot opened, and the first of eight Starlink dummy satellites were released into suborbital space. SpaceX plans to launch batches of 60 Starlink Version 3 satellites on future Starship missions, with each flight adding 20 times the capacity of what a single Falcon 9 can deliver, launch commentator Dan Huot noted.

After the dummy satellites were deployed, one of the ship's Raptor engines was momentarily restarted, a demonstration expected to pave the way for future orbital missions that require deorbit burns.

Flight 10's launch was timed to position the Starship for a daylight descent and splashdown in the Indian Ocean. Several tiles on the ship's heat shield were removed to stress-test vulnerable areas across the vehicle during reentry. SpaceX added multiple metallic tiles, including one with active cooling, to test alternative heat shield materials. The ship also was outfitted with functional catch fittings to provide thermal and structural performance data for future launch tower captures.

The Starship survived the intentionally stressing reentry profile but was not unscathed. A protective skirt around the engine bay was damaged, and a control flap partly melted near the hinge that attached it to the ship's body. Nevertheless, the vehicle remained under control throughout its descent.

The Starship then lit its three center engines for a landing burn and hovered over the ocean and within view of a prepositioned camera on a

buoy northwest of Australia. The ship slowly contacted the water, tipped over and exploded, as expected, bringing Flight 10 to a close.

The demonstration was SpaceX's first full-duration Starship flight test since Flight 6 on Nov. 19, 2024, although not for lack of trying. After successful separation from Super Heavy boosters, Starship upper stages for Flights 7, 8 and 9—which took place on Jan. 16, March 6 and May 27, respectively—were prematurely lost for different reasons.

Flight 7 ended about 8.5 min. after launch due to fires in the Starship engine aft section triggered by propellant leaks from unexpected vibrations.

Flight 8 lasted 9 min. and 30 sec. due to an unrelated engine hardware failure that inadvertently caused propellants to mix and ignite. That set off a series of engine shutdowns and loss of the vehicle.

Flight 9 reached its intended trajectory, but fuel leaks caused the ship to lose attitude control, and it began to spin. The ship reentered the atmosphere in the wrong orientation and was destroyed during reentry.

SpaceX planned to return to flight a month later, but on June 18, the Starship being prepared to fly exploded on a test stand during fueling for a routine prelaunch static fire. The accident destroyed the vehicle and damaged the test stand and surrounding area.

Engineers determined the most probable cause was undetected damage to a composite overwrapped pressure vessel (COPV) in the Starship's payload bay section. The failure of the COPV, which holds gaseous nitrogen for the Starship's environmental control system, led to a structural failure that allowed propellants to mix and ignite.

SpaceX implemented several changes, including operating the COPVs at a reduced pressure. The company said it also added inspections and proof tests, updated its COPV acceptance criteria and developed a new nondestructive evaluation method to detect internal COPV damage.

Starship-Super Heavy flight tests began in April 2023. Musk said Starship refueling demonstrations would begin next year. "This is a great day for NASA and our commercial space partners," NASA's acting Administrator Sean Duffy wrote on X after the flight. "Congratulations to SpaceX on its Starship test." 🚀

CHINA'S HIGH H



EHang is looking to markets outside China, with test flights in Abu Dhabi and elsewhere.

Graham Warwick Washington

Over the past few years, advanced air mobility has taken off in China with the same irrational exuberance as it did in the West—but so far without the pressures of reality that have worn down the hype in Europe and the U.S.

Dozens of startups have sprung up since 2021, all racing to develop electric vertical-takeoff-and-landing (eVTOL) aircraft to fuel China's emerging low-altitude economy, the country's term for a combination of traditional general aviation and novel advanced air mobility (AAM)—in other words, drones and air taxis.

The new entrants are moving fast—much faster than their U.S. and European counterparts. Western startups are taking at least five years from founding a company to flying a full-

scale prototype; Chinese startups are averaging three years or less.

The rapid progress is happening on much less money than in the West. The leading U.S. eVTOL developers have raised billions of dollars. Together, the Chinese startups have raised hundreds of millions. "It takes seven times less to make an aircraft in China," says Sergio Cecutta, partner at SMG Consulting.

There is another key difference. Development of China's low-altitude economy has political support at the highest level. State, provincial and mu-

nicipal governments have announced more than \$15 billion in financial and other support for the country's AAM developers, Cecutta estimates.

Funding raised by startups, pre-orders secured from customers, and investments in manufacturing plants, test sites and demonstration zones generally have come from entities linked to governments that are looking to stimulate China's economy by enabling fast and efficient transportation of goods and people.

Such high-level political support for AAM has been largely lacking in the West. The refusal of German national and state governments to provide loan guarantees forced eVTOL startup Lilium into bankruptcy and rival Volocopter into the hands of the Chinese.

OPES

> STATE SUPPORT IS KEY TO CHINA'S EMERGING INDUSTRY

> MULTIPLE FULL-SCALE eVTOL VEHICLES ARE FLYING

> SMG CONSULTING RANKS THE LEADERS



EHANG

States in the U.S. have stepped up with incentives to attract manufacturers, but national-level support was limited until June 6, when President Donald Trump issued an executive order directing the FAA to launch a pilot program to integrate eVTOLs into the national airspace.

China snatched an early lead in October 2023 when it type-certified the first eVTOL, EHang's EH216-S two-seat multicopter, followed in February 2024 by certification of the first winged eVTOL, AutoFlight's V2000CG CarryAll uncrewed cargo aircraft.

But the Civil Aviation Administration of China (CAAC) is regarded as an outlier when it comes to eVTOL certification, approving the autonomous EH216-S under rules for large uncrewed aircraft that exist only in China. As Chinese startups work to certify their first passenger eVTOLs, they face airworthiness regulations similar to those imposed by the FAA. Progress has slowed.

China Rising Up Global AAM Ranks

Manufacturer	2025 Rank	2022* Rank	Country
EHang	1	7	China
Volocopter	2	2	China owned (2025)
Beta Technologies	3	3	U.S.
Joby Aviation	4	1	U.S.
Archer Aviation	5	6	U.S.
Eve Air Mobility	6	12	Brazil
AutoFlight	7	16	China
Robinson Helicopter	8	—	U.S.
Aerofugia	9	—	China
Wisk	10	5	U.S.
Volant Aerotech	11	—	China
Vertical Aerospace	12	10	UK
SkyDrive	13	—	Japan
ZeroG	14	—	China
Supernal	15	13	U.S.
Ascendence	16	18	France
TCab Technology	17	—	China

*Adjusted to include only passenger eVTOL manufacturers.

Source: SMG Consulting

"China's startups have shown incredible development speed, with some companies going from sketch to full-scale flying prototype in 13 months—unheard of in the West," Cecutta says.

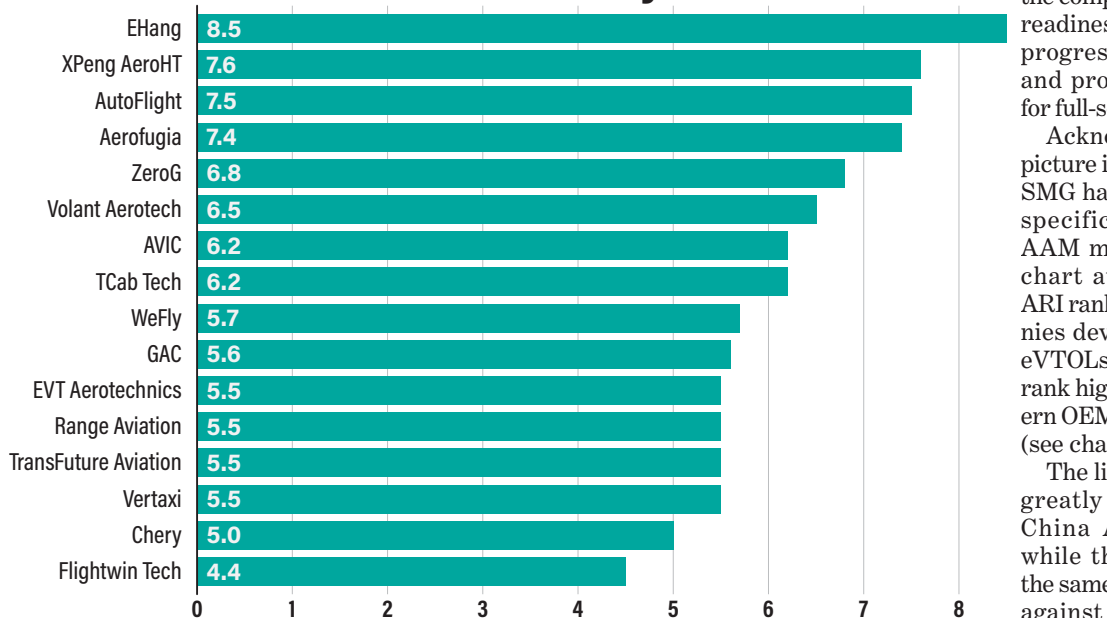
In an effort to track the progress of the nascent industry, SMG Consulting produces the AAM Reality Index (ARI), rating eVTOL developers based

on five elements: funding raised, the team that leads the company, the technology readiness and certification progress of their vehicles and production readiness for full-scale manufacturing.

Acknowledging that the picture is different in China, SMG has produced an ARI specific to the country's AAM manufacturers (see chart at left). The China ARI ranks the top 16 companies developing passenger eVTOLs, some of which also rank highly alongside Western OEMs on the global ARI (see chart above).

The listing has expanded greatly since SMG's first China ARI in 2021, and while the leaders remain the same, their performance against Cecutta's metrics has improved dramatically.

China AAM Reality Index



Source: SMG Consulting

EHang, No. 1 on both the China and the global ARIs, now scores 8.5, up from 4.6 in 2021. A top score of 10 would mean a certified aircraft has entered service and is being produced in very large numbers, Cecutta says.

Guangzhou-based EHang was the first manufacturer to receive type, production and airworthiness certification for an eVTOL. Subsidiary EHang General Aviation and Hefei-based operator Heyi Aviation also were granted the first air operator

certificates for passenger-carrying eVTOLs in March, marking the beginning of China's commercialization phase for AAM.

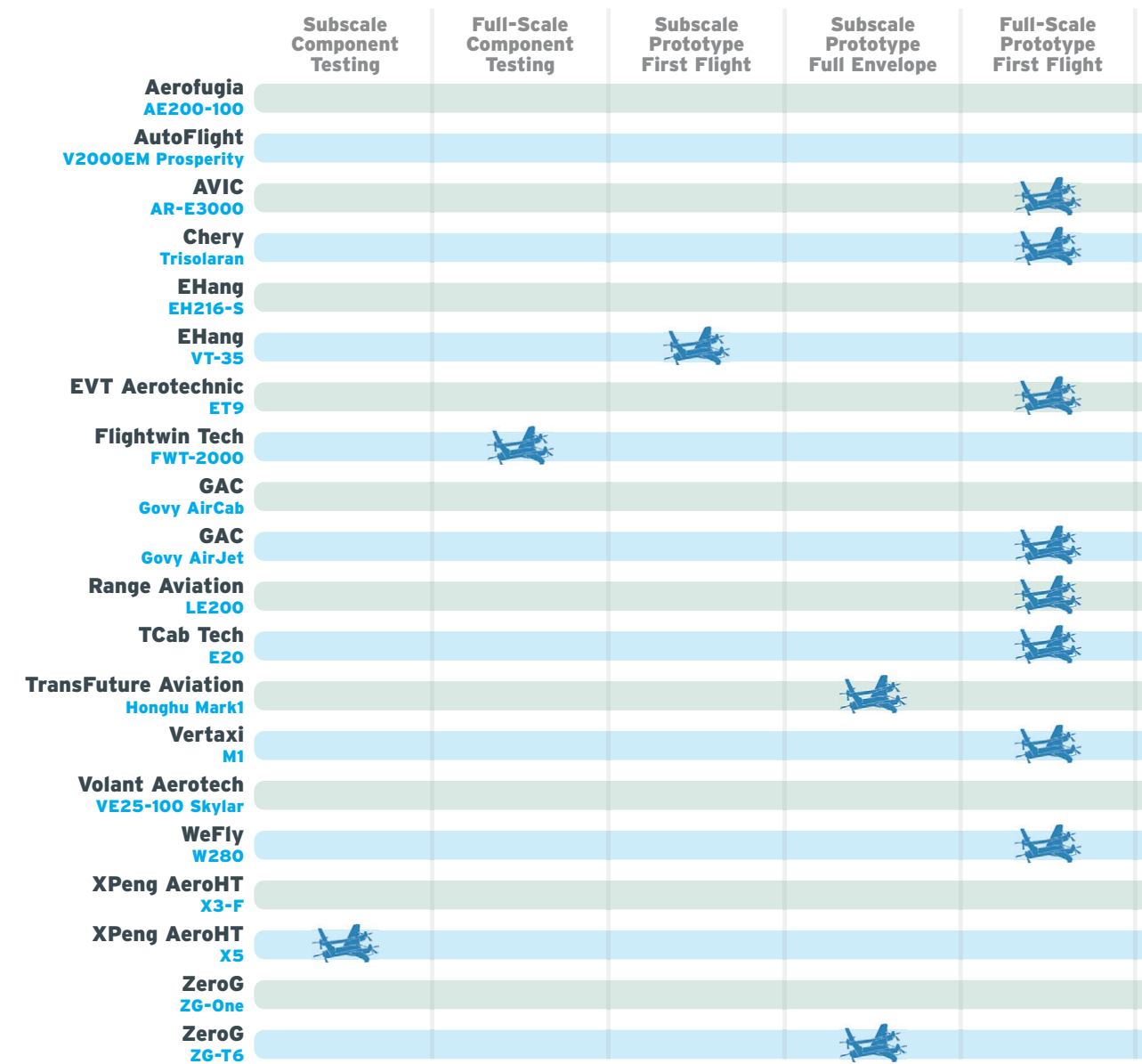
Initially, operations are tightly constrained and limited to aerial sightseeing to minimize risk. "We're adopting a phased strategy, EHang founder and CEO Huazhi Hu told analysts in May. "First isolation, and then integration; first tourism, then transportation; and first pilot projects, then expansion."

EHang and Heyi are rolling out

service in steps, beginning with trial operations with internal staff and invited guests then transitioning to commercial services. Trials have been underway at Guangzhou's Suigang Pier and Hefei's Luogang Park to gain sufficient experience before offering public ticket sales. Customers in other Chinese provinces are moving forward with plans for commercial service, Hu said.

EHang, meanwhile, is scaling up production of the EH216-S, doubling

Aircraft Development Progress



ZeroG is developing the ZG-ONE two-seat multicopter as the first in a family of eVTOLs.

the size of its factory in Yunfu, Guangdong province, and building additional assembly plants in Hefei in Anhui province and Weihai in Shandong province—all in cooperation with entities of the provincial and metropolitan governments. A facility dedicated to the emergency rescue market is planned in Beijing’s Fangshan district. By year-end, the Yunfu plant is



ZeroG

Full-Scale Prototype Full Envelope	Preproduction Aircraft First Flight	Preproduction Aircraft Full Envelope	Conforming Aircraft First Flight	Conforming Aircraft Full Envelope	Type Inspection Authorization	Type Certification
						
						
						
						
						
						
						

Source: SMG Consulting

By the Numbers: China's Leading Passenger eVTOLs

Manufacturer	China ARI	Founded	Location	Vehicle	Configuration	Operation	Pax	Payload (kg)	MTOW (kg)	First Flight	Certification
EHang	1	2014	Guangzhou	EH216-S	Multicopter	Autonomous	2	-	620	2017	2023
				VT-35	Lift + Cruise	Autonomous	2	-	-	2021	-
XPeng AeroHT	2	2014	Guangzhou	XF-3	Multicopter	Optional	2	-	880	2025	2026
				X5	Tiltprop	Piloted	5	-	-	-	-
AutoFlight	3	2017	Shanghai	V2000EM	Lift + Cruise	Piloted	4	350	2,200	2022	2026
Aerofugia	4	2006	Chengdu	AE200-100	Tilt + Lift	Piloted	5	-	2,500	2023	2026
ZeroG	5	2021	Hefei	ZG-ONE	Multicopter	Autonomous	2	-	780	2023	2026
				ZG-T6	Tiltprop	Piloted	5	-	2,500	2025	2028
Volant Aerotech	6	2021	Shanghai	VE25-100	Lift + Cruise	Piloted	4	500	2,500	2023	2027
TCab Tech	7	2021	Shanghai	E20	Tilt + Lift	Piloted	4	450	2,000	2025	2028
AVIC Changhe	8	1969	Jingdezhen	AR-E3000	Tilt + Lift	Optional	3	450	2,600	2025	-
WeFly	9	2022	Suzhou	W280	Lift + Cruise	Piloted	4	-	2,800	2025	2027
GAC Govy	10	2024	Guangzhou	AirCar	Multicopter	Autonomous	1	-	550	2024	-
				AirCab	Multicopter	Optional	2	-	-	2024	2026
				AirJet	Lift + Cruise	Autonomous	6	-	-	2025	2027
EVT Aerotechnics	11	2022	Nanjing	ET9	Lift + Cruise	Piloted	4	500	2,200	2024	2027
Range Aviation	12	2023	Shenzhen	LE200	Lift + Cruise	Piloted	5	600	2,600	-	2027
TransFuture Aviation	13	2022	Changsha	Honghu Mark 1	Tiltprop	Autonomous	6	450	2,500	2024	-
Vertaxi	14	2021	Zuhai	Matrix 1	Lift + Cruise	Piloted	4	500	2,000	2023	2027
Chery	15	1997	Wuhu	Trisolaran	Lift + Cruise	Autonomous	2	-	-	2024	-
Flightwin Tech	16	2008	Beijing	FWT-2000	Tiltrotor	Piloted	4	500	1,500	-	-

Source: Aviation Week, SMG Consulting

planned to have the capacity to build up to 1,000 units a year.

EHang is developing upgrades for the EH216-S, including motors and batteries. In addition to the multicopter EH216-S, EHang is developing the longer-range VT35, an autonomous two-seat lift-plus-cruise eVTOL. Expected to be unveiled this quarter, the VT35 is in full-scale flight testing, and certification is underway with the CAAC. EHang anticipates an expedited certification process, Chief Operating Officer Zhao Wang told analysts.

“On the passenger side, EHang is still all alone in having certified an eVTOL, but they might be joined by many OEMs in the 2026-27 time frame,” Cecutta says. Shanghai-based AutoFlight was the first to certify an

eVTOL weighing more than 1 metric ton when its uncrewed cargo V2000CG was approved in 2024.

The higher maximum takeoff weight—2,000 kg (4,400 lb.)—for the CarryAll, put the eVTOL into a certification category equivalent to the FAA's Part 21.17(b) special class for powered-lift aircraft, breaking new ground. AutoFlight has now received type, production and airworthiness certificates, and it delivered the first V2000CG to operator Heli Chuangxing Intelligent in early August.

The startup is now pursuing type certification of the passenger-carrying V2000EM Prosperity, which uses the same lift-plus-cruise airframe, and approval is expected in 2026. AutoFlight also has broken ground on an assembly facility in Wuhan in

Hubei province, establishing a manufacturing presence in Central China.

AutoFlight, ranked third on SMG's China ARI, and XPeng AeroHT, ranked second, are the best-funded eVTOL companies in China, each with almost three times more money than any of the others, Cecutta says. They are also examples of the strong involvement of China's automotive industry in the low-altitude economy. Electric vehicle (EV) manufacturer XPeng owns AeroHT, and leading EV battery-maker CATL agreed to invest “hundreds of millions of dollars” in AutoFlight in August 2024.

The automotive industry is engaged in the Western AAM market as well. Toyota is the largest single investor in Joby Aviation, and Stellantis is a major backer of rival U.S. eVTOL de-

TransFuture's Honghu Mark 1 is one of a few tiltprop eVTOLs in a market that favors lift plus cruise.

veloper Archer Aviation. But in China, the involvement is on a different scale, and it is direct as well as indirect.

Including XPeng AeroHT, four of the 16 OEMs on the China ARI are subsidiaries of automakers, while others including EHang have collaboration agreements in place with automotive manufacturers or their suppliers.

Chinese automakers see the low-altitude economy as an extension of their existing markets. This is most obvious in the case of XPeng AeroHT, which is developing a combination drive-fly vehicle, the Land Aircraft Carrier, as its first product. The X3-F eVTOL is a two-seat, optionally piloted air module that is carried inside a six-wheel, hybrid-electric recreational vehicle.

Certification testing of the multi-copter X3-F is underway, and AeroHT, which completed a \$250 million Series B funding round in July, is building a manufacturing facility in Guangzhou that is planned to come online in 2026



TRANSFUTURE AVIATION

automaker Geely, owner of Volvo and Lotus. The company is developing the AE200-100, a piloted five-passenger eVTOL air taxi, targeting certification in 2026. The CAAC issued Aerofugia with a CCAR-135 operating certificate for the AE200 in May, similar to the FAA Part 135 rules under which Archer and Joby plan to operate their eVTOLs.

Other automakers pursuing the AAM market include Guangzhou-based GAC Group under the Govy and Chery brands. GAC Govy is developing two eVTOL vehicles: the optionally piloted two-seat AirCab and autonomous six-seat AirJet air taxi. A third eVTOL, the single-seat drive-fly AirCar, was flown in 2024, but its sta-

Of the 16 companies on the China ARI, no fewer than 13 have flown full-scale prototypes, which is a remarkable achievement. Of the 15 Western eVTOL OEMs listed on SMG's global ARI, only seven have flown full-scale vehicles.

Among those developing winged eVTOL vehicles, even fewer have accomplished the key development milestone of transitioning between thrustborne vertical and wingborne horizontal flight at full scale—three Western and three Chinese.

"Transition is difficult all over the world, irrespective of the configuration," Cecutta says. "Of the Chinese OEMs that are not developing multi-copters, only three have transitioned, and they also happen to be who the low-altitude industry in China sees as the eVTOL leaders." The three are Aerofugia, AutoFlight and Volant Aerotech, which is developing the VE25-100 piloted four-passenger eVTOL air taxi.

TCab Tech has extended its preorder backlog for the E20 eVTOL to include a customer in Abu Dhabi.

After a rapid start, the eVTOL industry's pace has slowed as it tackles the challenges of certifying passenger-carrying vehicles. This it shares with Western industry, where target dates for flying certification-conforming aircraft and receiving type inspection authorization (TIA) from the regulator have slipped later and later.

"There are no conforming aircraft flying or on their TIA-equivalent milestone in China," Cecutta notes. For now, the CAAC seems neck and neck in a race with the FAA to type-certify the first passenger-carrying winged eVTOLs, with several Chinese OEMs targeting 2026—the same year being pursued by Archer and Joby, but with a similar risk that the goal could slip into 2027. 🌀

TCAB TECH



and ultimately be capable of producing up to 10,000 vehicles a year.

XPeng AeroHT has announced plans for a follow-on vehicle, internally dubbed the X5, a piloted five-passenger tiltprop eVTOL air taxi, and reports suggest the company may pursue an initial public offering. Among Chinese eVTOL startups, only EHang has gone public thus far, listing in 2019.

Ranked fourth on SMG's China ARI, Aerofugia is a subsidiary of Chinese

tus is not clear. GAC Govy signed an agreement in June with the municipal government of Yichang, Hubei province, to establish a production facility.

GAC ranks 10th on SMG's China ARI, and in 15th place is automaker Chery, based in Wuhu in Anhui province, which is developing a three-part drive-fly vehicle named the Trisolaran (from the Chinese science-fiction novel *The Three-Body Problem*). Flight testing began in 2024.

TECH TAKE

By **Graham Warwick**

For the latest, go to [AVIATIONWEEK.COM](https://www.aviationweek.com)

Elroy Transitions Uncrewed eVTOL

U.S. startup Elroy Air has transitioned its hybrid-electric, vertical-takeoff-and-landing Chaparral between vertical and horizontal flight, a key milestone in development of the uncrewed cargo aircraft.

ELROY AIR



Elroy aims to start extending the Chaparral's range envelope.

Three transition flights have occurred since July 31, Elroy says, with the aircraft autonomously converting from thrustborne vertical takeoff to wing-borne cruise flight, reaching a maximum speed of 70 mph and completing the flights with a vertical landing.

Powered by a turbogenerator and batteries and designed to carry a 300-lb. payload 300 mi., the Chaparral is equipped with distributed propulsion, with eight lift propellers on wing booms for vertical flight and four propellers under the leading edge of the wing for cruise flight.

Since its first flight in November 2023—the first for a turbogenerator-equipped hybrid-electric aircraft—Elroy has modified the Chaparral prototype with three-blade lift propellers and four-blade propulsion props to handle the complex aerodynamic and structural load interactions, CEO Andrew Clare says.

“You have to be able to transition to efficient wingborne flight to reduce the power demands on the system,” he says. “And what we’ve seen in our flight data at this speed is we’re recharging our batteries onboard from the hybrid-electric powertrain, and that is what enables us to do long-distance flights.”

“We have data showing that we achieve a four-times reduction in power

demand once we’re in forward flight, compared to the power demands of vertical takeoff and landing,” Clare says. “[Also] the batteries, the powerplants, everything’s heating up. Now that we’re in efficient cruise flight, our data is showing that our thermal system is cooling everything down.”

“So the reason this milestone is such a big deal for us is that we can now fly as long as we have fuel,” he says. “Our team has already shifted focus to demonstrating long-range flight. We’ll be doing a 25-mi. flight by the end of [August] and then demoing that to our customers and partners in September.”

Having demonstrated the ability to lift 300 lb. in vertical flight, expanding the range envelope will be Elroy’s focus for the next several months.

“We will come back to expanding speed at a future point,” Clare says. “This airplane is designed to cruise well over 100 mph, but the goal was to get to the point where we fully unlocked efficient forward flight and then push on distance, because that’s what our customers care about.”

“By the end of this year, we’re going to be moving cargo from point A to point B, which is going to be an exciting milestone for us and for our customers,” he says. “And then we’re looking toward delivering Chaparrals to customers in the coming couple years.”

Eve To Test Beta Motors on eVTOL

Beta Technologies was founded in 2017 to develop electric propulsion systems, not just electric aircraft, and its engine-first strategy is beginning to pay off.

Rival electric vertical-takeoff-and-landing (eVTOL) startup Eve Air Mobility is to test Beta’s lift and propulsion electric motors on its engineering prototype as an alternative to units from Japanese motor manufacturer Nidec.

“Beta comes in with a proven and mature solution to the distributed propulsion of the eVTOL with the same lift-plus-cruise aircraft configuration, and this will give Eve operating flexibility and optionality in our program,” Eve CEO Johann Bordais told analysts on an Aug. 6 earnings call.

Beta has flown multiple generations of its propulsion and lift electric engines on conventional- and vertical takeoff-and-landing versions of its Alia

electric aircraft. The U.S. startup is now certifying its H500A propulsion motor with the FAA, with the V600A lift motor to follow.

Eve’s eVTOL configuration has eight lift propellers on wing booms and a pusher propeller for cruise propulsion. The original Nidec lift motors are being installed on the full-scale engineering prototype in Brazil after completing extensive ground tests at the supplier’s facilities, Bordais said.



EVE AIR MOBILITY

Eve is ground-testing the four-blade stop-fold lift propeller for its air taxi.

“In parallel, we signed with Beta an agreement to test their propulsion electric motors on our prototype,” he said. “Nidec continues to be committed and involved with our eVTOL, and they bring engineering and production expertise.”

Beta brings a startup mindset and “adds agility to our program with a proven and tested track record of lift-plus-cruise eVTOL flights, along with their strong relationship with the FAA,” Bordais added.

Beta became the first manufacturer to accomplish transition between vertical thrustborne and horizontal wing-borne flight with a piloted eVTOL in April 2024, its Alia A250 demonstrator flying on both the V600A lift and H600A propulsion motors.

Eve has tested the pusher propeller on its full-scale prototype and has installed and powered up the first Nidec lift motors. These drive a two-blade lift prop on the prototype, but Eve has moved to a four-blade propeller for the conforming aircraft.

The new propeller is fixed pitch, with a mechanism that scissors the blades together so that they stop while aligned with the airflow to reduce drag in cruise. “This is a design that generates less vibration and is quieter than the previous configuration,” Bordais said. The new lift prop is being ground-tested on Eve’s truck-mounted propulsion test rig.

The engineering prototype is on track to fly by year-end with both Nidec and Beta motors installed, he said. The first of five planned conforming prototypes

for development and certification testing is expected to fly by the end of 2026, and Eve is still targeting certification in 2027.

Joby Executes Flight Between Airports

Joby Aviation has conducted its first piloted flight between two public airports, the latest milestone to be touted by electric vertical-takeoff-and-landing aircraft developers keen to show their progress.

The pilot-production aircraft flew from Marina to Monterey airports in California on Aug. 13, a distance of 10 mi. Involving a vertical takeoff, transition to wingborne flight and vertical landing, the flight took 15 min., including 5 min. in a holding pattern in wingborne mode at Monterey. Altitude and speed were representative of an air taxi service mission, the company says.

While not the first flight by a piloted electric vertical-takeoff-and-landing (eVTOL) aircraft between two public airports, it was the first to involve a vertical takeoff and vertical landing.

UK startup Skyfly Technologies flew its prototype Axe eVTOL between Turweston Aerodrome and Bicester Airfield in England in July, but the single-seat aircraft took off and landed conventionally. Also in July, Vertical Aerospace flew its prototype VX4 eVTOL from Cotswold Airport to RAF Fairford in the UK, accomplishing the 17-mi. flight in wingborne conventional takeoff-and-landing mode.

“Successfully flying from Marina to Monterey showcased operations of our aircraft integrated in the broader transportation network and further validated its performance to ensure we’re prepared for service on Day 1,” says Didier Papadopoulos, president of aircraft OEM at Joby.

Joby says the ability of its tiltprop S4 to integrate into FAA-controlled

airspace was demonstrated when the eVTOL successfully sequenced with other aircraft at Monterey Regional Airport, including a holding pattern to accommodate an arriving airliner. “A Joby mobile charging station was set up at Monterey Regional Airport, where we landed,” the company says.

Rival startup Archer Aviation says it achieved its own testing milestone on Aug. 18 when it conducted the longest piloted test flight to date of its Midnight eVTOL, with a 55-mi., 31-min. flight in wingborne conventional-takeoff-and-landing mode. The aircraft has flown at speeds up to 150 mph, the company says.

Amprius Sees Drone Battery Demand

Amprius Technologies has delivered silicon-anode lithium-ion batteries to drone manufacturers to meet growing demand for higher energy density to increase endurance and payload. The SiCore batteries are being produced on the company’s pilot line in Fremont, California.

On Aug. 7, Amprius announced second-quarter revenue of \$15.1 million, up 350% year over year, driven by a greater than 450% increase in SiCore shipments. More than 90% of second-quarter revenue came from the aviation sector, driven by increased strength in the drone market.

Amprius was founded in 2008 to develop advanced lithium-ion batteries using silicon rather than graphite anodes to improve performance. Silicon anodes have a higher theoretical specific energy but expand and contract significantly during charging and discharging, causing degradation.

Amprius overcame this challenge by using silicon nanowires, thin filaments of silicon grown on the anode that can expand and contract without damage. This resulted in the SiMaxx battery, which has achieved an energy density of 500 Wh/kg, compared with 260 Wh/kg typical of lithium-ion batteries.

But SiMaxx batteries require special production processes, so Amprius developed a different type of silicon-anode cell, SiCore, that can be produced using standard battery manufacturing equipment. SiCore batteries now in pilot production have an energy density of 450 Wh/kg.

The initial production SA102 SiCore cell was announced in April, and samples from the Fremont line have been supplied to multiple uncrewed aircraft system (UAS) developers for evaluation. These include Airbus subsidiary Aalto, which used the batteries to conduct a record 67-day flight of its Zephyr solar-powered stratospheric UAS that concluded on April 28.



AIRBUS

Airbus Aalto’s solar-powered Zephyr lands after completing a 67-day flight.

“SiMaxx put us on the map,” says Amprius President Thomas Stepien. “It got us to and above 500 Wh/kg, and it’s been the foundation of the company. We introduced SiCore about 18 months ago, and now that has come very close to that energy density bar. What we announced earlier this year is 450 Wh/kg, so not quite there yet.

“The advantage of SiCore is it uses standard lithium-ion processing equipment. SiMaxx is our silicon nanowire technology, and it takes specialized equipment that we’ve developed internally. SiCore has really allowed us to use contract manufacturers around the world,” he says. “So we have seen a strong shift since announcing SiCore of customers saying, ‘Well, if I can get almost the same maximum performance of SiMaxx, let’s go ahead and do [SiCore], because it’s a little bit quicker for us to deliver.’”

Where other advanced battery startups have encountered funding challenges in scaling up production of their new cells, Amprius decided to stay asset-light and work with contract manufacturers. “We have five contract manufacturers that are making SiCore cells for us,” Stepien says. “SiMaxx is only made here in Fremont.”

Amprius announced a contract manufacturing agreement in May with a battery manufacturer in South Korea, which is now tooling up to produce SiCore cells. “Many of our customers are asking for a geographic spread—for supply chain reasons, sometimes for other reasons—outside of China, where four of the five [contract manufacturers] are located,” Stepien says. ☛

JOBY AVIATION



Joby’s pilot-production S4 eVTOL flew between two airports in California.

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AN APPRECIATION

JAMES A. LOVELL

1928-2025

By **Tom Hanks**

During the deep dive into all things Apollo 13 amid preproduction for the film, Jim Lovell took me night-flying in his twin-engine Beechcraft Baron from a grass-strip airfield outside of Austin, Texas. No one was at the airport, so after a pilot check walkaround of the airplane, we took off.

Jim had given me an assignment—to fly his airplane. I am not a pilot. I have no license, although I could be trusted to, well, steer for a while, which I did, but only after he placed a triangle-shape cardboard cutout over my side of the cockpit. The cutout was the same size and dimensions of the window of Aquarius, the Apollo 13 lunar module.

My assignment was to get to altitude, then attitude, find two stars in the night sky and fly toward them. Jim had had to find the same stars during the Apollo 13 mission in 1970 to establish the location and position of the crippled spacecraft, or else he and his crew would have been lost. We had studied the star charts over dinner at his house, with his wife, Marilyn, coaching me.

Finding Antares was a bunt. It's a big star, and I knew where it was in the sky from the Planetarium Astronomy class I had taken during my first year at Chabot College four years after Jim's return from space on Apollo 13. I was able to throttle the airplane, then bank and crab it into a direct line with the big star. "Good," Jim said. "Now find Nunki."

Nunki. Nunki is a very faint dot of light, a star I had never heard of, never seen and certainly never found in the night sky while flying an airplane over Texas. But we had looked at the charts, so after a bit of banking, steering, searching and eliminating other pips of starlight, I saw it in my cutout window, I thought.



Lovell in April 1970 during training for the Apollo 13 mission, intended to be the third to land on the Moon.

"Yep. That's Nunki," Jim said. "Hanks, you were made for flying."

Hah! The highest praise imaginable!

We continued on for another hour. I confessed that, despite the growls of the two engines, flying at night above the glow of Austin and guided by the stars of the cosmos created a sense of peace and place unlike any other.

"Yeah," Jim said. "We keep it to ourselves, or else everyone would be up here. Take us back on 172." He meant the compass heading that would return us to the airfield.

I flew the airplane all the way, descending at the right speed, the right approach, until we were only 500 ft. above the grass.

"I'll take it now," Jim said.

He would safely land the airplane, but first we had to buzz the landing strip to scare off any deer that might be feeding in the night. "Don't want to run into a deer with you in the plane," Jim said. "There'd go the movie." 🐇

*U.S. Navy Capt. (ret.) James Lovell, who died on Aug. 7 at age 97, was selected as an astronaut in 1962 and flew on the Gemini VII, Gemini XII and Apollo 8 missions before becoming commander of the nearly disastrous Apollo 13 mission to the Moon in 1970. Lovell's book, *Lost Moon*, was the basis of the 1995 film *Apollo 13*, in which Tom Hanks portrayed Lovell.*



Lovell received the Congressional Space Medal of Honor in 1995, with Hanks in attendance.

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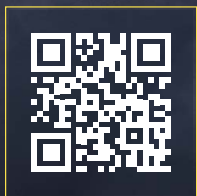
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