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Italy, the UK and other European countries are awaiting integration of the MBDA Meteor missile on the Lockheed Martin F-35.

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ON THE COVER

Now on a European tour, Beta Technologies' Alia is set to make its Paris Air Show debut, and its planned participation in the flying display would mark a milestone for electric aircraft. This year's show at Le Bourget takes place June 16-22. Our special report on European aerospace, including interviews with five of its leaders, begins on page 44. Beta Technologies photo by Brian Jenkins.

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FEEDBACK



BEHIND THE SCENES

A team of Aviation Week Network editors reported from the International Air Transport Association Annual General Meeting in New Delhi at the beginning of June (page 32). Some of them caught up with IndiGo CEO **Pieter Elbers**: (from left) Senior Asia-Pacific Transport Editor **Adrian Schofield**, European contributor **Kurt Hofmann**, Executive Editor for Commercial Aviation **Jens Flottau**, **Elbers** and Managing Editor of Aviation Week's *Arabian Aerospace, African Aerospace* and *Show Business* **Mark Pilling**. Asia-Pacific Correspondent Chuanren Chen (not pictured) also covered the event.

OF SPACE AND TIME

One major issue with trying to use orbital satellites in place of airborne warning and control system aircraft not mentioned in "Rise of Space-Based Aircraft Tracking Spells Threat to E-7As" *(June 2-15, p. 17)* is the matter of keeping the satellites relevant technologically. It is easier and less expensive to fly a terrestrial-based aircraft to a facility to add/replace new hardware than to launch spacecraft to do the same job in orbit. There is also the question of how many satellites would be required to keep watch over an area 24/7, as satellites are constantly moving to stay in orbit.

While a satellite can be placed in geosynchronous orbit (that is, staying over a single terrestrial location), it needs to be placed at a relatively high altitude, resulting in a small but significant signal delay. In the case of a missile attack, that delay would be catastrophic.

In addition, small drones and/or stealthy targets are hard to detect at a distance normally. Moving the radar into orbit compounds the problem.

Space-based radars might be good for spy satellites, but tracking moving targets both on the ground and in the air? That would add time that our warfighters can ill afford to waste.

Jacob Katz, Norfolk, Virginia

NO COMPROMISE ON SAFETY

The FAA is coping with the same issues in 2025 as it was when I worked at Newark Tower in the 1960s and '70s *("Fixing U.S. ATC," May 19-June 1, p. 16)*. I served at McGuire AFB in New Jersey in 1965, and I joined the FAA at Newark Tower in February 1968. Troubles abounded, with shortages of qualified controllers, demanding work rules and traffic volumes that caused stress on individuals and the safety of flight.

The current FAA air traffic control system was designed in the mid-1950s and remains the foundation of today's operational environment. The unrecognized, fundamental failure is the management system supporting and operating the air traffic control system, which still reflects the 1950s-era paradigm. The FAA has demonstrated its inability to cope with the basic staffing, training and operational control requirements. Technology remains outdated, and failures are increasing.

In 1995, Rep. Norman Mineta (D-Calif.) introduced H.R. 1441, a bill intended to address the continued FAA structural problems, create a new and efficient management structure and meet the demands of a growing aviation community. The legislation aimed to transfer the air traffic service from the FAA to a corporation that would charge fees for service and provide for efficient research and planning.

Congress, industry and public agencies should consider this fundamental change without delay. Safety is being compromised.

Maurice F. Connor, retired air traffic control supervisor, Port St. Lucie, Florida

A CALL FOR ARMS CONTROL

In his recent viewpoint "U.S. Defense Mobilization Pathways" *(May 5-18, p. 66)*, Byron Callan failed to suggest government ownership of defense industrial infrastructure.

The demise of America's defense industrial base is simply a reflection of the deindustrialization of America. This was brought about by Reaganomics (unfettered capitalism will always produce the best outcomes), hubris after the collapse of the USSR (the end of history) and globalization (cheapest is always best). This means that perpetuating the fantasies of Willow Run bombers and Kaiser-built fleets is counterproductive.

During World War II, the Defense Plant Corp. (a government entity) owned manufacturing facilities and leased them to private industry. But true "out-of-the-box" thinking would have recognized that nations everywhere, just like at the end of World War I, are overburdened with excessive national debts as the result of the 2008 financial crisis, tax cuts and COVID-19. Instead of beginning a new global rearmament race, an arms control conference (for both conventional and nuclear weapons) along the lines of the Washington Naval Treaty should be initiated.

The world spent $2.7 trillion on defense in 2024, mainly with borrowed money. We live on a planet in peril. To propose spending even more money on weapons is both morally indefensible and fiscally irresponsible.

Guy Wroble, Denver

CORRECTION

The right vertical axis in the graph in "Shaky Ground" *(May 19-June 1, p. 20)* should have been on a scale of 0-5%.

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

WHO'S WHERE



Peder Jungck has been promoted to chief innovation and strategy officer for intelligence and security from vice president and general manager of intelligence solutions at *BAE Systems*, where he has worked for 12 years. Before that, he was chief technology officer of cybersecurity at SAIC and founding CEO and chairman of CloudShield before SAIC acquired it.

CAE has named **Matthew Bromberg** as president and CEO, succeeding Marc Parent, effective Aug. 13. Bromberg joined the company in an interim capacity on June 16. He was corporate vice president of global operations at Northrop Grumman and prior to that was president of military engines at Pratt & Whitney, a subsidiary of RTX. In addition, **Calin Rovinescu**, former president and CEO of Air Canada, has been named executive chairman, while **Sophie Brochu**, former president and CEO of Hydro-Quebec, has been appointed a lead independent director.



Eva Karlsson has been named chief operating officer at *Saab*, effective Aug. 1, and a member of the group management team. She was president of segment land vehicles for Europe, Middle East and Africa at Dometic, before which she worked at Assa Abloy and ABB.

Fairbanks Morse Defense has appointed **Steve Pykett** as CEO. He was president of investment castings and previous to that was president of airfoils at Precision Castparts. He also held management positions at L3Harris Technologies and GKN Aerospace as well as Rolls-Royce, where he worked for 18 years.

Craig Smyth has been named president and CEO of *PrimeFlight Aviation Services*, succeeding Dan Bucaro, who stays on as board chair. Smyth was group CEO of Worldwide Flight Services and CEO of Menzies Aviation.

Precision components manufacturer *Barnes Aerospace* has appointed **George Whittier** as CEO. He held the same title at Fairbanks Morse Defense and prior to that was president and chief operating officer at Morey. Whittier is co-founder and chairman of the Wisconsin Defense Industry Council.



Gary Lew has joined *Aquila Air Capital* as chief financial officer. He is the founder of Capitola Partners and was a senior advisor at Pivotal Corporate, before which he was principal and executive vice president at Vx Capital Partners.

Uncrewed aircraft systems startup *Angels Aircraft* has appointed **Sean Stiefel** chief strategy officer. He is founder and former CEO of hedge fund Navy Capital and had worked at Millennium Partners, Northwoods Capital Management and Barclays as well.

David Lloyd has joined *Emerging Fuels Technology* as chief commercial officer. He was head of strategy at Qantas, where he oversaw sustainable aviation fuel plans for the carrier and helped advance such plans for the Australian government. Before joining Qantas, he worked at Virgin Australia.

Supply chain management company *Incora* has appointed **Michael Turner** chief financial officer, succeeding Ray Carney. Turner held the same title at Vibrantz Technologies, 3D Systems and Innovative Chemical Products.



Craig Skilton has joined *APOC Aviation* as vice president of components. He is founder of Digital Flight, has worked as vice president of supplier development at SkySelect and was head of digital solutions at AJW Group.

Radia, a startup aiming to develop the world's largest aircraft, has hired U.S. Air Force Maj. Gen. (ret.) **Kenneth Thad Bibb, Jr.,** as vice president of business development for defense and U.S. Air Force Gen. (ret.) **Mike Minihan** as a strategic advisor. Prior to retiring, Bibb was deputy inspector general of the Department of the Air Force and prior to that was commander of the 18th Air Force in Air Mobility Command. Minihan was commander of Air Mobility Command and before that served in Indo-Pacific Command and United Nations Command.

Randy Jones has joined *Nighthawk Flight Systems* as vice president of sales and marketing. He was an aerospace and defense sales executive at Craftsmen Industries and previous to that worked at Kalogridis International, LINK and Sagevision Business Development.

Gulfstream Aerospace has promoted **Juan Hernandez** to vice president of field support from director of technical support. He has worked on Gulfstream's technical operations team since 2008. Before joining the company in 1998, he served in the U.S. Army, where he was an avionics technician.

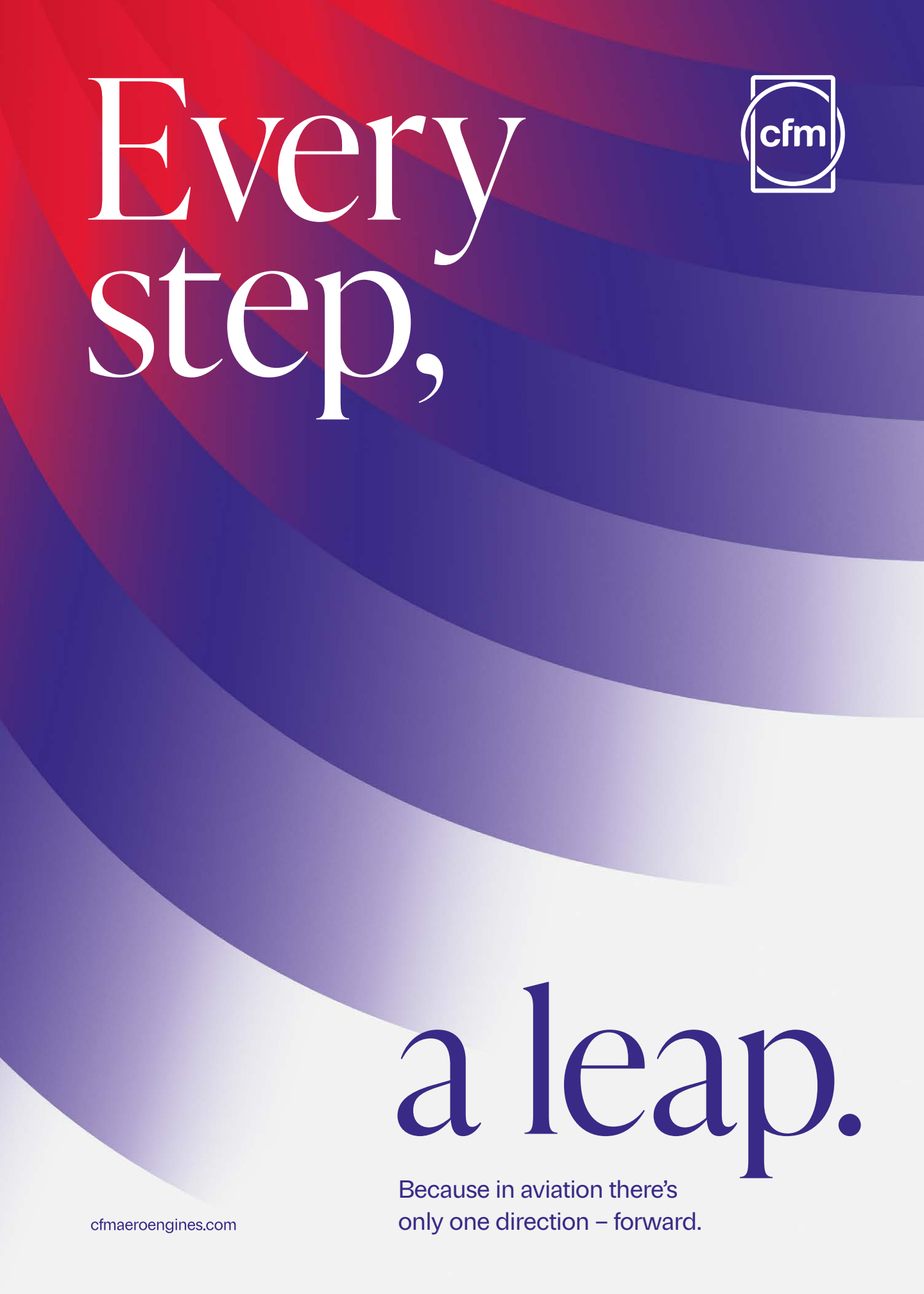


Brendan Lodge has been hired as regional director of UK/European Union and international markets at the *International Aircraft Dealers Association*. He brings over 25 years of experience in aircraft sales and financing in the U.S., UK and Europe, most recently as advisory services and aircraft acquisition specialist at Jet Support Services Inc.

The *African Business Aviation Association* has elected **Dawit Lemma** as chair and **Craig Middleton** as vice chair and treasurer. Lemma is founder, chairman and CEO of service provider Krimson Aviation Holdings and a board director for Women in Aviation International, among other organizations. Middleton is the sales and account management director at General Aviation Services and had been aviation and hotel director at Bequia Air.

Andrew Parker has been appointed to the board of directors at electric aircraft developer *Vertical Aerospace*. He is also a nonexecutive director at Babcock International Group and was director general of MI5 in 2013-20.

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


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SAAB

DEFENSE

Thailand and Sweden have completed negotiations for Bangkok's acquisition of 12 Saab Gripen E/F fighters for delivery by 2034 to the Royal Thai Air Force.

The Philippines and Korea Aerospace Industries have signed a $700 million follow-on contract for the acquisition of 12 additional FA-50PH light fighters to be delivered by 2030.

Ukraine claimed to have destroyed one-third of Russia's cruise-missile-carrying strategic bombers after an audacious drone raid deep inside Russian territory (page 22).

Anduril's valuation soared to $30.5 bil-lion after the defense technology startup raised $2.5 billion in a Series G round led by billionaire Peter Thiel's Founders Fund.

German defense technology company Helsing plans to acquire training and surveillance aircraft manufacturer Grob from H3 Aerospace for an undisclosed price.

The European Commission has green-lighted the planned UK-Italy-Japan industrial joint venture to develop the Global Combat Air Program fighter.

Under agreements with Dassault, Tata Advanced Systems is to build Rafale fuselages in India, with the first section to be completed in 2028 at a new production facility in Hyderabad.

India's VEM Technologies has delivered to Hindustan Aeronautics Ltd. the first center fuselage to be produced by private industry for the Tejas Mk. 1A light combat aircraft.

GE Aerospace and Kratos have expanded their partnership on small affordable turbofans to include development of a 1,500-lb.-thrust engine for reusable uncrewed aircraft.

COMMERCIAL AVIATION

CEO Guillaume Faury says Airbus plans to select an engine in 2027 for the launch of its next new narrowbody airliner around 2030 and service entry in 2037-38 (page 58).

The Trump administration reportedly has suspended sales of aircraft technologies to China for use by state-owned commercial aircraft manufacturer Comac.

The FAA is seeking a single integrator to spearhead proposed air traffic control system upgrades, with a target delivery deadline of Jan. 1, 2029.

U.S. President Donald Trump has directed the FAA to lift the ban on overland civil supersonic flight within 24 months and replace it with an en route noise standard.

The first passenger-carrying electric aircraft landed at a major U.S. airport June 3, Beta Technologies' Alia CX300 at New York's John F. Kennedy International Airport, carrying a pilot and four passengers (page 38).

Archer Aviation completed the piloted first flight of its Midnight electric vertical-takeoff-and-landing vehicle May 30, flying the air taxi for 6 min. and taking off and landing conventionally from a runway (page 38).

SPACE

Japan's Ispace failed in its second at-tempt to land a spacecraft on the Moon June 5. Communications could not be established after the Resilience lander completed its landing sequence.

The Trump administration withdrew the nomination of Jared Isaacman to head NASA in a move that may be linked to a falling-out between Trump and Elon Musk (page 14).

FROM THE ARCHIVES: 100+ YEARS OF AVIATION WEEK AT THE PARIS AIR SHOW



1919 Paris Aeronautical Exposition



1957 Dassault's Mirage III prototype



1971 the Soviet Union's Tupolev Tu-144 supersonic transport. (It crashed at the show two years later.)



1981 U.S. Army/NASA/Bell XV-15 tiltrotor research aircraft

Northrop Grumman's SpaceLogistics subsidiary has integrated twin robotic arms on its Mission Robotic Vehicle for launch in 2026 under DARPA's Robotic Servicing of Geosynchronous Satellites program.

The U.S. Space Force awarded BAE Systems a $1.2 billion contract to build 10 satellites for its missile warning and tracking constellation in medium Earth orbit.

Northrop Grumman is adding $50 million to a joint project with Firefly Aerospace to build and operate a new medium-lift launch vehicle, the Eclipse (page 17).

OBITUARIES

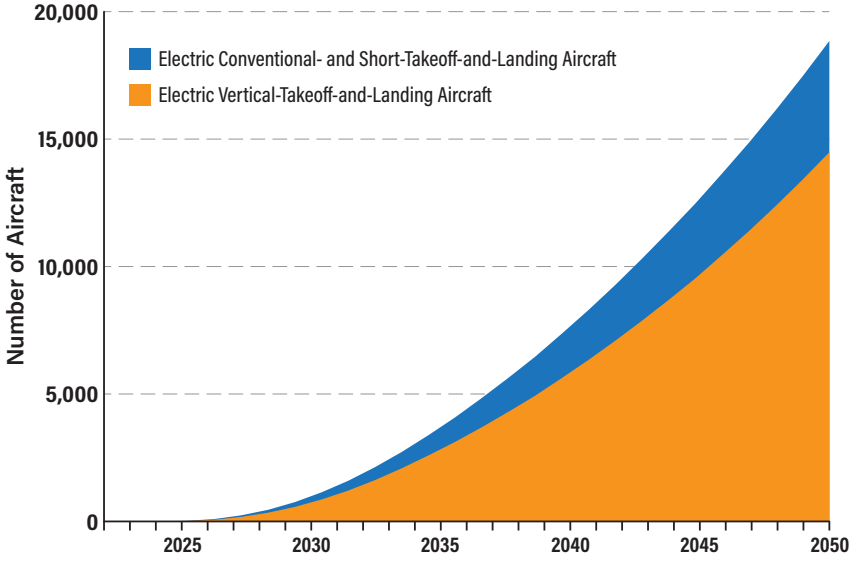
Marc Garneau, Canada's first astronaut to reach space, died on June 4. He was 76. Born in Quebec City, he became a Canadian Armed Forces officer and flew as a mission specialist aboard the shuttle orbiter Challenger in October 1984 on STS-41G, NASA's 13th space shuttle flight. He went on to fly two more shuttle missions and later became Canada's transport minister.

Jim Schuster, who led the turnaround of Raytheon Aircraft and its transition to Hawker Beechcraft, died on May 8. He was 72. Schuster joined the aircraft manufacturer as chairman and CEO in 2001 in the midst of financial struggles and prepared the company for its $3 billion sale to private equity firms Onex and Goldman Sachs in 2007.

DATA SPOTLIGHT

Delays Hit AAM Fleet Forecast

In-Service Aircraft



Source: Aviation Week Network 2025 AAM Fleet Forecast

The Aviation Week Network's 2025 Advanced Air Mobility forecast envisions a global fleet of 600 electric vertical-takeoff-and-landing aircraft by 2030, excluding those in China. This is down by 200, or 25%, from last year's forecast because certification is taking longer than expected. As a result, the forecast shifts many service entry dates to the right. The outlook for electric conventional- and short-takeoff aircraft is also less positive, down by roughly 40% to 200 units by 2030.

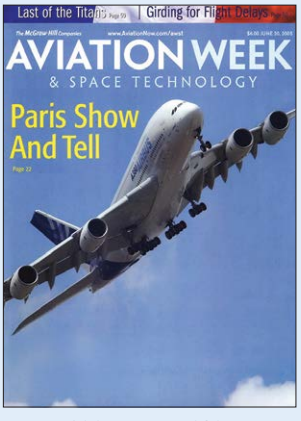
Find out more about the AAM Fleet Forecast and The AAM Report *at* **AviationWeek.com/awin-aam**



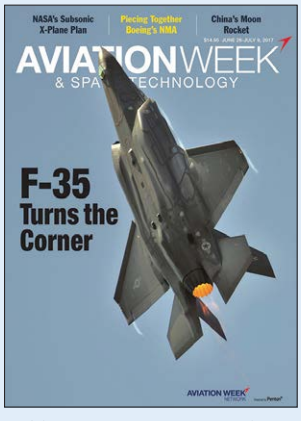
1989 Soviet Antonov An-225 with the Buran orbiter, seven months after the orbiter flew in space



1995 Airbus' Beluga, developed to fly subassemblies between factories



2005 Airbus A380, the star of the show



2017 Lockheed Martin's F-35, the highlight of the flight display

Gallery *See a selection of 25* AW&ST *Paris Air Show covers since 1919:* **AviationWeek.com/AWST-PAS-Covers**

UP FRONT
RICHARD ABOULAFIA



THE SPECTER OF TRANSATLANTIC decoupling haunts this year's Paris Air Show. Two upcoming events, the NATO summit in the Netherlands on June 24-25 and the Trump administration's threatened imposition of 50% tariffs on EU imports on July 9, are casting dark foreshadowings over Paris. Those two events present risks—and for some, opportunities—for both the military and civil sides of the aerospace industry.

The NATO summit might see an even worse version of the U.S.-Europe rift that marred the Munich Security Conference in February. In Munich, U.S. officials, led by Vice President JD Vance, criticized European domestic politics and highlighted profound differences between the U.S. and Europe on backing Ukraine against Russia. The NATO summit could produce more doubt about the U.S. military's European presence and the future of U.S. support for Ukraine.



ANDERS BERGSTRAND/SAAB

Part of the industry sees a strong upside to this decoupling. Europe, now on notice about possibly facing Russia alone and filling capability gaps left by U.S. pullbacks, is not only ramping up defense spending, but also emphasizing European industrial capabilities. The stock prices of U.S. defense companies have done reasonably well this year, but European defense stocks are setting impressive all-time records.

As a result, U.S. defense contractors face diminished prospects in Europe and supercharged European competitors in export markets. European companies should demonstrate a new level of confidence at Le Bourget. They also will be promoting non-U.S. systems on the basis that the U.S. is a less reliable security partner.

It is hard to believe, but just a few months ago, the Trump administration was threatening the territorial sovereignty of several allies. That is not good for weapon sales. Canadian Prime Minister Mark Carney recently told the CBC: "Seventy-five cents of every [Canadian] dollar of capital spending for defense goes to the United States. That's not smart."

These headwinds also affect U.S. suppliers. Given the risks of U.S.-EU decoupling, U.S. system- and component-makers can expect fewer opportunities on new platforms in Europe (and elsewhere), such as the Global Combat Aircraft Program or NATO's Next-Generation Rotorcraft Capability program.

Second, tariffs imposed by the U.S. against Europe will result only in losers. Trump's threatened July tariffs, to be implemented under the International Emergency Economic Powers Act (IEEPA), are on uncertain legal ground. But the administration has also announced a Section 232 trade investigation focusing on commercial aerospace. This would take longer to result in tariffs but would not be subject to the same legal challenges as IEEPA tariffs. Either way, despite the U.S.' $80-plus billion trade surplus in aerospace, the administration seems to want to change the situation.

Such change can only be for the worse. If the tariffs are imposed in July or after the Section 232 investigation is concluded, retaliation will be inevitable. Indeed, EU officials have made it clear that retaliation against Boeing in particular is likely. Since the U.S. has an aerospace trade surplus with Europe, it is hard to see how this would not backfire, with slower growth and lower profits.

The risks of military and economic decoupling between the U.S. and its allies are intertwined. Some European countries might try to smooth over trade tensions with the Trump administration by making high-profile purchases of U.S. defense equipment, but most will likely view a buildup of domestic capabilities as the best way to derisk from economic and political shocks. In the event of a trade war, nothing would keep the EU from imposing tariffs on U.S. defense equipment in retaliation for U.S. tariffs and to help European defense companies.

Tensions between the U.S. and the Western alliance threaten the strong historical strategic and economic ties between them. But the U.S. cannot completely decouple from Europe and Canada—supply chains are simply too enmeshed and cultural links too deep.

It is also notable that, despite numerous scares since Trump took office, the U.S. is still in NATO and still has troops in Europe, the cutoff of U.S. support for Ukraine proved temporary, and bellicose talk against Canada and Greenland has come to nothing. There is no trade war between the U.S. and any Western country. Indeed, investors are profiting from market rebounds whenever Trump backs away from his aggressive trade moves.

But it has only been five months, with 43 of his 48-month term to go. And Le Bourget will be followed directly by two events that may prove pivotal, not just to the industry but to the Western alliance.

Contributing columnist Richard Aboulafia is managing director at AeroDynamic Advisory.

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QUANTUM LEAP

GARRETT REIM



IF YOU WANT TO GO FAST—AND far—in space, the consensus is that you have to go nuclear.

The U.S. Space Force, DARPA and NASA in recent years have funded several nuclear propulsion development efforts they believe could make spacecraft rapidly maneuverable around Earth or efficient for long-distance travel to the Moon or Mars.

But the problem with nuclear propulsion is, well, it is nuclear. The general U.S. public is not too keen on the idea of a derelict spacecraft reentering Earth's atmosphere and scattering radioactive debris across the continent. That very scenario happened in 1978, when the Soviet Union's Kosmos 954, a maritime surveillance satellite powered by a nuclear reactor, reentered the atmosphere, strewing highly enriched uranium-235 across northern Canada.

Accordingly, the U.S. government has a thick book of regulations on the use of nuclear-powered spacecraft. The 2027 launch date for the DARPA-NASA nuclear thermal propulsion technology development program, known as the Demonstration Rocket for Agile Cislunar Operations, was put on indefinite hold after hitting regulatory snags for safely testing the system on the ground, DARPA told Aviation Week in January.

Enter Portal Space Systems, a company that promises the rapid maneuverability of nuclear propulsion—using thermal energy collected from the Sun. The startup, which raised $17.5 million in April, sees solar thermal propulsion as a far easier way for spacecraft to achieve high-delta-v maneuverability without the regulatory hassle and technical complexity of nuclear propulsion.

In early 2026, the Seattle-based company plans to conduct its first on-orbit demonstration of its spaceflight computer, avionics and other software aboard Momentus' Vigoride 7 orbital service vehicle in low Earth orbit (LEO), Portal Space Systems CEO and co-founder Jeff Thornburg tells Aviation Week. Later in the year, the startup intends to launch a demonstration of parts of its solar thermal propulsion system.

The concept is not a new idea; it has been around since the 1950s. In the 1990s, the technology was pushed forward by several outfits, including the Air Force Research Laboratory. But new advances in 3D printing have made the technology feasible, Thornburg says.

Solar Thermal

An alternative to **nuclear space propulsion**



PORTAL SPACE SYSTEMS

"Until recently, we weren't additively manufacturing high-temperature alloys," he says. "[The] intellectual property that we're bringing to the party, a lot of it is centered around our design for additive manufacturing with high-temperature alloys for what we call our Hex thruster."

The company's solar thermal propulsion system, dubbed Flare, is made of a 3D-printed Hex heat-exchanger thruster and solar concentrator mirrors. The mirrors are tucked against the sides of Portal's Supernova spacecraft like a Japanese fan during launch. Once on orbit, the mirrors are extended on struts and unfolded (see image), making the spacecraft about one-third the length of a basketball court, Thornburg says.

"It's kind of like the kid on the playground with the magnifying glass," he says. "We're focusing that solar energy on the heat exchanger and then passing propellant through it."

To store energy, the system has a thermal battery with a phase change material like the molten salt that the nuclear power industry uses, Thornburg says. "We're not using molten salt because it's very corrosive, and I want to use this thing for multiple years on orbit," he explains.

The system is constantly heating the battery. "If, for some reason, we pass into the shadow of the Earth, it's retained the heat, so we can still keep firing the thruster," Thornburg says, noting that the battery can hold a charge for 30-45 min. "The idea is you would likely be able to glimpse the Sun within 30-45 min. again to recharge."

The Flare solar thermal propulsion system uses ammonia as propellant.

"Because I don't have to carry oxygen, because I'm not burning anything, I can carry twice as much fuel," Thornburg says, noting that this "minimally extends your range [two times], and we often can have 10 or 20 times the maneuverability capability of most space systems on orbit."

Portal Space says the Flare system gives spacecraft the ability to perform high-delta-v maneuvers that would be useful for space domain awareness missions for the U.S. Space Force. The startup says a spacecraft should be able to use its solar thermal propulsion system to transfer from LEO to medium Earth orbit in minutes, from LEO to geostationary space in hours or from LEO to cislunar space in days.

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LEONARDO
TECHNOLOGY FOR A SAFER FUTURE

SPACE > Breakup between U.S. government and SpaceX would be difficult p. 16

CONGRESS PUSHES BACK

- NASA IS LEADERLESS AFTER ISAACMAN IS AXED
- TRUMP PROPOSES 30% CUT TO THE AGENCY'S CIVILIAN WORKFORCE
- WHITE HOUSE EYES MARS LANDER DEMO



The timing of Trump's dismissal of Isaacman points to the latter's association with Elon Musk.

BILL INGALLS/NASA

Irene Klotz Cape Canaveral and Long Beach, California

With minimal fanfare and no press, the White House released details of its plan for a scaled-down NASA that calls for cuts to its workforce and several flagship programs. The surprise came the day after the budget's release when the Trump administration pulled its nominee to head NASA, the well-respected Jared Isaacman, who was expected to win an imminent Senate confirmation vote.

And then came the fireworks as Elon Musk, CEO of SpaceX—NASA's lead commercial contractor—capped a 130-day stint as a special government employee by publicly denouncing President Donald Trump's signature domestic policy bill, kicking off an exchange of vitriolic social media posts with the president. The barbs included mutual threats to break the SpaceX-NASA partnership.

Amid the spat, the Senate Commerce, Science and Transportation Committee, which oversees NASA, quietly released its version of Trump's reconciliation bill. If passed, the spending plan will include an extra $10 billion for NASA. The bill calls for reversing many of Trump's proposed cuts for NASA and restoring the agency's Space Launch System (SLS), Orion and Gateway programs, among others. The money would be within a fiscal 2025 supplemental bill, but could be spent until 2034.

Trump's budget plan would ax one-third of NASA's workforce and end dozens of programs, including a decades-long campaign to return samples from Mars that could reveal if life ever arose there. Budget documents posted on NASA's website late May 30—and without traditional briefings by agency leaders—show how the White House plans to achieve a previously announced 24% cut in the agency's spending for the year beginning Oct. 1. If enacted, the proposed $6 billion reduction would return NASA funding to an inflation-adjusted level not seen since 1961.

The budget would cancel the agency's SLS rocket and Orion spacecraft after the Artemis II crewed flight test, expected in 2026, and the Artemis III lunar landing, targeted for 2027.

The White House wants NASA instead to purchase commercial flight services, although none currently exist.

An international program to build a lunar-orbiting station, known as the Gateway, would be grounded ahead of the planned 2027 launch of the first two modules. Budget documents include $304 million to close out the Gateway while "alternative uses of the Gateway hardware are evaluated by commercial and international partners."

Overall, NASA's 17,391-member civil servant workforce would fall to 11,853 under the Trump plan.

An Office of Management and Budget (OMB) Technical Supplement to the 2026 Budget, released June 2, details the proposed employment cuts as follows: NASA's Science directorate would drop to 1,441 from 2,841 workers; Aeronautics to 882 from 1,575; Space Technology to 528 from 711; Exploration to 3,194 from 3,331; Space Operations to 1,588 from 2,351; the cross-agency Safety, Security and Mission Services to 4,220 from 6,533; Inspector General to 154 from 171; and education outreach STEM to zero from 49. The

OMB's current employment figures are slightly different from those in the White House's budget documents.

Overall spending on NASA planetary, Earth and space science would fall 47%, with similar cuts to aeronautics and space technology programs.

The proposed budget calls for canceling 19 operational NASA science missions that have cost $12 billion to develop, test, launch and operate, The Planetary Society, a nonprofit space advocacy organization, noted.

The missions include the Chandra X-ray Observatory; Juno Jupiter probe; New Horizons, which is in the Kuiper Belt beyond Pluto; Mars MAVEN atmospheric spacecraft; and more than eight Earth-observing missions. In addition, 21 other science projects in planning stages would be canceled.

The plan is an "extinction-level event" for science, The Planetary Society said. "It is unclear which enduring national interests were considered in this budget. . . . These consequences are not limited to a handful of space science centers—NASA science is everywhere, positively impacting 87% of congressional districts in all 50 states."

The White House's proposed budget also would reduce spending on space operations—including the International Space Station (ISS)—by more than about 25% as NASA works to transition its low-Earth-orbit research programs to commercially owned and operated platforms ahead of the station's planned retirement in 2030.

The Trump administration wants to scale back ISS operations, with fewer crew and resupply missions, and proposes a "rescoping" of NASA's Commercial Low-Earth-Orbit Destinations program, which would be capped at $272 million in fiscal 2026 and $302 million in 2027-28 before roughly doubling to $602 million in 2029-30.

As outlined in its May 2 summary proposal, the administration wants to reduce NASA's $25 billion budget to $18.8 billion. It funds only a single area of new growth: technology development to reach Mars.

Toward that goal, NASA's Exploration Systems budget would increase to $8.3 billion from $7.7 billion, with $930 million earmarked for Mars-focused programs, including $200 million to conduct a "near-term entry, descent and landing demonstration for a human-class Mars lander." That would be accomplished by leveraging existing contracts, according to the White House budget documents.

NASA is funding development efforts by SpaceX and Blue Origin for landing systems to ferry astronauts to and from lunar orbit and the surface of the Moon. In a webcast address to employees the day before the budget's release, Musk said SpaceX was aiming to launch an uncrewed Starship to Mars in 2026, the next time Earth and Mars are favorably aligned for interplanetary flight.

The same day the budget was released, Musk left the Trump administration, and the White House told Isaacman—a business associate of Musk's—that it was withdrawing him as the nominee to head NASA. A formal announcement followed May 31.

"It's essential that the next leader of NASA is in complete alignment with President Trump's America First agenda, and a replacement will be announced directly by President Trump soon," White House spokesperson Liz Huston said in an emailed statement.

The Senate was poised to vote on Isaacman's nomination in early June. The White House did not provide details about why it had lost confidence in Isaacman, a well-respected technology entrepreneur who twice has chartered private space missions from SpaceX.

"I am incredibly grateful to President Trump, the Senate and all those who supported me throughout this journey," Isaacman wrote on social media. "The past six months have been enlightening and, honestly, a bit thrilling. I have gained a much deeper appreciation for the complexities of government and the weight our political leaders carry.

"It may not always be obvious through the discourse and turbulence, but there are many competent, dedicated people who love this country and care deeply about the mission. That was on full display during my hearing, where leaders on both sides of the aisle made clear they're willing to fight for the world's most accomplished space agency."

During his confirmation hearing before the Senate committee in April, Isaacman said he supported the administration's plan to phase out NASA's SLS rocket and Orion spacecraft, but he took issue with the proposal to cut NASA science programs nearly 50%.

The timing of the White House's announcement, however, points to Isaacman's association with Musk, who publicly—and reportedly privately—clashed with some members of Trump's inner circle.

"Isaacman ran into the kind of politics that is damaging our country," Sen. Mark Kelly (D-Ariz.), a former NASA astronaut, said in a statement. "Republicans and Democrats supported him as the right guy at the right time for the top job at NASA, but it wasn't enough. It's incredibly frustrating that this administration did this to him and his family."

In an update on social media June 9, Isaacman said he had spent the last few months assembling "a pretty extensive plan" for NASA, shaped by insights from "a lot of smart, passionate people. . . . Everyone loves NASA and wants to help," he wrote.

The plan included flattening NASA's hierarchy by eliminating management positions, focusing on missions, recalibrating risk and concentrating resources on "the big-needle movers NASA was meant to achieve."

If cost-saving measures then led to "poor outcomes," such as canceling launch of the nearly complete Nancy Grace Roman Space Telescope, shutting down the Hubble or Chandra observatories prematurely or cutting the ISS crew size just to save money, Isaacman added: "I would have funded it myself to protect the science.

"That is not how it should work—and I honestly don't think it would have come to that. With the right political support and smart management—logic should prevail," Isaacman said.

The White House had not announced a new nominee as of June 11.

As part of the Senate's $10 billion proposed supplement for NASA, $4 billion would be used to procure SLS rockets for Artemis IV and V Moon landings; $2.6 billion to fully fund the Gateway; $20 million for a fourth Orion capsule; $1.3 billion for the ISS; and $325 million for a U.S. deorbit vehicle to remove the station from orbit after it is decommissioned in 2030. Another $700 million would be spent on a commercially provided Mars Telecommunications Orbiter and $1 billion for infrastructure upgrades at the Johnson, Kennedy, Marshall and Stennis field centers, as well as the Michoud Assembly Facility. The spending plans are pending the appropriations process.

Check 6 *Aviation Week editors discuss the Trump administration's bid to reshape NASA:* **AviationWeek.com/Check6**

A Breakup Between the U.S. Government and SpaceX Would Be Difficult

- TRUMP HAS USED GOVERNMENT AGENCIES AGAINST PEOPLE OR INSTITUTIONS THAT DISAGREE WITH HIM
- STARLINK REVENUE INSULATES SPACEX FROM SOME POTENTIAL LOST BUSINESS

Garrett Reim Seattle

In what might be a serious rupture in the foundation of the U.S. space industry, SpaceX CEO Elon Musk and U.S. President Donald Trump launched broadsides against each other on social media and in front of the press in early June, escalating a fight over deficit spending in the "Big Beautiful Bill."

The U.S. government is highly reliant on SpaceX's Falcon 9 medium and Falcon Heavy launch vehicles for a variety of missions, including its National Security Space Launch program, for which United Launch Alliance's Vulcan Centaur heavy-lift launch vehicle and its soon-to-be-retired Atlas V medium launch vehicle are the only certified alternatives. NASA also relies on the SpaceX Dragon crew capsule to ferry astronauts and cargo to and from the International Space Station (ISS).



ABACA PRESS/ALAMY STOCK PHOTO

The Trump-Musk relationship quickly deteriorated, threatening SpaceX contracts.

Despite that close relationship, long-festering differences between Trump and Musk—onetime political allies—burst out into the open and threatened to unravel close ties between U.S. government agencies and SpaceX. In retaliation for Musk's increasingly vocal criticism, Trump threatened on his social media website Truth Social on June 5 "to terminate Elon's governmental contracts and subsidies."

"In light of the President's statement about cancellation of my government contracts, @SpaceX will begin decommissioning its Dragon spacecraft immediately," Musk responded on X. Musk backed down about 5 hr. later after X user @Fab25june intervened. "Cool off and take a step back for a couple days," the user said. Musk replied a minute later: "Good advice. OK, we won't decommission Dragon."

NASA has no easy answer for replacing the Dragon spacecraft, as its alternative, Boeing's CST-100 Starliner, has struggled with leaks, thruster failures and other glitches. A Dragon capsule was being prepared to launch mid-June for Axiom Space's fourth private astronaut mission to the ISS. Another Dragon capsule is currently docked at the ISS, and NASA plans to carry four crew members on a Dragon there on its Crew 11 mission no earlier than July.

Differences between Musk and Trump emerged in recent weeks as Musk criticized the Republicans' "Big Beautiful Bill" for increasing the government's fiscal deficit by trillions of dollars over the next decade. Musk had led the Department of Government Efficiency for the past several months, resulting in the firing of thousands of workers and slashing of government programs to reduce spending.

Musk also was upset that his preference for NASA administrator, Jared Isaacman, was pulled from consideration on May 31, late in the confirmation process (page 14). On X, he pointed to Trump's public praise of Isaacman upon nominating him in December.

Musk and Trump traded insults on their respective social media websites, airing grievances and making threats. Trump warned in an interview with NBC News of "consequences" if Musk backed Democrats. Musk posted on X: "Whatever happens, we have got the spaceships, and they do not."

Musk and Trump became political allies during the 2024 election. The tech executive publicly endorsed the presidential candidate, rallying with him and spending more than $290 million to support Trump and allied Republicans.

Amid the volleys from social media and the White House, Musk threatened to start a new political party. "Without me, Trump would have lost the election," Musk wrote in another post. "Such ingratitude."

After a few days of public fighting, some signs emerged that the dispute was calming down, as Musk deleted posts about Trump's past relationship with financier and sex offender Jeffrey Epstein. The two also wished each other well. In the early hours of June 11, Musk posted on X: "I regret some of my posts about President @realDonaldTrump last week. They went too far."

SpaceX, founded in 2002, is less reliant on federal contracts than it was initially. The company's revenue appears to be coming predominantly from its Starlink satellite internet service in recent years. Musk said in early June that SpaceX is projected to generate about $15.5 billion in revenue this year, with its NASA business amounting to about $1.1 billion. "Perhaps an interesting milestone: @SpaceX commercial revenue from space will exceed the entire budget of @NASA next year," he wrote on X.

But SpaceX must seek permission from the FAA and Federal Communications Commission to launch rockets and fly Starlink satellites in low Earth orbit. Trump has used federal agencies against people or institutions that disagree with him, such as by cutting off government funding, launching investigations, stripping security clearances, allegedly slow-walking regulatory approvals and blocking access to government facilities.

Musk, at 53 years old, wants to settle humanity on Mars in his lifetime. He has criticized U.S. government regulators for not moving fast enough in green-lighting test launches of his Starship-Super Heavy launch system, which is critical to his plan to colonize the red planet.

The Space Sector Is Forgoing Civil Programs for the Defense Boom

> NORTHROP GRUMMAN TURNS AWAY FROM NASA

> ROCKET LAB SEES OPPORTUNITY AS AN END-TO-END SUPPLIER

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

Large swaths of the space industry are adjusting their North Star, increasingly focusing on chasing the booming military space market and deemphasizing other activities.

The course adjustments at many companies reflect changing geopolitical dynamics and spending realities.

Northrop Grumman recently disclosed a $50 million investment into a joint project with Firefly Aerospace to design, own and operate a medium-lift launch vehicle, newly christened the Eclipse. The 16-metric-ton-payload rocket, the first launch of which is planned no earlier than next year, is targeting the national security space launch market with the Pentagon's focus on proliferated constellations.



FIREFLY AEROSPACE/NORTHROP GRUMMAN

Northrop Grumman is putting $50 million into its joint program with Firefly Aerospace to develop a new medium-lift rocket called the Eclipse.

In the U.S., the Trump administration wants to slash NASA's budget by about a quarter in the latest spending request (page 16) while pushing to funnel billions of dollars into the space-heavy Golden Dome for America homeland missile defense architecture (*AW&ST* June 2-15, p. 15). The European Union is scaling up its military space ambitions, as are many of its member states, and Asia also is seeing an expansion of national-security-linked space activities.

In one of the most glaring examples of the new reality, Northrop Grumman CEO Kathy Warden said May 28 that the company's work with NASA "will not be a growth driver for us," if the proposed budget cuts hold. The company is NASA's fourth-largest contractor after the California Institute of Technology's Jet Propulsion Laboratory, SpaceX and Boeing.

The company is also maturing national security space technologies, to include missile warning and tracking payloads developed for the Space Development Agency (SDA) and the Missile Defense Agency.

Speaking at the Bernstein Strategic Decisions Conference in late May, Warden pointed to different areas of future focus for its space portfolio, such as restricted space programs and propulsion technology. New U.S. proposals, such as the Golden Dome, are poised to accelerate defense spending from space companies.

Rocket Lab similarly is looking to bolster its military business via a May 27 announced acquisition of U.S. electro-optical/infrared payload developer Geost. Rocket Lab was recently onramped to the U.S. Space Force National Security Space Launch Phase 3 Lane 1 contract to compete for low-risk launch opportunities with its Neutron medium-lift rocket. Its first such launch is targeted for this year. Last year, it debuted as a spacecraft manufacturer for the SDA's proliferated low-Earth-orbit constellation.

While Rocket Lab has long supported U.S. military missions with its Electron rocket, developments such as the Golden Dome architecture present new opportunities, CEO Peter Beck tells Aviation Week. "Make no mistake about it," he says. "We want to be a big provider to that program." The announced Geost acquisition allows Rocket Lab to be a key supplier for the tracking element of a future missile defense architecture, he notes.

The company has strategically acquired—or announced intentions to acquire—six companies since 2020 to provide components that together enable Rocket Lab to become an end-to-end provider for the U.S. military. Meanwhile, the ongoing Geost acquisition is "not the end of payload acquisitions for us," Beck asserts.

In Europe, where national governments and the EU are investing more in military space, that appetite has become a driver in the thinking of investors and startups, industry leaders shared at the recent SmallSat Europe Conference in Amsterdam. "We see much more influx of capital in that particular aspect, both in early-stage deals and late-stage deals," Starburst Ventures CEO François Chopard said at the conference.

Reflex Aerospace Chief Commercial Officer Dennis Moore said the company was set up with a dual-use market in mind, but it has seen the defense focus come to the fore only recently. The company has secured a security clearance for its facilities.

Fossa Systems, a Spanish and Portuguese startup that provides Internet of Things device connectivity from space, is shifting its focus to direct messaging between soldiers and what CEO Julián Fernández called "the Internet of the Battlefield." "We are all going to have to shift to these defense use cases, because I sincerely think that's where the money is going to be," he says.

—With Brian Everstine in Washington and Irene Klotz in Cape Canaveral

Ukraine's Surprise Strikes Highlight the Danger of Drones

> AT LEAST 11 RUSSIAN AIRCRAFT WERE DESTROYED IN JUNE 1 ATTACKS

> THE STRIKES INTRODUCE NEW OFFENSIVE OPTIONS AND REVEAL DEFENSIVE VULNERABILITIES

Steve Trimble Washington and **Tony Osborne** London

Three Ukrainian attack drones struck a Sukhoi Su-57 fighter on June 8, 2024, at a base 365 mi. deep inside Russia. Satellite imagery showed the strike damaged the stealth fighter, a small victory for Kyiv in a long, difficult war.

Satellite imagery confirms Ukrainian estimates that the drones destroyed at least 11 Russian aircraft, including nine bombers. Dozens more may have been damaged.

For Ukraine, the impact of Operation Spider's Web—the SBU's code name for the covert drone attacks—may play out for months. It is not clear how many of the aircraft destroyed were involved in strikes in Ukraine or even flyable, but the widespread nature of the attacks may still have some effect. In addition to the embarrassment from the failure to stop such a brazen operation, "Russia will likely struggle to replace the aircraft that Ukrainian forces damaged and destroyed," the Institute for the Study of War states in a June 1 assessment.

The attack also highlights a global trend in aerial warfare with implications for offensive planning and defensive preparations.

Springing attacks on enemy aircraft while they are parked on seemingly friendly soil is nothing new. At the outset of the Six-Day War in 1967, the Israeli Air Force launched a surprise raid into Egypt, destroying 452 aircraft on the ground. Nor is it new to blend conventional airpower with special operations units like the SBU. In 1942 the British Special Air Service infiltrated a Luftwaffe base in Egypt, then used machine guns loaded with tracer rounds to destroy or damage 37 parked aircraft.

Attacks on enemy airfields also feature in planning for future wars. In 2017, U.S. Air Force then-Brig. Gen. Alexus Grynkewich published an online essay after spending a year drafting the strategy for acquiring what became the Boeing F-47. In a future conflict, Grynkewich wrote, Northrop Grumman B-21s would strike enemy airfields while the next air superiority fighter swept the skies of any aircraft that had managed to take off.

MAXAR TECHNOLOGIES



Poststrike satellite imagery revealed the charred remains of two Russian Tupolev Tu-95 bombers hit by Ukrainian drones at Olenya air base near the Barents Sea.

That isolated action a year ago proved to be only a warning shot—or perhaps a sneak preview. On June 1, 2025, Ukraine struck again on a larger and deeper scale. In a creative aerial ambush devised 18 months and nine days earlier by the Security Service of Ukraine (SBU), semitrucks hauling portable cabins smuggled scores of armed drones deep into the Russian interior, parking in locations stretching from along the Finnish border on the Barents Sea to near the shores of Lake Baikal in Siberia.

Hiding in plain sight within range of several bomber bases, these "Trojan trucks" opened their cabin roofs and released more than 100 remotely piloted, first-person-view (FPV) drones.

Meanwhile, interest in ground-launched, short-range FPV drones is spreading. A day after the Operation Spider's Web attacks, the U.S. Defense Innovation Unit (DIU) launched Project GI, a competition offering $20 million in prizes to companies that can rapidly deliver such weapon systems with ranges beyond 20 km (12.4 mi.). Project GI aims to close a gap in the U.S. drone inventory.

"Today, warfighters lack the unmanned systems needed to train for

GE hypersonic engine test plans **p. 28**



A U.S. Army Patriot battery guards Ali Al Salem Air Base in Kuwait, but Air Force leaders urgently want a more robust, layered system to protect air bases from air and missile attacks.

STAFF SGT. KENNETH BOYTON/U.S. AIR FORCE

combat and prevail if called upon to use them," DIU Director Doug Beck said June 2. "Doing this [project] at speed will in turn help catalyze the necessary scaling and readiness through major acquisition and training efforts."

Although Ukraine lacks air superiority and a long-range bomber fleet, the country's repeated attacks on air bases inside Russia shows the advance of technology in the air littoral, a layer of airspace usually defined as below 10,000 ft. For Operation Spider's Web, the SBU reportedly deployed Ukrainian manufacturer First Contact's Osa drones. Each 5-kg (11-lb.) quadcopter can carry up to 3.3 kg of explosives to targets up to 8 km away, according to the manufacturer's website.

Meager attempts to protect the Russian bombers by covering the upper surfaces with old tires—possibly to confuse vision-based, autonomous targeting systems—failed to save the aircraft.

In addition to creating new offensive opportunities, the successful Ukrainian operation exposes defensive vulnerabilities that are as common in Europe and the U.S. as they are in Russia. Over the past two years, reports of unauthorized drone sightings have plagued several U.S. air bases, including a Lockheed Martin F-22 operating base in Virginia and a space launch complex in California. Last year, the Air Force paused the award of the Next-Generation Air Dominance contract for several months to review the original requirements, including whether the vulnerability of air bases could negate the advantages of a powerful new fighter.

"The F-47 is an amazing aircraft, but it's going to die on the ground like everything else if we don't protect it," Gen. David Allvin, the Air Force chief of staff, said at an event hosted by the Center for a New American Security in Washington on June 3.

Concerns about air base vulnerability are driving negotiations with the Army over whether the Air Force should be responsible for defending its own air bases. The Navy provides a layered air defense system to protect its fleet, but a long-standing policy requires the Air Force to rely on the Army for such protection.

"The bottom line is that the joint force needs more robust ground-based air defense, whether it's from an airfield or someplace that the Marines are operating or the Army is operating," Allvin said. "We do continue to need robust point defense for agile combat employment to work."

In Europe, the threat of similar attacks is acute. Most air bases are in the open countryside and near public roads. Their movements are easily monitored, and the aircraft are parked in the open air, often undispersed. Many of these air bases lack anti-drone equipment or the spare personnel to operate it if they did.

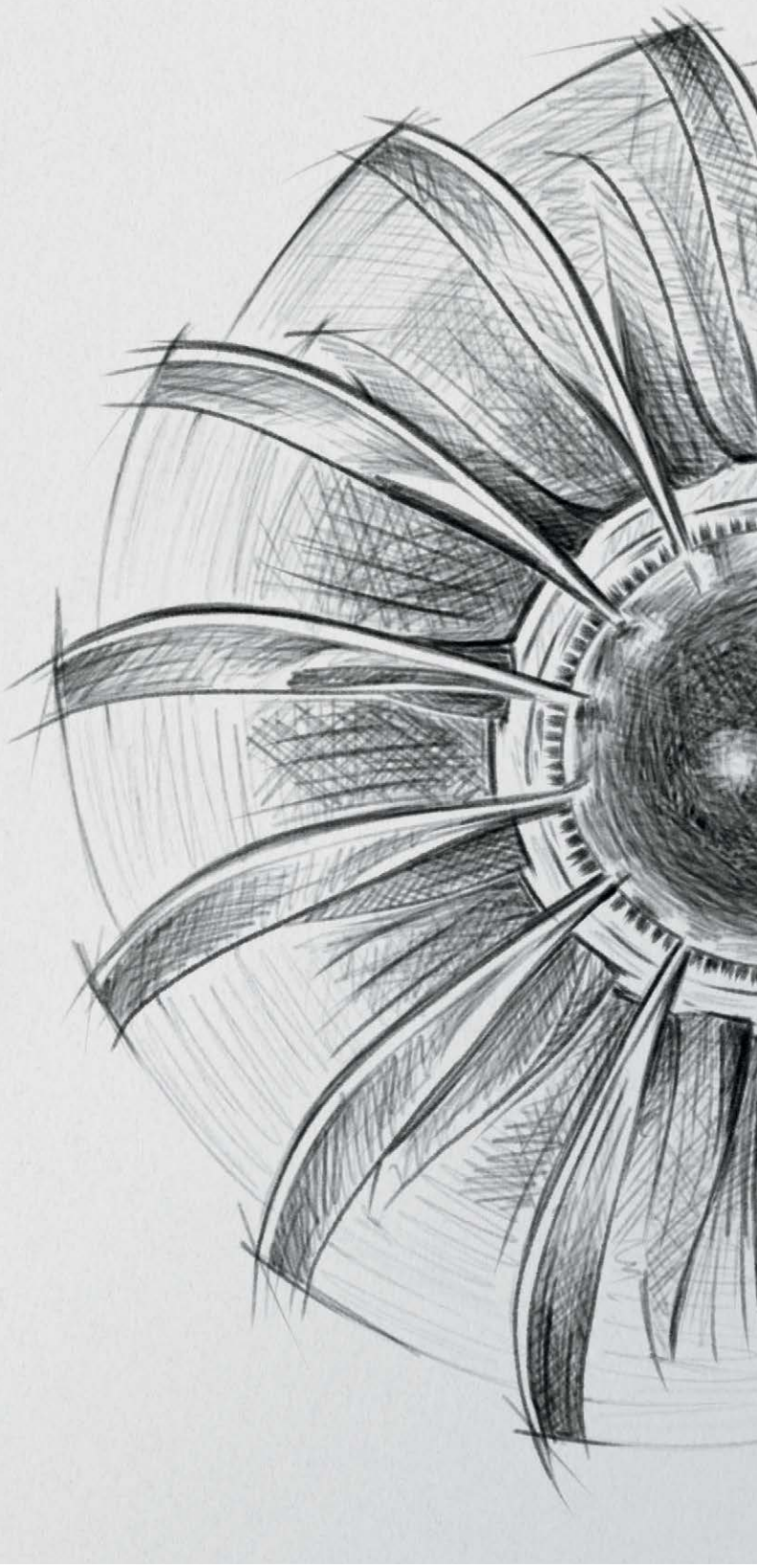
Some countries, like France and Germany, have multiple bases with transport aircraft and airlifters, but the UK, for example, has piled all of its air transport assets into one location, Brize Norton, to save costs.

NATO's Air Command is urging member countries to develop agile combat employment concepts to generate sustained combat airpower through dispersal. However, this does not necessarily work for intelligence, surveillance and reconnaissance platforms, which are often tethered to main or forward operating bases so their intelligence products can be processed and distributed.

While tankers and transports can operate from commercial airports, they tend to stick out.

China is increasingly building air bases with shelter infrastructure for large aircraft, including the KJ-500 airborne early warning aircraft based on the Shaanxi Y-8 turboprop airlifter. While not hardened, these 60-m-wide (197-ft.) structures with closing doors at both ends make the aircraft difficult to target on the ground, as overhead imagery cannot identify what aircraft is in a shelter. They would also prevent attack by small drones like those Ukraine used in Russia. These structures can be found at a People's Liberation Army Air Force base near Dalian, at Leizhuang near Guiyang, and at Jiujiang's Lushan air base.

Where ‘what ifs’



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The UK Eyes Broader Nuclear Mission To Strengthen NATO Defense

- THE COUNTRY COULD ADOPT F-35As FOR DUAL-CAPABLE AIRCRAFT NUCLEAR MISSION
- OTHER PRIORITIES CHALLENGE GOVERNMENT AMBITIONS TO REACH 3% DEFENSE SPENDING

Tony Osborne London

The UK could seek a broader deterrence role in NATO and readopt the air-launched tactical nuclear mission.

Facing a new era of global instability, the UK is considering bolstering NATO's deterrence strategy by participating in the alliance's nuclear sharing arrangements with dual-capable aircraft, potentially through an acquisition of the conventional-takeoff-and-landing (CTOL) variant of the Lockheed Martin F-35 Joint Strike Fighter. Ministers are tight-lipped, but proposals to commence discussions with the U.S. and NATO about joining the initiative are among the options in the government's long-awaited Strategic Defense Review (SDR), finally released on June 2.

The UK is the only nuclear-armed country to offer its deterrent to NATO. Officials in the country contend that involvement in nuclear sharing would not only garner the UK more "credit" with allies, but more crucially also manage escalation risks.

The idea is part of a grander vision to reposture the UK military to warfighting readiness. Prime Minister Keir Starmer is calling for armed forces that are battle-ready, highly integrated and more lethal.

Ministers insist that the government will carry out all 62 recommendations in the report and deliver them over the next decade. However, the plans lack detail, substance and urgency, and critics maintain that they will be challenged for resources.

For years, the UK was one of the few NATO members to maintain defense spending at the targeted 2% of GDP. Now, with demands for higher spending to appease U.S. President Donald Trump, the country is feeling the heat. The SDR's architects, led by former NATO Secretary General Lord George Robertson, were tasked with halting the hollowing out of UK defense capability and rebuilding the armed forces for the 2040s using a fixed financial profile. The plans rely on UK defense spending reaching the equivalent of 2.5% of GDP in 2027. The Labour administration hopes this can rise further in the next Parliament to 3%. But persistently low economic growth threatens to derail those plans, and Starmer himself has stated that reaching the 3% target remains "subject to economic and fiscal conditions."

At the next NATO summit, planned for June 24-25 in Amsterdam, alliance leaders are expected to call for even more ambitious defense spending targets—potentially as high as 3.5% of GDP. That demand that will tug at the UK's purse strings.

The NATO-first strategy pivots the UK back to the Euro-Atlantic region, with a focus on the pressing threat of Russia. This plan does not ignore China completely, instead acknowledging Beijing's technological advancement and how adversaries increasingly ally with one another.

The SDR namechecks the UK's relationship with the U.S. extensively, describing it as "unlike any other." It modestly notes a change in U.S. security priorities without addressing whether Washington remains a reliable partner.

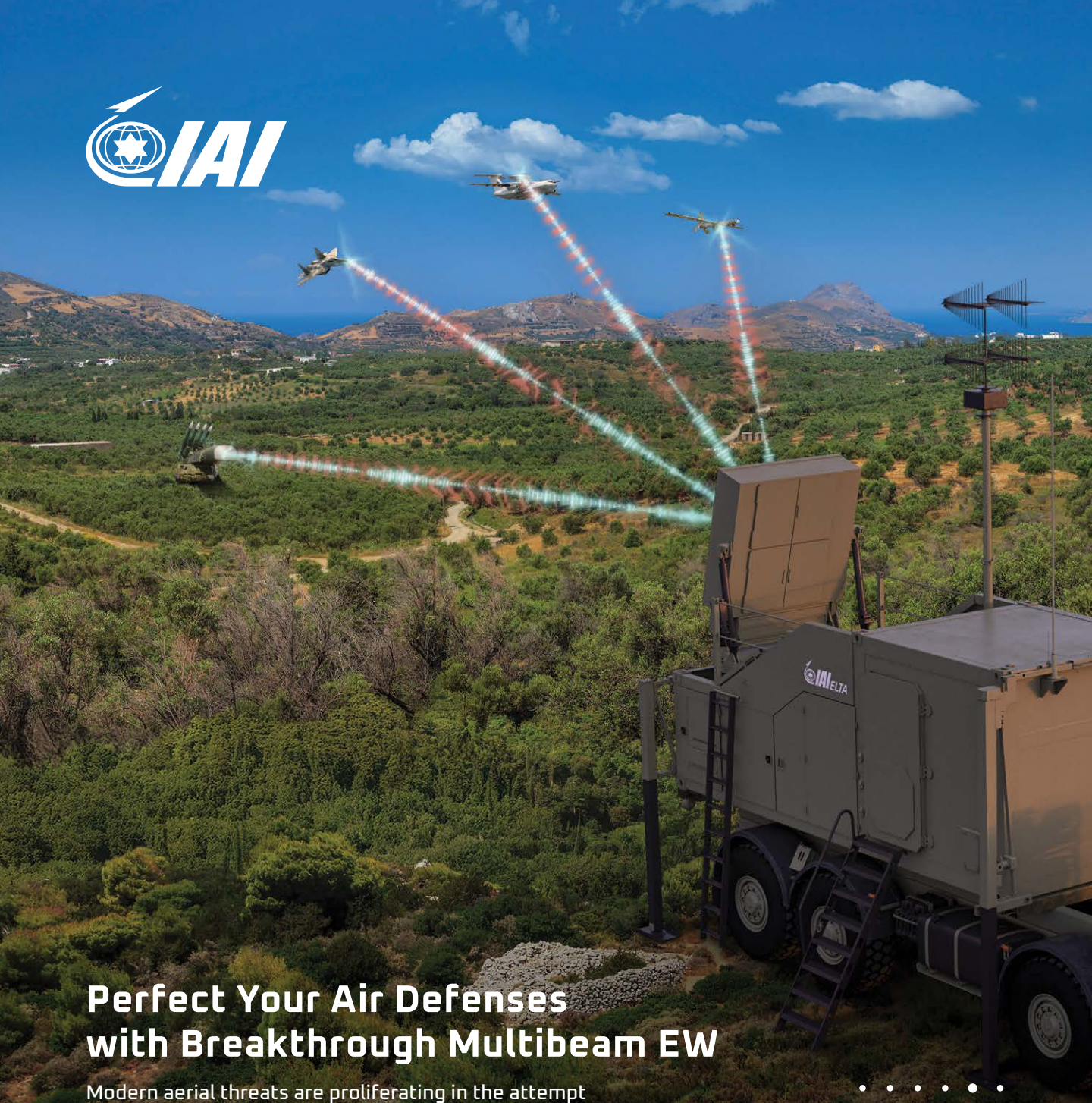
Before the money spigots can open, Defense Secretary John Healey says there needs to be reform. The SDR calls for speedier acquisition processes, a closer relationship with industry and a greater focus on innovation to make the UK "the fastest innovator in NATO."

Procurements should be measured in months, not years, the document says, pointing out that contracts on projects valued above £20 million ($27 million) currently take an average of 6.5 years to be awarded.



The Strategic Defense Review hints that the UK's F-35B Joint Strike Fighters could be joined by conventional-takeoff-and-landing F-35As.

HELAYNA BIRKETT/ROYAL NAVY



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Starmer said the era of post-Cold War peace dividends is over. The UK will increasingly have to rely on defense as an engine for growth to realize a "defense dividend," he stressed. Investment is expected to emerge from a defense industry remobilized with "always-on" manufacturing capability and greater government support for exports.

Healey hinted of pain to come through "stronger budget control and efficiencies" worth £6 billion made during this Parliament. These savings would be reinvested back into defense, he said, but no details have emerged about where they would come from.

While the Royal Navy is the biggest winner in the SDR, which calls for new nuclear submarines and hybrid air wings for the carriers, the review recognizes a need to grow the Royal Air Force's (RAF) bulk using uncrewed autonomous collaborative platforms and to expand support capabilities.

For the first time, an official UK public document has mentioned adding the CTOL F-35A to supplement the F-35B, an option that could enable a dual-capable aircraft mission. The dual-capable task, using U.S. dual-key B61 free-fall nuclear weapons, would restore to the RAF a nuclear role lost in 1998 with the withdrawal of the WE177 family of UK-developed nuclear weapons. The SDR also commits to the Global Combat Air Program future fighter project with Italy and Japan.

The SDR recognizes shortfalls in the size of the UK's future airborne early warning fleet of Boeing E-7 Wedgetails, too. As only three are on order, the plan calls on the country to acquire more, potentially in conjunction with NATO partners. More Airbus A400M airlifters should also be purchased and augmented with commercial transport services where needed. Furthermore, the review recommends that the UK acquire a new fleet of "cost-effective" jet trainers to replace both the BAE Systems Hawk T1 and the troublesome T2 variants. The RAF also needs to be more resilient and invest in deeper stockpiles of weapons, fuel and spare parts.

Conspicuously absent were plans to acquire a new fleet of medium helicopters.

Taking lessons from Ukraine, Healey said £1 billion would go to funding homeland air and missile defenses. The document does not discuss ground-based systems, only referring to a plan to invest in "improving the foundations" of Integrated Air and Missile Defense—perhaps a hint at new surveillance capabilities. Some commentators have described the UK's approach as more akin to a "Tin Dome" rather than the $175 billion U.S. "Golden Dome" proposed by the Trump administration.

The SDR does propose working through such initiatives as the Delivering Integrated Air and Missile Operational Networked Defenses project to enhance networked air defenses across Europe, investments in long-range precision strike and networking platforms through a so-called Digital Targeting Web to shorten decision chains. It also calls for enhancing European air and missile defense through space-based overhead, persistent intelligence, surveillance and reconnaissance capabilities developed with NATO partners. The UK also plans to purchase more than 7,000 domestically made long-range munitions. These would include a mix of "top-end high-precision weapons and cheaper systems to provide mass," defense officials said.

Industry welcomed the SDR's findings. UK aerospace and defense trade association ADS said there were "encouraging signs" of how the Defense Ministry plans to become a "better customer" and support industry. The reforms would allow "industry to plan, invest and, critically, retain the skills needed to build highly complex platforms," ADS CEO Kevin Craven said.

With the SDR published, the government is now expected to produce a defense industrial strategy in the coming weeks, and more details about programs are expected in the defense investment plan due in the fall.

The SDR's Aerospace Recommendations

- **Continue commitment to the Global Combat Air Program (GCAP) with Italy and Japan.**
- **Explore options for a mixed F-35A/B Joint Strike Fighter fleet.**
- **Purchase the F-35A, potentially enabling the UK to join the U.S.-NATO dual-capable aircraft initiative once equipped with dual-key B61 tactical nuclear weapons.**
- **Recognize that the UK's planned fleet of three Boeing E-7 Wedgetails is insufficient for round-the-clock surveillance.**
- **Acquire a new "cost-effective fast jet trainer" to replace the BAE Systems Hawk T1 and Hawk T2s in service. The T1 is flown only by the Red Arrows aerobatic team.**
- **Procure more Airbus A400M airlifters, plus augmented organic airlift capacity with commercial services to reduce demand on military fleets.**
- **Invest in autonomous collaborative platforms (ACP) to work with the Eurofighter Typhoon, F-35 and GCAP combat aircraft and operate from UK aircraft carriers.**
- **Procure about 7,000 long-range munitions, including advanced high-end missiles and low-cost weapons to provide mass.**
- **Create hybrid carrier air wings, mixing F-35s and helicopters with ACPs, uncrewed aircraft systems and other uncrewed platforms.**
- **Launch a Digital Targeting Web to speed up decision-making and link sensors, deciders and effectors.**
- **Explore maritime surveillance capability for the UK's new Protector uncrewed aircraft system to allow it to work with Boeing P-8 Poseidons and Type 26 frigates.**
- **Develop space-based overhead, persistent intelligence surveillance and reconnaissance capabilities with Euro-Atlantic partners to support air and missile defense initiatives.**

The SDR did not mention major rotary-wing programs, such as the New Medium Helicopter, nor future phases of the UK's Boeing CH-47 Chinook fleet renewal.

Win the Invisible War: Control the Electronic Battlefield with Next-Generation EW Technology

The modern battlefield exposes forces to a rapidly evolving threat scenario, with deadly threats increasing in number and in complexity. Large volumes of inexpensive suicide drones dive in on unsuspecting targets, and modified commercial drones drop mortar bombs or grenades on them. More advanced Unmanned Aerial Systems (UAS) stealthily deliver precision munitions, while high-end long-range missiles from the air, ground and sea hit their targets with pinpoint accuracy. The threat is increased when forces are detected and tracked by the enemy using advanced imaging SAR radars, which are effective in all lighting and weather conditions, and are deployed on high-altitude aircraft from standoff ranges.

However, these threats bear an inherent vulnerability: their operation is dependent on the electromagnetic spectrum. Guided weapons require wideband datalinks to allow their operators to close the firing loop. Systems with GNSS navigation require satellite signals to find their way to the target. SAR radars use electromagnetic radiation to sense the environment and generate targets. In order to exploit this vulnerability, modern forces deploy Signals Intelligence (SIGINT) and Electronic Warfare (EW) assets to detect and identity threats, and to actively deny their operation.

Recent conflicts have demonstrated the importance of EW as a crucial arena that surrounds the physical battlefield and carries a critical impact on operational outcomes. Forces in the Eastern European conflict, and elsewhere, are investing heavily in EW assets, especially at the tactical and regional levels. No battle zone is left without EW support, at risk of leaving troops without crucial alerts and protection.


Credit: IAI-ELTA Group

Responding to the challenge of the electronic battlefield, IAI, through its systems and sensors subsidiary – ELTA Systems Ltd. (IAI ELTA) – has leveraged its decades-long heritage in SIGINT and EW to provide a mobile EW suite that enables maneuvering forces to win the battle for superiority in the electromagnetic domain.

At the heart of the EW suite is the revolutionary Scorpius technology of Staring Multibeam AESA (Active Electronically Scanned Array). With its multibeam capability, Scorpius can simultaneously detect and jam multiple targets across the surrounding ground and sky – at greatly increased range and jamming power, as compared to legacy EW systems. Scorpius technology is applicable to all domains of air, land, and sea, providing effective EW defence and attack. In the Aegean arena, in particular, Scorpius systems can provide an arena-wide EW umbrella supporting critical national defence objectives.

In the land domain, Scorpius is complemented with a comprehensive squad of EW sensors and effectors, all mounted on rugged vehicles, to form a mobile EW suite. The suite provides highly sensitive detection, analysis, classification, and digital jamming techniques in order to counter the enemy's communications, radar, navigation, and other activities in the electromagnetic spectrum. A dedicated vehicle within the suite provides long-range Counter UAS (CUAS) defence. Mounted on highly mobile vehicles, the suite can be rapidly deployed even in tough terrain. Alternatively, the vehicles can be airlifted for rapid response to emerging threats.

The suite's operation is managed by a Command and Control vehicle, allowing for optimized planning and execution of a complex EW mission with multiple assets working in concert. Using advanced Artificial Intelligence (A.I.) techniques in all stages of operation, the suite automatically monitors hundreds of target networks and emitters, forms a situational awareness picture and Electronic Order of Battle, and provides extended analysis capabilities such as voice and signal pattern recognition as well as anomaly detection.

Finally, the EW suite can be connected to centralized headquarters, providing electronic awareness, data sharing, and coordinated EW collection and attack operations at the national level.

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Canada's New Government Gets Serious About Defense

> CANADA SEEKS TO JOIN EUROPE'S REARM PLAN

> F-35 ACQUISITION REMAINS ON HOLD PENDING REVIEW

Steve Trimble Ottawa

NordSpace founder Rahul Goel remembers that only about seven months ago, it was still difficult to be vocal in Canada about entering the defense market.

Goel, an aerospace engineer turned entrepreneur, founded the orbital launch company in 2022 to provide a sovereign space transportation option to support Canada's commercial satellite companies. Late last year, he saw an opportunity to capitalize on a new wave of interest in national security.



NORTH AMERICAN AEROSPACE DEFENSE COMMAND

Two Canadian CF-18s taxied during a recent binational exercise with the U.S. Air Force.

"It was pretty hard to talk about defense—and that being something that we're interested in as Canadians in NordSpace—without sort of getting people squinting at us," Goel told an audience here at the Canadian Space Launch Conference on April 29.

Those days appear to be gone. In response to President Donald Trump's repeated proposals to annex Canada as the "51st state," defense spending has suddenly become a popular issue. Prime Minister Mark Carney, the Liberal Party leader, won the election on April 28 on a platform that emphasized Canada's defense responsibilities to maintain its sovereignty.

The question now is whether Ottawa will follow through on Carney's election rhetoric. Canadians have heard politicians make big promises on defense spending that then fail to materialize fully.

Two years after taking office in 2015, then-Prime Minister Justin Trudeau released the "Strong, Secure, Engaged" policy to ramp up defense spending over a decade. Several elements of the plan eventually came to fruition, including the acquisition of new fighters, maritime patrol aircraft and uncrewed aircraft systems.

But the defense budget Carney inherited for this year is projected to represent only 1.37% of GDP, ranking Canada as the fifth-lowest spender as a share of GDP among the 32 members of NATO. The country's defense industry also complains about a tediously slow acquisition process (*AW&ST* April 22-May 5, 2024, p. 23).

Despite the government's track record, Canadian suppliers have noticed a difference this time. "I felt it today, honestly, in the meetings I've had with uniformed people," Thales Canada CEO Chris Pogue said in a May 29 interview during the Cansec convention here. "I could feel them having a different conversation than they would have had a year ago."

A meeting with one Canadian military officer in particular was telling, Pogue said. "A senior officer in the air force was very clear on changing the way they approve projects deeper and deeper down in the organization to give more authority to move faster," he explained. "That wouldn't have been a conversation we would have had a few years ago."

The final proof of Canada's commitment to national security should come soon. Carney pledged on May 27 to complete an agreement with the European Union by Canada Day, July 1, to join the ReArm Europe Plan, which aims to create a $1 trillion war chest for financing acquisitions of military equipment. He also unveiled a plan to release his government's first budget in the fall.

Canada's National Defense Department faces several major decisions. One of Carney's first acts as prime minister was to launch a review of the Royal Canadian Air Force's acquisition of 88 Lockheed Martin F-35As, opening the door to reviving a competition to replace an aging fleet of Boeing F/A-18A/Bs. The country must also consider Trump's invitation to join the Golden Dome air and missile defense shield, which comes with a $61 billion price tag. An $8.1 billion contract to deliver a new lead-in trainer for the air force is up for grabs as well.

Finally, the Royal Canadian Air Force is developing requirements to acquire its first fleet of airborne early-warning and control aircraft. The U.S.-built Boeing E-7A faces competition from two platforms based on the Bombardier Global 6500: the Saab Global Eye and the L3Harris-Israel Aerospace Industries system.

Previous Canadian governments had outsourced most of the direct work generated by defense contracts to other countries, but therein lies another sign that times have changed.

"Now is the time to scale up our production here at home," Defense Minister David McGuinty told the Cansec audience. "Now is the time for your government to invest in you—to capitalize on the immense and growing defense opportunities."

New Study Quantifies Severity of F-35 Pilots' Neck and Back Pain

> EQUIPMENT AND SEAT ANGLE ARE MAIN CONTRIBUTING FACTORS

> U.S. MEASURES HAVE NOT COMPLETELY SOLVED PROBLEMS

Brian Everstine Washington

A new Royal Netherlands Air Force study into a long-standing issue facing Lockheed Martin F-35 Joint Strike Fighter pilots highlights a specific occupational hazard for the first time. Flying the F-35 can hurt, to the point of affecting the mission, pilots say.

Unique characteristics of the Lockheed Martin fighter, particularly the high-tech and heavy Collins Aerospace helmet-mounted display, have long been known to cause neck and back pain among pilots. The issue has been the focus of research for years, driving changes to the helmet itself and the creation of physical training regimes.

The Royal Netherlands Air Force (RNAF) study, released May 1 by the Aerospace Medical Association, for the first time quantifies how much flying the F-35 can affect its pilots compared with those flying legacy fighters. In the study, 61 pilots who had previously flown the Lockheed Martin F-16 responded to a questionnaire regarding neck and back pain after the RNAF adopted the F-35. The responses showed a "statistically significant higher prevalence of back pain among F-35 pilots compared to F-16 pilots," the study says.

Specifically, 46% of F-35 pilots reported back pain, compared with 8% of F-16 pilots. Relatedly, 51% of F-35 pilots reported neck pain compared with 38% of those in F-16s.

Notably, 83% of those who responded that they experienced pain "reported a negative impact on flight performance," and 38% said it affected flight safety.

"This study represents the first investigation into neck and back pain among F-35 pilots and shows a higher rate of both back and neck pain compared to F-16 pilots," a summary states. "Equipment and seat angle appear to be the main contributing factors. Targeted interventions are needed to prevent structural injuries, improve performance and increase deployability."

While the study's authors say it is the first investigation, the issue has long been known, according to researchers in the U.S. Air Force, which flies the most F-35s. However, the study's findings show there is still progress to be made.

The specialized 711th Human Performance Wing inside the Air Force Research Laboratory is tasked with studying and supporting how pilots can best operate, and the wing says it has been following the topic for years.

"The 711th . . . has been an integral part of the USAF's answer to the challenge of aircrew neck and back pain for years and continues to support through research and expert consultation," says Dr. Ryan Mayes of the Air Force's School of Aerospace Medicine.

The wing's research has focused heavily on the F-35's specialized helmet, directing changes to its weight and lowering the center of gravity as part of a series of updates. The Gen III Helmet, first deployed in 2018, has a lower overall weight. However, the timing of the RNAF study shows that the pilots who responded to the questionnaire have been using the lighter-weight helmets.

The wing's focus on F-35-specific issues dates back to an epidemiological characterization of neck and back pain in 2014-15, after which the service established a program called "Optimizing the Human Weight System." As part of this program, experts in strength and conditioning are embedded in flying squadrons to work on preventing neck and back pain issues.

Additionally in 2014, the wing helped sponsor an F-35 International Aeromedical Community of Interest (ACOI), which meets twice per year with all JSF partners invited to share human systems integration and aeromedical issues for the aircraft, according to the wing.

For the RNAF study specifically, the Air Force and U.S. Navy—which oversee the F-35 Joint Program Office—received the results at ACOI meetings in both the fall of 2024 and spring of 2025.

"Pilot neck and back pain is an excellent example of the need for aerospace medicine and physiological research, expert consultation and education, as well as demonstrating the need for effective human-systems integration," the Human Performance Wing states.



R. NIAL BRADSHAW/U.S. AIR FORCE

Despite efforts to lighten the F-35 helmet, it is linked to ongoing neck and back pain among pilots, according to a new study.

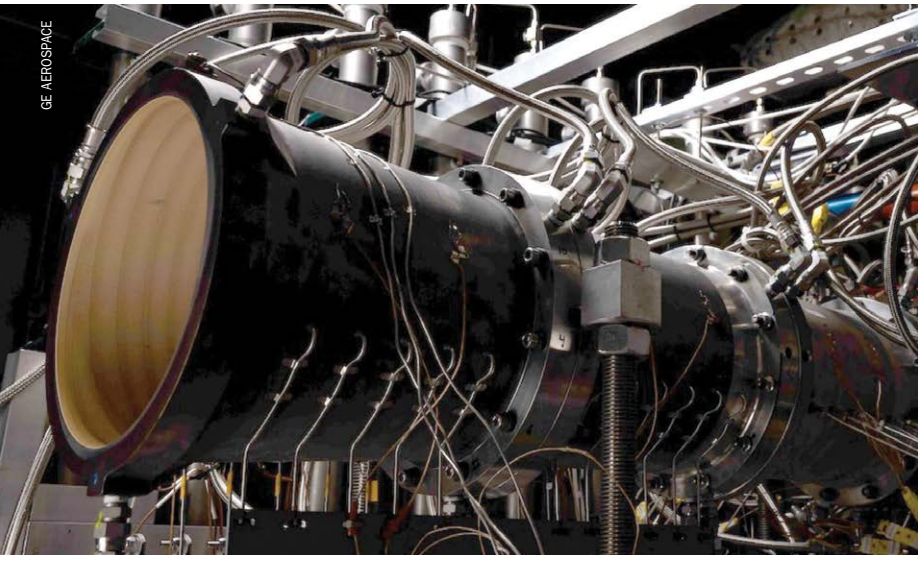
GE Aerospace's Big Hypersonic Propulsion Bet Faces Crucial Tests

- 3X ENGINE TEST WITH ROTATING DETONATION COMBUSTOR SET FOR THIS SUMMER
- THE COMPANY ALSO IS EYEING PROPULSION FOR STANDOFF ATTACK MISSILE

Steve Trimble Evendale, Ohio

GE Aerospace's three-year campaign to develop a reusable, air-breathing propulsion system to power large hypersonic aircraft by the end of the decade faces a critical test this summer.

In the coming weeks, GE Edison Works plans to stage the first ground rig test of the 3X, a dual-mode ramjet (DMRJ) rated at 3,000 lb. thrust with a 15-in.-dia. inlet and driven by a rotating detonation combustor (RDC). The series follows a successful demonstration in 2023, known internally as the "Half-X," of an engine with the same configuration, but scaled down to 500 lb. thrust.



GE AEROSPACE

GE Aerospace tested the Half-X dual-mode ramjet in late 2023, proving the validity of its rotating detonation combustor design.

Future hypersonic vehicles may require turbine-based combined-cycle (TBCC) engines with high-speed modules that deliver 3-10 times more thrust than the 3X. GE expects this upcoming DMRJ test series to confirm whether the configuration can scale up to those sizes.

"If we can demonstrate a scale-up from Half-X to 3X, there's a lot of confidence that it'll continue to scale up to 10X and beyond," Mark Rettig, general manager of advanced programs at Edison Works, told journalists here on June 2. "That's the ultimate vision."

Scaled-up versions could power DARPA's proposed Next-Generation Reconnaissance Strike aircraft, which the agency hopes to fly in prototype form by decade-end. If successful, the design could be developed into a reusable, hypersonic combat aircraft later in the 2030s. DARPA's propulsion requirements involve a TBCC configuration, which pairs a 30,000-38,000-lb.-thrust, high-Mach turbine engine with a DMRJ.

GE Aerospace started preparing for such a vehicle in 2022 by partnering with and then acquiring Innoveering, a small company working on a DMRJ. To that hypersonic propulsion system, Edison Works added several emerging GE technologies: the high-Mach turbine engine, the RDC, high-temperature ceramic matrix composites and an integrated inlet and exhaust system for both low- and high-speed flow paths.

In combination, GE believes that the resulting TBCC propulsion system can solve the myriad problems with reusable hypersonic flight, starting with the gap between the Mach 2.5 maximum speed of a reusable turbofan and the Mach 3.5 minimum speed of a conventional ramjet.

The new high-Mach turbine engine raises the speed threshold for the cutover to the ramjet. By adding the RDC, Edison Works believes it can also lower the minimum speed of a ramjet to cover the remaining gap. The advanced materials can help the engine endure temperatures at hypersonic speed, and the integrated inlet and exhaust system simplifies the complexities of managing two flow paths.

"So, relative to an aircraft design, we have a lot of pieces that fit together really nicely to enable that kind of capability," Rettig said.

The next step is to show that the pieces actually work, especially the RDC. Instead of a standard deflagration combustion process, the RDC produces continuous detonations around an annular chamber. If these detonations in a supersonic flow can be controlled and sustained, the RDC process could, in theory, produce energy more efficiently and in a smaller space compared to deflagration combustion.

In the meantime, the Innoveering team is developing ramjet propulsion systems for a new class of high-speed cruise missiles. "We've demonstrated both a liquid fuel ramjet that is more tied to a Mach 4-ish kind of platform, with the Standoff Attack Weapon being one of the potential opportunities out there," Rettig said.

Little is known about the Air Force's plans for the Standoff Attack Weapon. A request for information tied to a 2022 market study by the service called for concepts that could be fielded in large numbers in fiscal 2030-33. The request set an assumed schedule for contract awards beginning in fiscal 2025.

GE also is exploring other applications for its nascent hypersonic TBCC propulsion system. The company is talking with Kratos about propelling the hypersonic glide vehicle now in production for the Multi-Service Advanced Capability Hypersonic Test Bed program, GE Aerospace Defense and Systems CEO Amy Gowder said.

"I think our propulsion system could couple with a vehicle, or could couple with folks in the solid rocket game, and together we could have an integrated propulsion system," Gowder said. "So I think we're exploring both options."



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Airbus' Top Worry Shifts From Suppliers to Trade

> OEM IS BUILDING 60+ SINGLE-AISLES MONTHLY

> TOILET SUPPLY SLOWS WIDEBODY PRODUCTION

Robert Wall Toulouse

Airbus is glimpsing the end of narrowbody and widebody production bottlenecks, elevating questions about the global trade environment as the biggest cloud over the company's prospects.

Although the company's aircraft shipments are trailing what is needed to meet the 820-unit delivery guidance for the year, Airbus Commercial CEO Christian Scherer said the target remains attainable. "The overall disturbance of supply has abated, largely," Scherer told reporters June 11. "It's not gone, but it is improving significantly."

Engine deliveries, in particular from CFM International, remain a problem for A320 output but are starting to trend in the right direction. "We believe between now and the end of the year, we will get the missing engines," Scherer said, even if CFM is still slightly behind the Leap-1A catch-up plan. Airbus has about 40 single-aisle aircraft assembled and awaiting engines before going to customers.

"Were it not for those engineless aircraft, our delivery performance . . . would be slightly above plan right now," he said. A sign of that progress is that narrowbody output is climbing beyond 60 aircraft per month as Airbus strives to ramp up to 75 per month in 2027.

On A350 widebodies, the main supply issue is toilets, Scherer said. Safran, suffering from its own supply chain bottleneck, has been late with component deliveries from its plant in Mexico.

Julien Puyou, head of Airbus widebody programs, said that Safran should start to deliver toilets on time in the coming weeks and be fully caught up by year-end. "We have our supply chain teams fully engaged on-site with them to help them, support them," Puyou said. "And of course, we are putting some pressure on them, too, so that they improve the recovery."

While production issues are trending in the right direction, trade worries remain. Scherer called the situation "the overriding concern," even while expressing hope that talks between the U.S. and others will succeed and prevent heavy tariffs.

Still, Airbus moderated its 20-year industrywide aircraft delivery outlook in its latest forecast, given the trade uncertainties. The aircraft industry is expected to take delivery of more than 43,420 new passenger and freighter aircraft, the OEM says. Total forecast deliveries are up 2.3% from the year-prior outlook, but that increase lags the 3.9% year-over-year increase in 2024's projection. The revision partly reflects a cut in the airframer's assumed GDP growth projection for the period to 2.5% from 2.6%.

Airbus projects delivery of 34,250 single-aisle aircraft seating more than 100 passengers over those 20 years, up from 33,510 in 2024-43. It also forecasts passenger widebody deliveries of 8,200 units, compared with the 7,980 projected last year.

Some markets are particularly affected by the trade situation, said Antonio Da Costa, head of market analysis and forecast for commercial aircraft at Airbus. But he asserted that airline demand remains resilient and will drive the need for growing fleets.

"We have not, at this moment, seen an inflection, with the possible exception of maybe the more domestic U.S. market," Scherer added. "But we have not seen an inflection, fundamentally, in demand from our customers."

Airbus included current tariff levels in its assumptions but not some of the highest rates the Trump administration has floated. The growth outlook "is all subject to assuming that tariffs will not become a kind of a 'Liberation Day' level of punitive levels of tariffs that will have, let's say, a very significant COVID-like impact on trade," Da Costa said.

One reason aircraft delivery rates are largely holding up is that the tariff effects likely will be felt more in the mature markets that are not the principal driver of aircraft delivery growth, he asserted. Lower fuel prices also are damping the effect of weaker GDP projections, Airbus suggests.



AIRBUS

Airbus is adding single-aisle final assembly capacity in Toulouse (pictured) and elsewhere to boost output to a combined 75 aircraft per month.

Aircraft deliveries to countries in the Asia-Pacific region are projected to drive much of the forecast demand, with China accounting for 9,570 deliveries and the other countries in the region for 10,050. By contrast, the North American market is expected to see 6,810 aircraft delivered, with Europe and some former Soviet states accounting for 8,070.

In addition, Airbus cut its global trade growth forecast through 2044 to 2.6% from 3.1%. The airframer nonetheless expects to deliver 970 new freighters compared with 940 in last year's forecast. Da Costa said high-value goods that typically use air freight, such as microchips, should continue to see healthy demand.

Airbus notes that more than 14,000 aircraft in the single-aisle delivery forecast are in manufacturers' backlogs, with a little more than 20,050 orders for airframers to win.

Although the airline industry has become more muted about growth projections in recent months, Bernstein analysts note that aircraft-makers are not keeping up with replacement needs. "Even with this lower outlook for traffic growth, deliveries from Airbus and Boeing will still significantly lag demand because production levels have been far below planned rates, and both companies are still struggling to bring delivery rates higher," Bernstein said June 9.

Airbus expects 56% of deliveries over the period to support growth; the rest would replace existing hardware.

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Supply Chain Issues Cloud India's Airline Growth Story

> SEAT DELAYS STALL AIR INDIA'S FLEET RETROFIT PLANS

> INDIGO GRADUALLY REDUCES GROUNDED AIRCRAFT TOTAL

Adrian Schofield New Delhi

The Indian airline industry is positioned for dramatic growth thanks to major aircraft orders placed by its two largest carriers. But in the short term, fleet refresh and expansion plans have been disrupted by supply chain issues and the related headaches of delivery delays and aircraft groundings.



Air India plans to begin its Boeing 787 retrofit program in July.

A PERIAM PHOTOGRAPHY/ALAMY STOCK PHOTO

Air India's extensive fleet upgrade program has been hit by chronic delays from seat suppliers (*AW&ST* June 2-15, p. 58). And rival IndiGo has been one of the carriers most affected by shortages of Pratt & Whitney engine availability in Airbus narrowbody fleets, although the problem has eased significantly since its peak.

Supply chain problems were a major topic of concern during the International Air Transport Association (IATA) annual meeting here June 1-3, with many airline executives expressing frustration at the lack of improvement. This issue has affected almost all carriers to some degree, with no resolution in sight.

The timing has certainly not been good for Air India. The carrier is attempting to make up for years of underinvestment by placing more than 500 orders and launching a sweeping retrofit program for its major fleets.

As with many other airlines, the slow delivery of seats has been the main pacing item for Air India's upgrade efforts, CEO Campbell Wilson said during a June 2 media briefing at the IATA event. This has been the most problematic supply chain issue for the carrier.

Four out of five of Air India's seat suppliers have caused delays, Wilson said. He noted that one supplier walked away from a contract "and left us in the lurch," causing a two-year delay in one retrofit program. Others have been pushed back about a year. "Things may be getting better, but I don't want to give anyone any credit because it's still very painful," Wilson said.

Some of the cabin retrofit programs are finally underway or starting soon. Work will begin on the first of Air India's Boeing 787s in July, and the retrofit of the aircraft is expected to be completed and certified in September or October, Wilson said. Once the first aircraft is completed, the rest of the 787 fleet will be retrofitted at a rate of 2-3 per month, and all should be completed by 2027.

Air India has begun what it describes as a "heavy refresh" of its Boeing 777 fleet, as the full retrofit program of these aircraft has had to be postponed. Panels and carpets will be replaced, and seats will be repaired but not replaced.

The full retrofit of the 777 fleet—including new seats—is set to begin at the end of 2026, Wilson said. This process is expected to continue through the end of 2027.

A retrofit for the airline's Airbus narrowbodies is already underway, and the first 27 aircraft are due to be completed by September or October. Air India has extended the retrofit to another 13 older narrowbodies, which will be addressed after the initial batch is finished.

IndiGo is one of many airlines that have had to ground a significant number of Airbus A320neo-family aircraft because of lengthy waits for maintenance checks on Pratt & Whitney geared turbofan engines.

The good news is that the carrier's aircraft on ground (AOG) number has declined steadily, although there is still some way to go. IndiGo's number of grounded aircraft has dropped to the mid-40s, down from a high point in the mid-70s about a year ago.

The total has reduced slowly, CEO Pieter Elbers said. "We would have liked it to be faster, but it has at least been a continued decline," he said. "Whether that's going to [proceed] at the same pace, or whether it may slow down a little bit, remains to be seen." But the rate "should not deviate too much from what we have seen so far," he added.

IndiGo is focusing more on meeting its capacity growth plans than on the number of aircraft on the ground, Elbers said. By leasing additional aircraft and inducting new deliveries, the carrier has been able to exceed its capacity expansion targets.

A positive sign is that the reduction in AOG has allowed IndiGo to start returning the damp-leased narrowbodies it added as a temporary measure.

The carrier has nearly 900 A320neo-family aircraft remaining on order and is taking delivery of an average of one each week.

IndiGo has seen levels of new aircraft delivery delays similar to those of other carriers, according to Elbers. However, the high volume of deliveries helps offset the delays. Elbers noted that would hit harder for airlines with fewer orders or less frequent deliveries than IndiGo.

The airline signed a memorandum of understanding with Airbus on June 2 to convert 30 more A350 purchase rights to firm orders. This would give IndiGo 60 firm orders for A350s in total, following an earlier order last year.

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ASK THE EXPERT



Jeffrey Miller
Aerospace Industry Leader
at Rockwell Automation

Rockwell Automation's Digital Thread for Supply Chain Resiliency

Rockwell Automation's Jeffrey Miller discusses how digital thread technologies and industrial data integration can strengthen aviation, aerospace, and defense industrial supply chains, reducing costs and improving resilience through extended connectivity and predictive capabilities

Q AW: What scope is there for aviation companies to use data to remove cost and time from their supply chains?

A JM: Global aviation supply chains, especially those for MRO are already advanced in their uses of product lifecycle data for integrated planning and inventory visibility. And there's more capability to be had by harnessing, contextualizing, and integrating data from broader sources, by applying industrial data management principles to enhance the sharing and use of distributed data to improve supply network performance and resilience. Most supply chain uncertainties, most unknowns convert into costly inventories. Better information, more complete contexts improve decision making. That drives cost out of aviation supply chains. Brittle supply chains are characterised by poor connectivity, gaps in data, and delays in awareness. By remediating these deficiencies, less inventory is needed for mitigation of uncertainty.

Q AW: Could you give a real-world example of how a digital thread can ensure a resilient supply chain?

A JM: Commercial carriers closely measure actual versus planned aircraft availability. A lot of effort goes into minimizing the frequency of unplanned AOG (aircraft on ground) events. A client found that a particular component accounted for a significant percentage of its unplanned groundings. It also determined that certain operating data of that component provided reliable a predictor of its remaining useful life. Those data enabled the scheduling of its replacement before predicted failure. But preventatively replacing a functioning component on an asset that's moving from place to place presented a complex challenge. Imagine trying to find the correct spare part for that tail number, at any one of many locations the aircraft will transit, along with a suitably trained line maintenance technician available at that place and time of transit, during a layover period of sufficient duration to perform the replacement procedure! Here's where the power of the digital thread for the supply chain came into play.
We enhanced the supply chain data model to include timely, systemwide visibility of spares inventory, transfer orders, planned receipts and scheduled consumptions. Then, we associated work instructions with line technician locations, availabilities and aircraft dispatch schedules. Finally, we wrote a simple solution-seeking routine to find the intersection of those criteria and issue work orders. In effect, all we did was take information that already existed in independent systems and apply digital thread principles to connect and contextualize those data so a decision could be made, and an AOG event avoided – all without need of human intervention.

Q AW: How do you make sure that different systems from different suppliers can talk to each other?

A JM: Applying the framework and rules of Unified Namespace during construction or updating of supply chain data architectures help assure interoperability between dissimilar systems. It can be difficult to interlock data from inventory,

warehouse management, factory systems, and production schedules from siloed enterprise and factory solutions. Today, those siloes may be bridged through intermediary architectures and standards, if data can be made visible. Companies realise this and they're willing to put money into new forms and levels of data integration. We identify and organize data using digital thread principles, industrial data modelling, and unified namespace capabilities to bring them together and remove barriers to interoperability.

Q AW: How important is inclusion of materials management in the Digital Thread, and how does it integrate with fleet operations and maintenance planning?

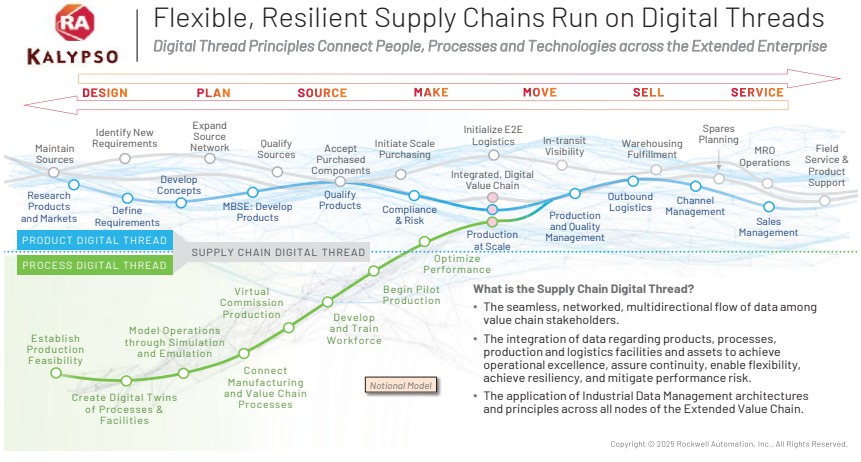
A JM: We're accustomed to performing line maintenance, conducting hangar-based MRO, and managing configurations each as closed processes governed by regulatory compliance, routine PM programs, Service Bulletins, and operational needs. Yet, the efficiencies of these processes are often determined by material management activities which, in general, have not been interlocked. Today, a growing number of spare parts management solutions are adopting AI-powered digital thread principles to reduce spare part cycle times and shorten AOG events. For MRO, and A- and B-checks, digital thread integration of spare part configurations, part location planning and visibility to multi-party inventory balance, fleet scheduling, line, hangar, and logistics capabilities are together enhancing aircraft availability.

Q AW: To what extent can better data connections alleviate the supply chain problems aviation has experienced since the pandemic?

A JM: Core digital thread principles are not yet as widely integrated into today's global aviation supply networks as they are in other industries, but deployment is accelerating. More timely and complete connections to data and sources make new capabilities available to address top issues of anti-counterfeiting, visibility, supply continuity and more. Today, these supply chain capabilities are helping companies navigate complex tariff and sovereign trade issues, where short notice sourcing decisions and dynamic material movements are becoming more frequent.

Q AW: Do digital thread principles have other applications in aviation?

A JM: Absolutely, yes! Digital thread principles are as vital to digital twins as they are to supply networks. Principles of data sourcing and formatting, architectures, accessibility, and timeliness are key to creating useful digital twins. Indeed, the value of a digital representation of physical thing or system is determined by the quality of the digital thread. We use digital twins to validate product designs, commission processes and whole factories. Airframers today are using process digital twins to optimize factory scheduling and enhance flexible manufacturing by modelling various operating scenarios. There is plenty of room for growth in the utility of digital twins in aircraft assembly to enable greater throughput for each unit of CAPEX investment.



Azul Bankruptcy Caps Tumultuous Time for Brazilian Airlines

> THE CARRIER DODGED CREDITOR PROTECTION FOR YEARS

> THE CHAPTER 11 FILING REFLECTS THE UNIQUE CHALLENGES BRAZILIAN AIRLINES FACE

Lori Ranson Washington

Azul's recent entry into Chapter 11 restructuring marked an unpleasant milestone for Brazil's aviation sector: All three of the country's major airlines have sought creditor protection in the past five years.

The development shows the paradoxical state of Latin America's largest aviation market. In Brazil, opportunities for growth are ripe, but significant challenges remain for airlines operating there. A common theme in the Chapter 11 cases of Azul, GOL and LATAM Airlines Group (parent of LATAM Airlines Brasil) was a lack of government support during the COVID-19 pandemic, leading to weaker balance sheets as the crisis waned.

Azul made every effort to avoid the same fate as its Brazilian peers. The carrier's decision to enter Chapter 11 bankruptcy protection, Raymond James analyst Savanthi Syth noted in a research report, "follows multiple attempts over the past few years to address the weight of liabilities accrued as a result of the COVID pandemic and the devaluation of the Brazilian real, resulting in [an approximately] 750% increase in interest expense versus 2019."

Despite reaching a deal in October 2024 to eliminate 3.1 billion real ($550 million) in obligations to 98% of its lessors and manufacturers, Azul's net debt jumped 50% year over year in the first quarter of this year.

Unlike its major domestic competitors, which largely operate narrowbody aircraft, Azul's fleet consists of Cessna Caravans, ATR 72-600 turboprops and Airbus A321neos, A320neos and A330 widebodies. That diversity has allowed the carrier to bring air travel to unserved markets in Brazil. Azul's network encompasses 160 destinations, and the carrier is the only operator on 82% of its routes.

"We have ATRs, we have Embraers, we have Airbuses that we use, like the U.S. majors do . . . the right airplane at the right time in the right market," Azul President Abhi Shah said at CAPA's Airline Leader Summit – Americas on April 3 at Grand Cayman. "That allows us to bring demand at the lowest cost possible."

Shah told Aviation Week in 2024 that when the airline entered the market in 2008, Brazilian airlines transported approximately 50 million passengers (*AW&ST* June 17-30, 2024, p. 50). Over the past 16 years, that has grown to 100 million, and Azul was responsible for 60% of the growth, flying approximately 30 million passengers, he explained.

More opportunities exist to grow the market. Azul calculates that Brazil had 0.5 trips per capita in 2022 compared with 0.8 for Mexico, 0.9 for Colombia and 2.8 for the U.S. Brazil has a population of just over 210 million.

There are no restrictions on foreign ownership of airlines in the country, but there have been few new entrants during the last couple years. "It's an emerging market," Shah said at the CAPA summit. But it is also a market with distinct challenges. He cited high fuel costs, noting that although Brazil produces large volumes, fuel is priced like an import, resulting in "some of the highest prices in the world."

Passenger litigation is also rampant in Brazil. In 2024, the International Air Transport Association (IATA) calculated that the country's three largest airlines—LATAM Airlines Brasil, Azul and GOL—averaged one lawsuit for every 227 passengers, giving Brazil the distinction as the world leader in claims. The association estimated the extensive litigation cost industry a collective $200 million per year.

"The government wants more airlines, including [ultra-low-cost carriers], to enter the market to create more competition, but this will not happen as long as Brazil is the country with the most lawsuits in the world," said Peter Cerda, IATA regional vice president for the Americas.

More recently, the association warned that a proposed 26.5% value-added tax in Brazil would increase fares and slash passenger demand by 30%. "It's time for the government to do their part and look at the long-term competitiveness of air transport in Brazil," the association stated.

Even in the face of those challenges, Shah concluded at the CAPA conference that Brazil's three incumbent carriers are "pretty well managed."

Azul's Chapter 11 filing occurs as its



TREVISAN AVIATION IMAGES/ALAMY STOCK PHOTO

Azul worked to avoid Chapter 11 for years, but balance sheet headwinds were too strong to overcome.


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potential merger partner, GOL, prepares to exit bankruptcy protection. In January, Azul reached a nonbinding memorandum of understanding with GOL parent Abra Group to combine the airlines. "[Merger and acquisition] ambitions [are] tabled for now, albeit management still believes in the merits of a merger with GOL," Syth of Raymond James stated.

As part of its restructuring plan, Azul's annual capacity growth in 2025-29 is scheduled to fall to 3.8% from 11%. The airline's estimated fleet count for 2025 is to drop to 170 from 201 and for 2027 to 172 from 218.

Analysis by JP Morgan concluded that the Chapter 11 filing is "undoubtedly negative for sentiment on Embraer, since Azul is one of its main clients." During the first quarter, the carrier had a firm order for 51 Embraer 195-E2s, representing 15% of the manufacturer's commercial aircraft backlog and 34% of its E195-E2 orders.

But JP Morgan predicts "limited effects on this year's operational figures, as we believe Embraer was not considering Azul as a relevant client in terms of aircraft deliveries this year." The JP Morgan analysts add: "Furthermore, most investors are already skeptical about potential deliveries for Azul, since this order has been sitting in the backlog for nearly a decade."

Azul is gaining support from key industry players in its Chapter 11 restructuring, including up to $300 million in exit equity investment from United Airlines and American Airlines, subject to certain conditions. Azul has reached an agreement with its largest aircraft lessor, AerCap, that will produce total annual cash flow savings of $334 million from 2025 to 2030. The company also estimates the cumulative contribution from lessors and manufacturers should average $275 million between this year and 2029.

When Azul concluded its out-of-court restructuring in late 2024, the company's management was optimistic that that would be a final fix to its balance sheet, but headwinds persisted, and the airline will spend the next year in Chapter 11. Nonetheless, that optimism remains on full display. CEO John Rodgerson has pledged that with the restructuring, "we believe that we are creating a robust, resilient, industry-leading airline."

ADVANCED AIR MOBILITY

U.S. Air Taxi Startups Mark Flight-Test Milestones, Although Gaps Persist

- JOBY LEADS ARCHER IN FLIGHT-TEST MILESTONES AND TEST HOURS
- BOTH STARTUPS FACE TIGHT DEADLINES FOR 2028 LOS ANGELES OLYMPICS

Ben Goldstein Boston

Archer Aviation and Joby Aviation continue to make headway in their race to develop and certify electric vertical-takeoff-and-landing air taxis, although an achievement gap appears to be growing in Joby's favor.

And while the two are not competing head-to-head in the urban air mobility sector, Beta Technologies continues to chart impressive progress developing the electric conventional-takeoff-and-landing (eCTOL) and electric vertical-takeoff-and-landing (eVTOL) versions of its Alia 250.

Archer's latest technical milestone was a first flight of its piloted, preproduction Midnight air taxi on May 30. The aircraft, tail number N703AX, departed from Salinas Municipal Airport, California, at 9:20 a.m. PDT and touched down 6 min. later, according to FlightAware. It reached a cruise speed of 125 mph and altitude of 1,500 ft., Archer said.

The aircraft took off conventionally from a runway with lift generated from its wing rather than propellers, so there was no transition between thrustborne hover and wingborne cruise as there would be in a typical eVTOL flight. After Archer finishes expanding the eCTOL flight envelope with longer flights and different patterns, it intends to test the aircraft in vertical hover before advancing to a full piloted transition between hover and cruise and back again, which is considered a key technical milestone in the development of an eVTOL aircraft.

Joby achieved that feat for the first time in a preproduction, piloted S4 aircraft on April 22 with the fourth and latest aircraft to roll off the production line in Marina, California, registration number N544JX. The company has since completed multiple transition flights with three different pilots at the controls and says it is now performing "routine" transitions as part of its internal flight-test program. Beta Technologies, for its part, was the first to transition with a pilot onboard in April 2024.



ARCHER

Archer made its first piloted flight with its Midnight aircraft on May 30.

Given that Joby completed a piloted transition before Ar-



JOBY AVIATION

Joby completed a first piloted transition flight with its S4 eVTOL on April 22.

cher's first piloted flight, the gap between the two rivals has come into clearer focus for many industry-watchers. Joby has six aircraft in its test fleet, five of which are preproduction, whereas Archer has just one piloted aircraft and an uncrewed prototype. Joby also is far ahead in flight time, having racked up more than 40,000 test flights with its uncrewed prototypes since 2017 and over 100 piloted flights since October 2023, while Archer has flown hundreds of times in its uncrewed Midnight prototype and just recently began flying with a pilot onboard.

"When it comes to aerospace, there is no substitute for flying, and the number of hours you spend flying the airplane is directly proportional to how well you understand it," says Sergio Cecutta, founder and partner at SMG Consulting. "That difference in flight hours puts Joby at an advantage over Archer."

While it is difficult to assess exactly how wide this gulf is in terms of progress toward type certification, Cecutta estimates the difference to be six months in an optimistic scenario and one year in a "more realistic" case.

Both Archer and Joby have plans to send their aircraft to the United Arab Emirates this summer for testing in desert conditions and nonrevenue market survey flights, with Archer targeting Abu Dhabi and Joby Dubai. Both say they remain on track to meet their goals. Joby says it has already shipped its first aircraft to Dubai. But it is unclear whether Archer will transfer its sole test asset abroad before it completes envelope expansion, raising the possibility that the company's goal may be delayed by some months.

As the air taxi startups execute on their flight-test programs, the challenge of the FAA's type certification process has become pronounced. Archer and Joby, for their part, are no longer telegraphing publicly a target date for certification and entry into service, reflecting the uncertainty surrounding the process of certifying for an entirely new category of aircraft.

Both Archer and Joby still need to roll out fully conforming aircraft for use in their certification flight-test campaigns. After completing their own internal testing and validation programs, they can obtain type inspection authorization and begin flying for certification credit. That can involve hundreds, if not thousands, of hours of flying—a tough challenge, considering the short duration of most eVTOL flights. The process will culminate in function and reliability testing, a series of tests in which the companies will perform simulated in-service operations to ensure reliability of the aircraft in mission-representative conditions. Even after receiving type certification, there will still be work ahead of service entry as they cement the groundwork and procedures for routine operations in complex urban airspace.

Considering the immense workload still ahead, Cecutta estimates type certification for Archer and Joby in 2027 and service entry in 2028—potentially drawing into question their plans to launch service in time for the Los Angeles 2028 Summer Olympics.

While Archer and Joby race to certify their air taxis, Beta Technologies is taking an entirely different approach. The Vermont startup is aiming to certify its eCTOL CX300 aircraft first, primarily for use in the cargo, medical and defense realms, to be followed by the Alia 250 VTOL, both of which share about 85% commonality, according to the company.


BETA TECHNOLOGIES

Beta Technologies landed at New York's John F. Kennedy International Airport with a pilot and four passengers on June 3.

Despite its somewhat quieter public profile, Beta appears to be making serious headway toward certification of the CX300. The startup achieved a major milestone when it flew into New York's John F. Kennedy International Airport on June 3 with a pilot and four passengers, following a 45-min. flight from East Hampton Airport on Long Island with a noncertified, production-intent aircraft, tail number N916LF.

Beta conducted the flight under an experimental-category market survey certificate that enables it to perform customer demonstrations including cargo, medical and passenger flights. A second production-intent aircraft, N214BT, is touring Europe on its way to conducting a cargo operational demonstration in Norway with customer Bristow.

With its strong momentum, Beta is on track to certify the CX300 by late 2026 and the Alia 250 by late 2027, SMG Consulting estimates.

Pratt Offers New Hot Section Option To Boost Geared Turbofan Durability

> UPGRADES EXTEND MAINTENANCE INTERVALS BY UP TO 40%

> THE NEW HOT SECTION CAPTURES 90-95% OF THE GTFA ENGINE'S TIME-ON-WING BENEFIT

Christine Boynton Asheville, North Carolina

After Pratt & Whitney unveiled its next-generation Geared Turbofan Advantage engine, the variant's specs caused operators of the base model to raise a figurative eyebrow.

"This was being worked starting middle of [2024] through first-quarter [2025], when we finally realized we had the ability to go do this," Deurloo explained during a briefing here ahead of the Paris Air Show. He described a

RTX



Pratt's facility in Asheville, North Carolina, focuses on machining, coating and finishing airfoil components—and will soon add an advanced casting foundry.

"For years, customers have been asking us, 'Why can't you retrofit the engine? This Advantage sounds great; why can't you bring it into the existing configuration?' " Rick Deurloo, Pratt & Whitney's president of commercial engines, recalled. Behind the scenes over the past year, the manufacturer has explored how to do just that.

Starting next year, geared turbofan (GTF) customers will be able to select a new hot section based on the next-generation Geared Turbofan Advantage (GTFA).

"We're taking that hot section out of the Advantage and bringing it right back into the base engine, including the combustor and the panels," Deurloo said. "Of [the GTFA's] time-on-wing benefit, we're going to get 90-95% of it just by bringing that hot section back into the base."

The GTFA itself is expected to offer roughly double the time on wing of its predecessor, Pratt says.

timeline for certification by the FAA and European Union Aviation Safety Agency "that will get this over the finish line by the end of the year."

Involving roughly 35 parts, the new hot section retrofit option is expected to be available to GTF customers two years before Pratt's projected switchover to full production of its Advantage variant.

Meanwhile, interim upgrades involving five parts are ongoing at Pratt maintenance, repair and overhaul (MRO) locations throughout 2025. According to the engine-maker, the upgrades extend the powerplant's maintenance interval by up to 40% over the base engine of "today"—loosely defined as batches delivered within the last six months—but will not be included on new deliveries until at least the first half of 2026, as the in-service fleet is prioritized. A "significant additional" number of engines will get the upgrade this year, Deurloo said.

Durability and production-related on-wing issues have plagued the GTF in the past several years, resulting in aircraft on ground (AOG) for related inspections and repair (*AW&ST* April 22-May 5, 2024, p. 44). The AOG situation remains Pratt's "biggest challenge," Deurloo acknowledged. The company sees a strong trajectory for improvement, citing MRO output and slightly fewer removals than anticipated for both the PW1100Gs that power Airbus A320neos and the smaller variants on A220s and Embraer E2s. Deurloo expects per-day AOG "will be coming down into the 350-plus range" by year-end.

Concurrent with the durability upgrades, Pratt is preparing for the GTFA's service entry in 2026, having received type certification from the FAA in February. The ramp-up to full production is expected to start slowly and take about two years as the manufacturer ensures its industrial systems can support that growth. By 2028, Pratt expects 100% of the engines it delivers will be GTFAs.

"If everything's going swimmingly a year into that cutover, we may say, 'let's accelerate that,' " Deurloo said. "But right now, we have a plan of record that has low production going to 100% by the first half of [20]28."

A 1.2-million-ft.^{2} blade and vane manufacturing plant in Asheville will be key to Pratt's ramp-up, simplifying the production stream of hot section components. Airfoils that previously racked up roughly 2,500 mi. of travel per part in shuttling among plants are now contained to a single building. At top capacity, Asheville is expected to produce roughly 300,000 blades and vanes each year, supporting both the aftermarket and manufacturers. The plant opened in 2022 and will boast foundry capabilities once Pratt installs on the production floor an undisclosed number of casting furnaces—described by one company executive as about three stories tall.

The site represents Pratt's vision for the factory of the future as it looks ahead to the "next evolution" of its GTF architecture.

"This is a very important year for us," Deurloo said. "The ramp is real. The demand is real. The evolution of the engine I talked about is real. Those things we need to get over the finish line, and we need to make sure that we position ourselves beyond [20]26."



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GE Is Checking Final Boxes as 777-9 Approval Nears

- BOEING 777-9 IS NOW FLYING WITH PRODUCTION-STANDARD ENGINES
- FLIGHT TESTS ARE VALIDATING NEW ANTI-COKING SYSTEM AND COMBUSTOR LINER

Sean Broderick Niskayuna, New York, and
Guy Norris Colorado Springs

As Boeing's 777-9 certification program moves through its final phases, flight tests are validating changes made to GE Aerospace GE9X engines that address issues flagged earlier in the prolonged development program.

The four-aircraft 777-9 test fleet includes some production-standard engines with reverse bleed systems (RBS) and redesigned combustor liners, GE Aerospace said during a visit to its dedicated Global Research Center ahead of the Paris Air Show.

Adding the RBS is a proactive move to reduce the chance of in-service disruptions due to fuel coking, or fuel deposit buildup. GE developed the RBS to address the issue on the CFM International Leap-1 family and opted to add it to the GE9X before service entry after early testing for the 777-9 GE9X revealed signs of potential coking.

First unveiled by GE in 2023, the RBS activates automatically after shutdown and blows air in the reverse direction through the existing engine bleed duct system. This cools the fuel nozzles, which prevents buildup from forming. The new combustor liner addresses cracking discovered in late 2022 that forced flight testing to pause.



Boeing recently reactivated its fourth 777-9 test aircraft, WH004, and added it to FAA flight testing.

JOE WALKER

"We got the new design incorporated into all production engines, so it's fixed," a senior GE9X program executive says. "We've continued to test. We've done component testing. We haven't found any additional cracking like we'd found on the one test finding."

GE began delivering production-standard engines to Boeing in July 2024. But flight testing was soon halted due to cracked thrust links and did not resume until this year (*AW&ST* June 2-15, p. 53). During that period, GE completed its required 3,000-cycle (3K) test that simulates extended-operations (ETOPS) conditions—a requirement for ETOPS approval at service entry. Part of the FAA's validation is inspection of the completely disassembled test article—a step that is expected to happen this summer, GE says.

Neither the RBS nor the redesigned combustor liner were on the 3K test article, GE confirms. Both will be approved before service entry through separate testing and validation.

Beyond validating the latest changes, GE also plans to conduct a second round of dust-ingestion testing. The GE9X completed 1,600 cycles of dust-ingestion work in 2021, marking a first for an engine certification program (*AW&ST* Oct. 12, 2020, p. 22).

The tests—which produced no findings, GE notes—are seen as crucial to help ensure a smooth entry into service, particularly given that the model's two largest customers, Emirates and Qatar Airways, are based in notoriously harsh environments. The trials also provide a dataset GE could tap to help it better address unforeseen issues.

"You have a fleet leader running inside the company where you're learning ahead of the fleet, telling you things that allow you to proactively be ready and start managing those engines in the fleet," says Arjan Hegeman, vice president of commercial future of flight engineering.

According to Boeing's timeline, most of the 777-9 FAA flight-test work should wrap up by year-end. Some ETOPS testing may spill over into 2026, CEO Kelly Ortberg said at a late-May Bernstein conference, but that would not derail the current plan of making long-awaited first deliveries in 2026.

Launched in 2013 with first deliveries eyed in 2019, the 777-9 has been beset by a series of technical problems and a rapidly shifting regulatory landscape. While the extra time was not welcomed by customers, it has allowed for work such as GE's RBS and dust-ingestion trials to help ensure a more predictable early service life—a standard that has proven challenging for all three large turbofan enginemakers to meet on their newest programs.

"We have made the most of the extra time we've had to make sure that this engine is ready to go into service," the senior GE9X executive says.

The GE9X, designed to deliver 10% better fuel efficiency than the largest GE90 variant, has surpassed 27,000 cycles and 17,000 hr. of testing. The figures are easily the most for any of the company's engines before service entry.

The work has been crucial to helping validate the advanced design, which includes five different GE-manufactured ceramic matrix composite parts: combustor inner and outer liners, high-pressure turbine (HPT) Stage 1 shrouds and nozzles, and HPT Stage 2 nozzles.

Boeing, which has rolled out 33 777-9s, recently reactivated 777-9 WH004 and added it to FAA testing, which formally began in July 2024. Since its reactivation—it had been parked since November 2021—WH004 has been flying regularly as part of the four-aircraft test fleet.

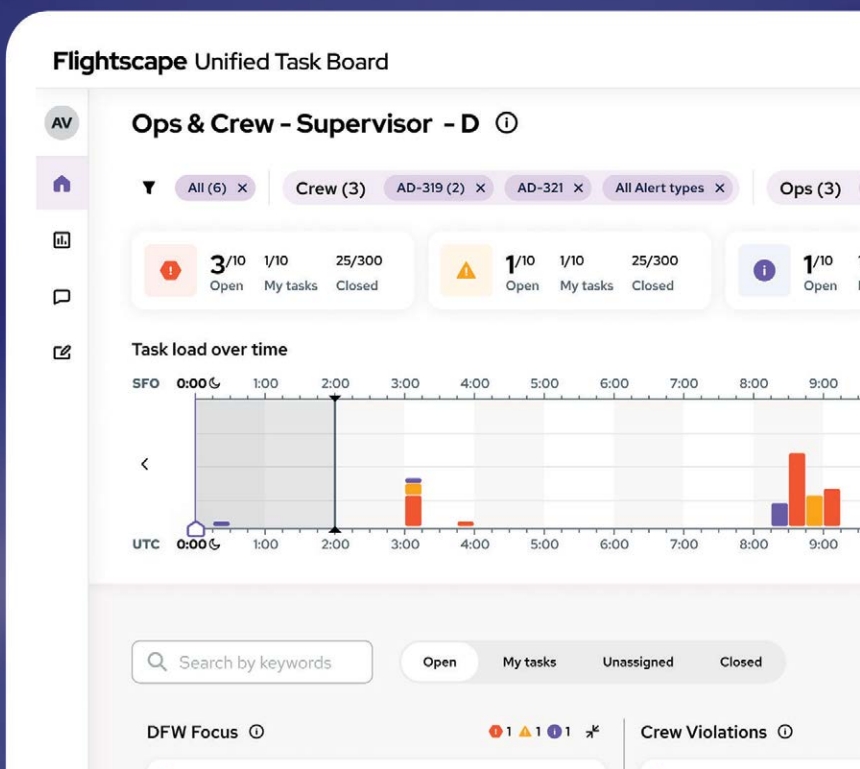
WH001 has recently been conducting stability and control tests—a key indicator of progress toward service entry with flight control system architecture that satisfies both the European Union Aviation Safety Agency (EASA) and the FAA. Multiple identical units met the FAA requirement for redundancy, but EASA wanted dissimilarity—ideally from different suppliers. Among other things, the compromise includes different components within the BAE Systems-developed integrated flight control electronics unit that includes the flight control computers and actuator control electronics.

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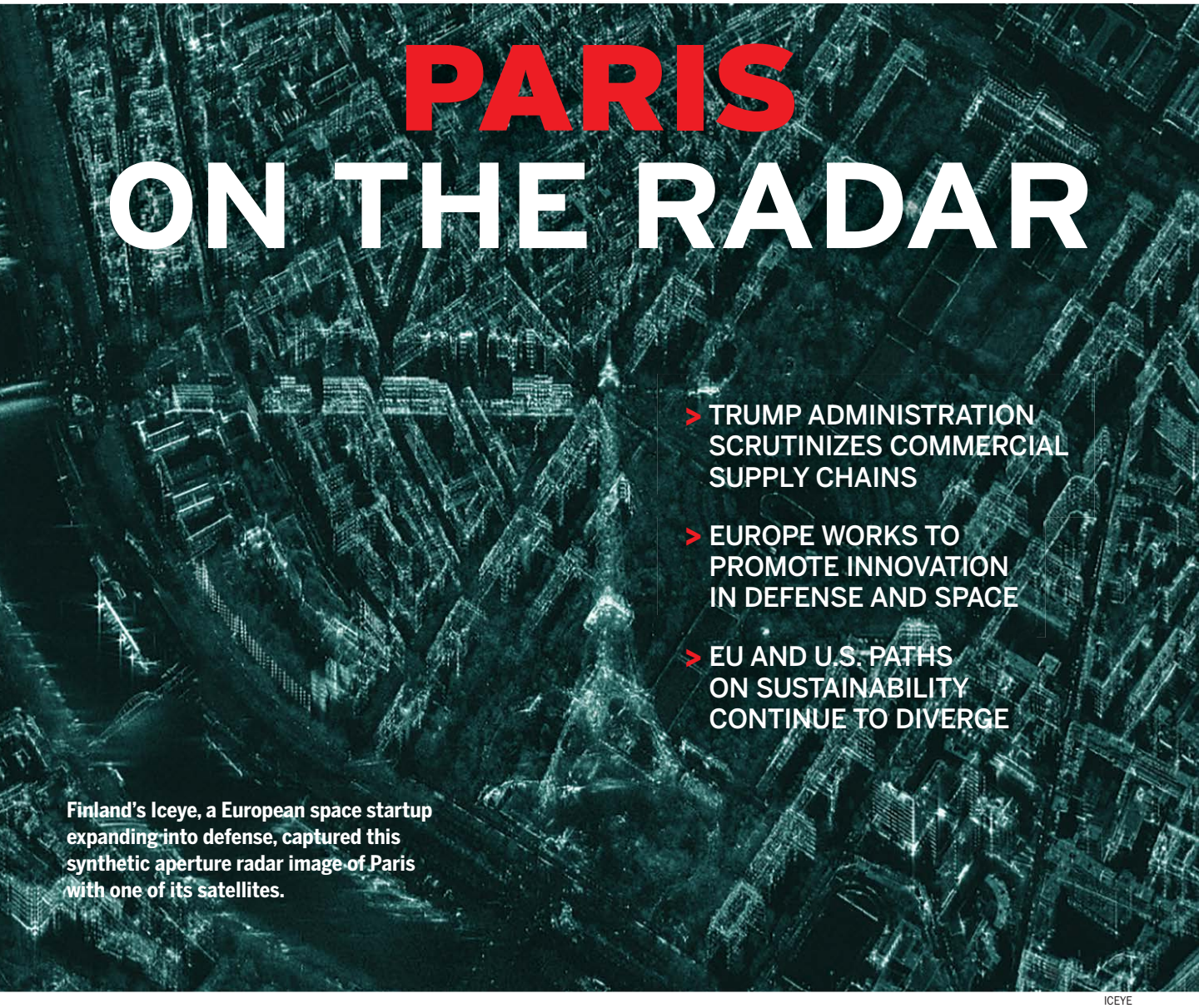
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PARIS ON THE RADAR

- TRUMP ADMINISTRATION SCRUTINIZES COMMERCIAL SUPPLY CHAINS
- EUROPE WORKS TO PROMOTE INNOVATION IN DEFENSE AND SPACE
- EU AND U.S. PATHS ON SUSTAINABILITY CONTINUE TO DIVERGE



Finland's Iceye, a European space startup expanding into defense, captured this synthetic aperture radar image of Paris with one of its satellites.

ICEYE

Graham Warwick Washington

Aviation has shaped—and been shaped by—change since before the Wright brothers flew at Kitty Hawk or Louis Blériot crossed the English Channel. But the velocity, complexity and turbulence of change has reached new levels, challenging the aerospace industry's ability to adapt.

Hot wars, cold wars and trade wars. Climate change and supply chains. The aerospace industry finds itself at a nexus of forces not felt in recent history. Military alliances are being tested and sustainability targets questioned as fundamental differences between Europe and the U.S. come into sharp focus.

As the Paris Air Show opens, attention is on the widening Atlantic divide and the possibly of a distancing—perhaps even a decoupling—of aerospace and defense ecosystems. The show takes place as the U.S. and European Union strive to reach an agreement on a trade deal before President Donald Trump's July 9 deadline to impose punitive 50% tariffs on EU goods.

The aerospace gathering is also occurring on the eve of a NATO summit and a decision to increase the alliance's defense spending target to 5% of GDP. Under intense pressure from Trump to carry a higher burden for their own defense, more European nations have moved to meet the current 2% target, and industry on both sides of the Atlantic is already seeing the payoff (page 46).

Having already embroiled aerospace in its tariff fights (page 56), the Trump administration is taking aim at the global supply chain on which the industry is built. The U.S. Commerce Department launched an investigation in May to determine whether the import of commercial aircraft, engines and parts is a threat to national security. Scheduled to be completed by January, the investigation was initiated under Section 232 of the Trade Expansion Act of 1962, which empowers the presi-

dent to restrict imports if they are found to threaten to impair U.S. national security. Trump has used Section 232 to justify imposing tariffs on other industries, from steel to trucks.

The investigation seeks to determine the extent to which U.S. domestic production of commercial aircraft and engines can meet expected domestic demand and to understand the role of foreign supply chains in meeting that demand as well as the potential for foreign nations to "weaponize" their control over those supplies.

Industry lobby group the Business Roundtable asserts that conditions previously used to justify tariffs under Section 232 are not present in the commercial aerospace industry, where supply chains are aligned with U.S. interests, exports are strictly controlled, and manufacturing operations in the U.S. ensure high domestic content.

But the Aerospace Industries Association (AIA) has encouraged the Trump administration to use the Section 232 investigation to address existing trade barriers, encourage foreign investment in U.S. industry and secure preferential trade terms. The AIA cites the deal struck with the UK in March, which includes an exemption from Section 232 tariffs for aircraft engines and parts.

The global air transport industry held steady to its net-zero 2050 goal at the International Air Transport Association Annual General Meeting in New Delhi in June, despite public comments from many airline leaders that the target is unachievable given the current trajectory of sustainable aviation fuel (SAF) production volumes and costs (page 81).

But government commitments to sustainability remain very different on either side of the Atlantic. The EU says its SAF mandates are here to stay, despite deep concerns among European airlines that the legislation is failing to create the affordable SAF market it promised. Fuel suppliers are not delivering, they say, and without urgent action, the credibility of the mandate will be severely undermined.

The U.S. and EU took opposing approaches to stimulating SAF production, Washington favoring the carrot of a tax break over the stick of Brussels' mandate. While the U.S. approach was threatened by the climate-skeptical Trump administration's opposition to green energy, the massive spending bill now before Congress continues the SAF tax break, although the bill itself faces strong opposition.

Any sort of stick is unlikely to be wielded over SAF producers in the U.S., but the EU is planning a carrot to back up its mandate in the form of the Sustainable Transport Investment Plan (STIP). Set to be released this year, the plan is expected to provide specific EU funds to support production of renewable fuels, particularly the power-to-liquid e-fuels favored over biofuels in Europe. The region's airlines describe STIP as the EU's chance to make or break its SAF mandates.

Trump's antipathy to green technology includes plans for deep cuts in NASA's aeronautics research budget (page 14). These include ending the X-66 Sustainable Flight Demonstrator and Electrified Propulsion Flight Demonstration programs. Boeing and NASA will conduct a ground demonstration of thin-wing technology for the next single-aisle aircraft, but work on next-generation turbine engines will be delayed and rescoped.

Europe is not without its own abrupt shifts on sustainability. Decisions by Airbus and ATR to delay development of hydrogen-electric and hybrid-electric airliners, respectively, threw a spanner in the works of the EU's Clean Aviation research program, which was planning flight demonstrations for both powertrains by the end of the decade. Clean Aviation is still hoping to resurrect a hybrid flight demonstrator.

Compared with the U.S., Europe's innovation ecosystem continues to underperform in investment and outcomes. This was underlined late in 2024, when the region's leading electric vertical-takeoff-and-landing (eVTOL) startups both filed for insolvency after German federal and state governments declined to provide loan guarantees that would have unlocked much-needed additional private investment.

Volocopter was acquired in March by China's Wanfeng through its Austrian subsidiary Diamond Aircraft, but Lilium was forced back into insolvency when a rescue deal fell through. Europe lost its lead in eVTOL. And this despite a European regulator that led in creating the first airworthiness specifications for eVTOLs in 2019, while the FAA wrong-footed industry in 2021 by changing course on type certification.

"Whether the EU can create a lasting aerospace and defense innovation ecosystem to rival the U.S. remains to be seen."

But in the U.S., advanced air mobility startups have found it easier to tap into sources of nondilutive government funding. Investor interest has pivoted sharply away from electric aviation toward space and defense, however, and Europe has moved to put in place funding mechanisms to encourage innovation in sectors it considers far more strategic to the autonomy and security of the EU.

The U.S. has steered hundreds of millions of dollars toward small startups through the Pentagon's Defense Innovation Unit as well as the Air Force AFWerx and Space Force SpaceWERX organizations. Although falling well short of the sought-after procurement funding for programs of record, this support has proved useful in attracting investors keen to break into defense and space.

Europe and NATO are taking a page from the same book and have established various innovation funds in a bid to foster defense (page 70) and space startups (page 52). Part of the EU's €800 billion ($910 billion) ReArm Europe plan is to widen European Investment Bank lending to defense and security projects and accelerate the Savings and Investment Union to mobilize private capital in support of small and midsize companies.

Many European startups in aviation, defense and space will be present at this year's Paris Air Show. Whether the EU can create a lasting aerospace and defense innovation ecosystem to rival the U.S. remains to be seen. Europe may hope to mimic the meteoric rise of such new U.S. players as SpaceX and Anduril, but it remains fragmented in government spending and industrial organization.



Access all the news, updates, videos and podcasts from the 2025 Paris Air Show at **AviationWeek.com/Paris**



Saab is boosting production of its counterdrone Giraffe 1X sensor.

REARMAMENT RAMP-UP

- EUROPE RUSHES TO MAKE MORE DEFENSE EQUIPMENT
- ATACMS PRODUCTION COULD MOVE TO EUROPE
- SAAB ADDS SENSOR PRODUCTION IN ENGLAND AND SWEDEN

SAAB

Robert Wall London

European defense manufacturing is undergoing a renaissance, spurred by the promise of billions in increased government spending and a sense of urgency that the region needs to bolster its armed forces.

New factories are springing up to build components to address a range of needs. They include plants to make enough sensors for customers looking to ensure they can spot threats as well as missile-making facilities to furnish the weapons to intercept those targets. Companies are either scaling up or scrutinizing plans to assess where they need to bulk up to address an anticipated surge of orders or, in some cases, assure security of supply.

The sense of urgency is palpable. "We used to have plenty of time and no money," says Carl-Johan Bergholm, the head of Saab's surveillance business, a major driver of the company's expansion. "Now we have plenty of order intake and no time. If we don't grow with our customers, someone else will."

It is not just industry officials who are anxious. A recent Eurobarometer survey found that 81% of respondents support a common defense and security policy among EU members, the highest level in more than 20 years.

> "Europe's defense purchases this year have focused on munitions and missiles, but **companies see an upswing ahead for other systems."**

And 78% of those surveyed expressed concern about the region's defense and security in the next five years.

Rheinmetall CEO Armin Papperger, whose company has been expanding armored vehicle and ammunition production capacities, said the company recently struck an agreement with Lockheed Martin to create a missile-making joint venture. The German tank-maker would control 60% of the business, with the rest held by the U.S. defense giant. The two were already partners on rocket motors, and Rheinmetall is becoming a supplier to the Lockheed F-35 program.

Lockheed previously said it was pursuing a weapons production site in Europe as the company scales up output across different families of missiles. Tim Cahill, president of the company's Missiles and Fire Control business, said recently that Lockheed also has its eye on a similar arrangement in the Middle East, adding that the effort is not as far along.

Under the European missile joint venture, Rheinmetall will work on the Army Tactical Missile System (Atacms) rocket, Guided Multiple Launch Rocket (GMLR) system, Hellfire missile, Joint Air-to-Ground Missile (JAGM) and PAC-3 interceptors. The joint venture will have a production capacity of more than 10,000 missiles per year, Cahill said, roughly split



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among 600-800 Atacms, about 2,500 GMLRs, 5,000 Hellfires, 5,200 JAGMs and 250-300 PAC-3s. Annual sales from the partnership, if fully booked and ramped up in a few years, could reach some €5 billion ($5.7 billion), Papperger said.

Rheinmetall will furnish warheads and rocket motors as part of the deal. The company plans to break ground next month at a rocket motor facility in Unterluess, a village in northern Germany. The plant should be ready in about a year. Missile assembly eventually will take place there, too.

The joint venture may evolve to become an expanded delivery entry for Atacms, including the U.S., Papperger said, as the U.S. Army and Lockheed shift their focus to production of the longer-range Precision Strike Missile.

Down the road, the two companies may work to pursue technology and joint intellectual property toward future programs, Papperger noted.

Rheinmetall also struck an agreement with Iceye to start producing synthetic aperture radar satellites in Germany at a new defense electronics facility it is building. More deals are under discussion, he added.

Munition demand is fueling expansion elsewhere. Diehl, which provides the ground-launched IRIS-T system to Ukraine, is scaling up personnel and site capacity, as is MBDA. The European missile joint venture expects to produce twice as many missiles this year as in 2023, driven by the appetite for products such as the Mistral and Aster air defense missiles. The company is investing €2.5 billion in new facilities and equipment over five years and has plans to add staff.

South Korea's Hanwha Aerospace is growing its European footprint as well. The company agreed in April to produce rockets for the K239 Chunmoo system in Poland after already agreeing to make the launcher there. Hanwha expects to start producing CGR-080 rockets within three years through a joint venture with Polish defense company WB Group. Hanwha will hold a 51% stake in the joint venture, and WB Electronics will control the rest.

"Our industries will also gain the opportunity to jointly enter new European markets," said Billy Boo-hwan Lee, head of Hanwha Aerospace's Precision Guided Munitions business. The company signaled it plans to expand further in Europe, too, eyeing additional production bases after raising capital in April to help foster its global expansion.

All the expansion is not without challenges. In some cases, a shortage of precursor materials hampers higher output. And in some regions, local rules encumber rapid factory plans. Personnel needs are a concern as well, and some companies are looking to tap Europe's large skilled automotive workforce.

Europe's defense purchases so far this year have focused on munitions and missiles, but companies see an upswing ahead for other systems. Airbus CEO Guillaume Faury told shareholders in April the company is exploring what internal investments are needed to address that coming order wave.

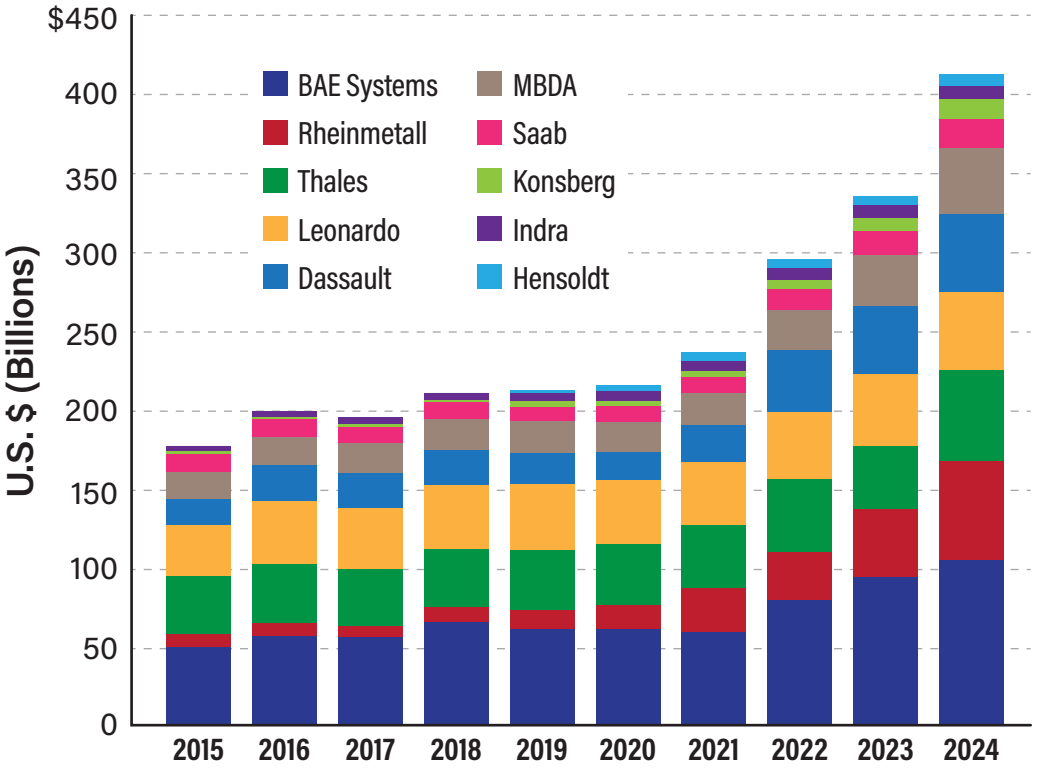
Defense electronics provider Hensoldt is also examining what it may need to do. "We have to consider the next steps of scaling our production," CEO Oliver Dörre said.

Hensoldt already has been expanding, which it says should address its needs through around 2027, but the company is realizing that will not be sufficient afterward. The company expects to finalize plans for further investment over the coming months.

The company has agreed on expansion efforts covering a range of activities, including boosting production of printed circuit boards. With customers hunting for more sensor capacity, Hensoldt determined it needed to build more circuit boards to have certainty of supply, increasing the figure to 80,000 per year from 36,000 over a two-year period.

Saab is similarly in growth mode. In February, the company opened a sensor production facility in Fareham, England, where it is building

European Defense Contractor Order Backlogs



Source: Companies' financial reports



LOCKHEED MARTIN

some equipment ahead of orders to meet growing customer demand for quick delivery. In April, Saab said it would expand radar and sensor operations in Gothenburg, Sweden. The company also said in January that it was scaling up Sirius Compact passive electronic warfare sensor production in Finland.

In terms of investments, Saab CEO Micael Johansson says: "We will continue to be forward-leaning."

Saab is working on several fronts, he noted during a recent investor event. It is adding facilities that rely more heavily on robotics to accelerate production or in some cases redesigning equipment to facilitate greater automation. It also is helping suppliers financially to scale up to mitigate bottlenecks.

In a tangible sign of Europe's efforts to rebuild production capabilities that have long been dormant, Denmark asked Scandinavian ammunition-maker Nammo in March to revive a disused munitions plant in Elling that was closed by a prior owner in 2020 after a period of losses and declining orders.

Rheinmetall will help build PAC-3 missiles in Germany under a joint venture agreement with Lockheed Martin.

The Danish facility is only part of Nammo's scaling up that the company projects will double or triple its revenue and staffing by the end of the decade. Output of some products, such as advanced artillery ammunition, is going up tenfold, a company official said.

European company efforts are not just focused on strengthening their local industrial footprints. Saab is growing in India and the U.S., and Rheinmetall and Nammo also are expanding.



‘Europeans Need To Wake Up’

The European Union’s first defense and space commissioner, **Andrius Kubilius**, *sat down with Aviation Week Executive Editor for Defense and Space* **Robert Wall** *to talk about European rearmament, space ambitions and lessons from Ukraine.*



EUROPEAN UNION

AW&ST: **You’ve been in the job now for six months. How do you see the defense landscape?** The weakness of Europe, it is very clear, was that we were not taking defense issues seriously because we were believing that Americans can do the job, and we were enjoying a peace dividend.

Now it’s become much clearer that [Russian President Vladimir] Putin’s aggression can go on and on and even expand. The German intelligence services are warning us that Russia can be ready to test [NATO’s collective defense] Article 5 during the next 3-5 years. On the other side, we hear from the American administration their plans—that they need to shift more and more of their attention, and also resources, toward the Indo-Pacific to mitigate the rise in Chinese military power. It means that their ability to defend Europe, as it was done by them until now, is diminishing. That means that we Europeans need to wake up and start to be serious about our defense.

Even back in September of last year, when I was nominated as commissioner, there was quite a lot of skepticism that there’s no European Union defense policy, there are no funds, the new commissioner is coming with an empty portfolio, and he will not be able to do anything. Now member states and the public started to see what we’re facing, what kind of challenges we’re facing, what kind of threats we’re facing and how much there is a need for collective action—for EU member states with that added value which the European Union can bring to defense.

We’re not competing and we shall not compete with NATO. That was one of my very strong statements from the very beginning. But we can bring added value with our industrial policy, with our ability to raise additional funds, with our possibilities to speed up some bureaucratic procedures, which are not allowing industries to ramp up production. All that only the EU can do, and we’re trying to do.

Any areas where you thought Europe was in better shape than you had appreciated? I was positively surprised by the information I got in the space area with some of the services which we’re getting from [the European Space Agency’s (ESA)] Galileo, from Copernicus. We are, as Europeans, capable [of building] the best systems in the world—all those services which are crucial for our daily life, but also crucial for our defense capability. We sometimes have this internal complex of not believing in our capabilities. This shows me that we have capabilities. We are able to agree collectively, like it is done in space through ESA, to develop very highly technological projects in a successful way. For me, it was an inspiration that maybe we can learn something from space and bring that knowledge into defense, where exactly there is a lack of those capabilities to work collectively.

The EU is incentivizing member states to spend more on defense. But industry is wondering: Why does Brussels not act as a buyer of transport aircraft or other capabilities? First of all, legal experts are saying that, according to the treaties, we cannot buy weapons. But the treaties also are saying that EU member states, while they are implementing defense policy, need to gradually move toward a common European defense. I’m asking myself a rhetorical question: If not now, when are we going to start to move toward collective defense?

Secondly, we are looking into the possibility of having some equipment which we could really use in a collective way through some kind of strategic pooling—for example, when we’re talking about military mobility that we need to have. So those things are not far away.

You are starting to build the new multiyear EU budget. What's your view on defense spending? We are ambitious. I cannot tell you the numbers. I'm trying to show everywhere why we need to be ambitious. The biggest amount for defense is spent by member states. What experts are saying—and I absolutely agree with them—[is that] there is no single market. Member states usually are taking care only of their own national defense industry. That is why our defense industry is not able to use the power of the size of the European market to build its own competitiveness in the global markets. And that is why our industries are losing in global competition. Then national governments are not procuring from the European defense industry because they see that that industry is too weak.

We need to understand that if our defense spending will increase only on a national level, perhaps it will end [up] with even bigger structural problems. So that is why we are looking very much into all the possibilities [for] how we can incentivize joint procurement and joint development. And to do that, the only possibility is to have financial power at a European Union level to incentivize joint procurement and other very much-needed collaborative actions. When member states will spend €800 billion ($910 billion) during the next four years, we need to have appropriate levels of financial power on the EU level.

Beyond IRIS², what defense space efforts would you like to launch? I am looking, first of all, for an Earth-observation governmental service. That sounds very bureaucratic, and we need a better title, not [to] try to hide the purpose: intelligence data. That is one of those strategic enablers that we still do not have, where we are dependent on American services. Since the Americans are more and more declaring they will shift resources toward the Indo-Pacific, we need to speed up.

We are working very practically on studying what kind of structure we need to have, what kind of system—how we can use private systems for an initial period, then how we can pool existing governmental capacities and then build our own EU-wide capacity. So we are planning some initial possibilities, maybe with commercial services data, which will get somewhere around 2027. Of course, the EU system will be a little bit later.

Second, I'm asking what space will look like at the end of the next decade. We can predict that—I'm calling it the space revolution—will start to be more and more visible, including more activities in exploration of the Moon, of space, maybe manufacturing in space, and so on. To be ready, we need to be very effective in coming back with our launch and transportation services. I'm speaking with ESA to convince not only ourselves, but also to convince the general public and politicians that we need to invest in launch.

> *"I would measure my achievements in a very practical way: Did we manage to deter Putin or not?"*

There are a lot of launch startups in Europe. How many rockets can European demand sustain? For the time being, we see those capabilities we have now—the Ariane 6, Vega-C and Kourou [spaceport]—can cover demand from public institutions. But it's very clear that if demand will grow, we need to have new capabilities to launch. We need to have some kind of clear, strategic analysis and strategic view [of] what will be the proportion of heavy launchers and also what we call those microlauncher options, where we see a lot of different startups and other smaller companies engage—which can be quite a big need, especially if we are talking about what I call revolution in space.

We often are speaking about space for defense, but I'm always saying there is another side: defense of space. We shall need a very quick ability to launch something. Microlaunchers can be much more useful than big, Ariane 6-type launchers.

Back to defense. What is more important: fielding new equipment or more existing equipment to sustain war for more than a day or two? Both. That's for NATO to say with the capability targets. From my side, we need to procure in advance what is needed. But also we need to have in mind that, for example, you cannot procure drones in advance—at least the massive drones. Because as Ukrainians are saying, [within] two months they become obsolete. Because the Russians are learning.

When I asked Ukrainians what is their advice to us, they said: "Don't keep them in stock. Create special teams of constructors, engineers, digital guys, operators and so on who would be ready, you know, very quickly, to expand all that is needed to produce drones at that moment and stockpile components which are needed to produce drones. But you don't know which kind of drone you will need to produce."

Second, definitely, what is very important, if we are looking into what I call Day X, we need to take care of how to make our defense industry able to produce, to maintain and to repair in conditions of war. We cannot allow ourselves not to take care of our defense industry and just procure on the global market. That is why our statement that we need to invest more, to invest better and to invest European is not about protectionism. It is about creation of one of the most important defense resources, which is the defense industry.

Do you think Europe needs to look at avoiding components subject to U.S. International Transfer in Arms Regulation (ITAR) rules? Some companies are advertising their own products as produced in Europe. I saw one with a final sentence, with a nice picture of their product, a nice technical description. And it ends with a statement: China-free, Russia-free, ITAR-free. The American defense industry is really very good. It's advanced, and so on and so on. And we have no problems with that. But you know, if you are procuring weapons and there is ITAR regulation, and you don't know where relations between the U.S. and Europe will move—despite the fact that I am 150% a transatlanticist—it makes question marks.

You have a five-year mandate. How will you judge your own success? I would measure my achievements in a very practical way: Did we manage to deter Putin or not?

Europe Launches Effort To Increase Its Independence in Space

> ESA SEEKS A BIG FUNDING BOOST FOR SPACE RESILIENCE PUSH

> TWO GERMAN LAUNCH STARTUPS AIM TO FLY BEFORE YEAR-END

Robert Wall Amsterdam

Europe's quest to reinvigorate its space capabilities received a boost at the start of the year when the Trump administration took office, amplifying the region's concern about dependence on the U.S. By the end of the year, it should be clear whether Europe can match its ambition with progress in action.

ROCKET FACTORY AUGSBURG



Rocket Factory Augsburg is racing against Isar Aerospace to achieve the first successful orbital launch from European soil.

"There is both the need and also the will to achieve sovereignty in space," Fabio Angellotti, space segment leader at the European Union Agency for the Space Program, said at the recent SmallSat Europe symposium here.

That sentiment is shared elsewhere. "There is a profound change, at least at the European Space Agency [ESA] management level, toward security and resilience—I've never seen anything like this before," added Ian Carnelli, head of ESA's systems department.

But Europe also needs to change how it goes about investing in space. "We need much faster procurements, bigger procurements—and much more coordinated [ones]," Carnelli said. Rather than investing in technologies across member states to please them, Europe should concentrate on project-oriented investments, he asserted.

Those sentiments underpin a drive by the European Commission and ESA to funnel more money into the mission and coordinate their efforts. An early test of the ability to turn words into action could come this year, when ESA plans to ask member states for €1.3 billion ($1.5 billion) to support an initiative to bolster European industry's research and development of key technologies for future systems.

The goal is to take items at Technology Readiness Level 6, the prototype stage, or higher and apply them in space, Carnelli said. "We're talking about advancing stuff to enable building constellations of satellites using these technologies within the next three years," he explained.

ESA plans to include money for the European resilience effort in its next three-year funding request to member state ministers in November. Technologies to which ESA is looking to provide additional money could include quantum computing, highlight-stabilized optics and air-breathing engines to support work on cubesats or very-low-Earth-orbit spacecraft.

The EU's first defense and space commissioner, Andrius Kubilius, has said the bloc needs a sovereign, security-focused Earth-observation system. ESA Director General Josef Aschbacher said on May 20 that talks with the European Commission are showing "significant progress" toward a future Earth-observation government service. "The focus is on defining the right spatial resolution, revisit time and a clear implementation plan," he said.

The European Union's next funding cycle does not begin until 2028, but initial budget decisions, including on space investments, are expected over the coming months.

Another test for Europe will come before year-end, when stakeholders in the IRIS^2 secure satellite communication program are set to convene to decide whether to build the constellation of around 290 low-Earth-orbit satellites, plus 18 in medium Earth orbit and a yet-to-be-defined very-low-Earth-orbit element.

But questions linger around the program, even after the EU and ESA late last year awarded the SpaceRISE industrial consortium a €10.6 billion, 12-year concession contract to deploy and run the system. A funding gap between projected costs and budget remains at around €1 billion, says Stephane Israel, partner at Boston Consulting Group in Paris and former CEO of Arianespace. The momentum needed to deliver the system also has not emerged, he added.

Other industry officials expressed concern that European governments are talking about building their own constellations, threatening the financial viability of IRIS^2. "It remains a huge challenge to make it a success," Israel said.

One of the biggest issues for Europe is determining how to achieve autonomy, given the region's fragmented setup with space efforts spread across individual states, the European Commission and ESA.

In many cases, governments are focused on building out their own national security space infrastructure, rather than on collective action. Poland is investing in more space-based Earth-observation capacity under an agreement to buy three spacecraft from Iceye. Germany, France and Italy have long been active in satellite-based reconnaissance

nationally. The UK also has started to invest in space-based reconnaissance after years of relying on Washington for such information.

The European reality is that space investment, especially as it relates to defense, is driven by national capital interests, not by those of Brussels. "We need to federate government, national agency, member state efforts," Carnelli says, and ensure those systems are interoperable.

Another tenet of Europe's space autonomy drive is independent launch capability. The region has historically relied on Arianespace's Ariane and Vega rockets for access to space but is looking to diversify by supporting a cadre of European startups. The first few companies hope to demonstrate this year that they are ready for prime time after early setbacks.

German startup Isar Aerospace is gearing up for a second launch attempt before year-end, Chief Commercial Officer Stella Guillen said. Isar failed on March 30 in what would have been the first orbital mission launched from European soil, as Spectrum rocket's flight had to be aborted shortly after clearing the launch tower at the Andoya Spaceport in Norway. The company is wrapping up a formal report on the incident but does not expect any redesign.

"Thanks to Elon Musk and also Donald Trump—I think they are motivating Europe even more now."

Isar is looking to scale up output within a few years to address customer interest, she said. "There is a huge demand in Europe at the moment," she noted.

Rival Rocket Factory Augsburg (RFA) similarly is targeting launch before year-end. The German company aims to conduct a hot-fire test of the first stage at the SaxaVord Spaceport in Scotland before the end of the summer, said Ibrahim Ata, head of acquisition and delivery. RFA suffered a setback last year when the first stage caught fire during testing, derailing its efforts to achieve an inaugural flight.

Ata said that one lesson the company took from the event is to have more component redundancy and to keep the pace of development going. It is now building two three-stage RFA One launchers, and the fairings, second and third stages of both rockets have been completed.

PLD Space in Spain aims to follow next year, as do French startups Latitude and MaiaSpace. The latter is a subsidiary of ArianeGroup, a joint venture between Safran and Airbus.

"Thanks to Elon Musk and also Donald Trump," quipped Pablo Gallego Sanmiguel, senior vice president of sales and customers at PLD Space. "I think they are motivating Europe even more now."



ASK THE EXPERTS



Bethany Davis
Head of the Z4 Program and Certification for JetZero



Scott James
President and CEO of Applied Dynamics (ADI)

Solving for Time: JetZero and ADI Partnering to Accelerate Airplane Innovation

Aviation Week Network spoke with JetZero's Head of the Z4 Program and Certification Bethany Davis and Applied Dynamics International CEO Scott James. We explored how their partnership leverages digital engineering and a hybrid workforce to dramatically accelerate the development of a Part 25-Transport Category certifiable blended wing body airplane—a design JetZero calls "all wing" owning to the larger lift surface a blended wing body delivers. JetZero's Z4 is expected to be up to 50% more fuel efficient than comparable tube and wing airplanes.

Q AW: How does JetZero's approach differ from traditional aircraft development?

A BD: JetZero's approach is focused on solving for time. Historically, airplanes were designed and flown much faster than today, but the industry has slowed considerably. Through digital engineering and our lab strategy, we aim to return to those roots and accelerate development of a Part 25-Transport Category Airplane. Our team members have backgrounds at major manufacturers, so they understand the complexities. We use proven, qualified components already flying on Part 25 airplane to reduce risk. The main challenge isn't individual components—it's integration. That's where our labs are essential, preventing costly surprises and significantly reducing risk.

Q AW: What specific capabilities made Applied Dynamics International the right partner for JetZero?

A SJ: Our partnership with JetZero came naturally from ADI's experience and proven track record, including our work with Gulfstream to develop what's widely seen as the industry's top digital twin and lab environment. ADI is built on three pillars—shown in the three squares in our logo: our edge computing software, our dynamic design and build team, and our dedication to model-based systems engineering.

We bring three key capabilities to JetZero's digital test enterprise: open architecture to avoid obsolescence and vendor lock-in; modular systems that simplify reconfiguration and cut design, build, and maintenance costs; and advanced automation driven by our edge computing software. This automation grows from basic tests to "lights-off" testing—running without constant oversight—cutting sustainment costs as labs evolve from innovation hubs into efficient validation centers. JetZero knew that selecting the right partners, including ADI, was vital to meeting their ambitious timeline.

Q AW: How do your labs transform the traditional aircraft development timeline, and what specific advantages does each lab provide?

A BD: Our three-lab approach lets us decouple systems integration from airframe construction, running both in parallel instead of one after the other. This accelerates development—we build the airplane while ensuring systems are ready when the airframe is complete.

We move through three specialized environments: the Flying Qualities Lab, where we develop flight control laws (CLAW) and validate system sizing for hydraulics, actuators, and landing gear; the Integration Test Facility, where we use real hardware like Thales flight control computers

and other system controllers and avionics; and the Iron Bird, where we test the full flight control system with hydraulics to confirm actuator performance predicted in the Flying Qualities Lab for our all-wing design.

This step-by-step validation has helped us attract top engineers who know we're serious about execution. When problems arise, our labs let us quickly pinpoint the cause—software, connectors, or harness design. And our 285,000-square-foot Long Beach facility, with its rich Douglas Aircraft history, gives us a physical testing advantage that pays off throughout development.

Q AW: How is support from the Air Force influencing the development timeline?

A SJ: The Air Force's urgency comes from real strategic concerns. They've been public about China's timeline on Taiwan and the logistics this could strain, especially fuel transport, in a conflict. These concerns, detailed in Congressional reports, align closely with JetZero's schedule for a tanker airplane that could address this vulnerability. Our rapid development isn't just commercial—it's a national security priority the Air Force understands and values.

A BD: The Air Force has been very supportive because they share our urgency around solving for time. They recognize how much longer development takes now compared to the past. The Air Force is pushing to restore the innovation and speed that once defined aerospace, replacing manual, federated processes and tools that slow progress with a digital thread. Many of us entered this field with excitement about building incredible aircraft, but bureaucracy and antiquated tools can dampen that spirit. That's why the Air Force emphasizes "buying back time" and strongly supports our digital tools, lab-driven rapid prototyping approach; it's a strategic move to accelerate critical aerospace capabilities. The tyranny of distance, especially in the Indo-Pacific, strains the attributes of range and endurance needed to deter threats, and JetZero is poised to beat the strategic clock that is ticking and deliver capabilities quickly.

Q AW: How does your remote testing capability solve talent acquisition challenges and further accelerate your development timeline?

A BD: Remote testing helps solve one of the biggest challenges for a commercial OEM: finding and keeping specialized talent. About half of our team is on-site in Long Beach, with the rest working remotely—a model we've followed since our founding during COVID. Team members come in for physical tests but can work from anywhere once remote environments are ready. This has let us build a global operation, with team members across the U.S., Montreal, Germany, and beyond. Our digital setup gives us access to top talent, no matter where they are.

A SJ: Traditional aerospace development required experts in one place, creating inefficiencies. Our remote labs change that. A test engineer in Florida can run simulations, while a control systems expert in Montreal and a hydraulics specialist in Michigan work on the same test in real-time, each seeing exactly what they need. This real-time collaboration, regardless of location, brings specialized insights together more efficiently than ever.

About the Experts

Bethany Davis is Head of the Z4 Program and Certification for JetZero and previously led the company's Aircraft Systems and Labs teams. Her 20+ year aerospace career includes 10 years at Gulfstream, posts at Delta, and a Fulbright scholarship with Volaris. Bethany is a flight instructor and Air Transport Pilot.

Scott James is the President and CEO of Applied Dynamics, or ADI, where he spent more than two decades driving innovation in digital engineering for the global aerospace and defense industry. He is also the co-chief architect of ADEPT, the market-leading, open architecture, industrial edge computing software platform.

European Ramp-Up Plans Are Roiled as Industry Heads to Le Bourget

> DELIVERY DELAYS AND TRADE UNCERTAINTY PERSIST

> MANUFACTURERS IN EUROPE IMPLEMENT MITIGATION STRATEGIES

Jens Flottau Frankfurt

Just as European aerospace begins to see credible signs of recovery in its long-troubled supply chain, new uncertainty is hitting the sector. Will the threat of U.S. tariffs and retaliatory action by the EU derail the process and put planned production increases in doubt again?

When industry meets at the 2025 Paris Air Show, there likely will be no answers yet, since deadlines are constantly moving. Only a day after U.S. companies. "The supply chain has progressively recovered," Safran CEO Olivier Andries says. "We were getting to a situation where we were close to normalization at the end of last year."

But that could change again. "We see some signals from suppliers telling us, basically, that they have inflationary costs because of the tariffs and that they would like us to absorb the extra cost, some of them threatening to stop deliveries," Andries says. Therefore, he explains, Safran is "monitoring the situation very carefully" as it "creates a new element of potential disturbance in the supply chain."



SAFRAN

Safran is rearranging part flows for CFM International Leap engines to ease the burden of U.S. tariffs.

President Donald Trump had threatened to escalate tariffs on EU goods to 50%—25% in the original plan and currently 10%—he suspended them until July 1, pending a negotiated settlement that might include aerospace tariffs. The EU has a detailed plan to retaliate against tariffs that targets a broad range of aerospace products, such as completed aircraft and many smaller components manufactured by U.S. suppliers.

Dealing with trade issues is a huge complication for European aerospace

Andries is not the only one who is worried. The levies "are adding complexity and remain uncertain in terms of implementation, scope and duration," Airbus CEO Guillaume Faury says. He deems even the current 10% imposed "significant."

At the other end of the airframer spectrum, Deutsche Aircraft co-CEO Nico Neumann concurs that parts of the supply chain may suffer, and manufacturers could feel the effects down the line.

On the other hand, Bank of America analyst Ron Epstein says he anticipates that the tariff impact "will be significantly more manageable than expected around two months ago."

If so, that would be in part due to the creativity of Europe's aerospace companies in circumnavigating tariffs. For example, Airbus delivered an A350 to Delta Air Lines in Japan. Operating only international routes, the aircraft will not be formally imported into the U.S. for the time being. Part imports to feed the Airbus final assembly line in Mobile, Alabama, and for aircraft delivered to U.S. airlines are subject to the 10% tariffs.

"We are optimizing logistical flows," Andries says. "Any time we can change the flow, we go directly from Country A to Country B without stopping by the U.S. if it is not necessary." Whatever net exposure remains will have to be covered by customers, he notes. "We will apply a tariff surcharge, and we won't be shy," Andries says. "At the end of the day, the tariff situation is creating inflation. So be it."

MTU Aero Engines is applying similar tactics. Low-pressure turbines made in Poland for assembly in Pratt & Whitney PW1100G engines are no longer shipped to the U.S. but straight to Munich, where MTU operates its own final assembly line for the engine type. The company also is trying to build up alternative sources for nickel and titanium outside the U.S. According to CEO Lars Wagner, MTU is shifting flows to and through tariff-free bases. One option he mentioned is exporting more from its facilities in China, since they are protected by that country's tax-free regime.

Wagner says it is "highly unlikely" that MTU would set up alternative sites, as that would take considerable time and investment. Changing MTU's own supply chain would take 3-5 years, he estimates. Tariffs are covered in some contracts with its customers, meaning that the company is protected, but they are excluded in others.

For now, production increases are proceeding as planned, although they are not linear. Airbus in particular has suffered in the first few months of the year and is building up sizable A320neo inventory, as CFM International has shifted more Leap-1A production to airlines and the aftermarket rather than the final assem-

bly lines in Toulouse and Hamburg. Andries says the situation will normalize over the coming months, allowing Airbus to equip the half-finished aircraft with engines and deliver them to customers.

Safran expects Leap production to grow 15-20% this year. Airbus expects to hand over 820 aircraft in 2025, up from 766 last year.

Some of this—and in particular Airbus' ability to execute on its longer-term growth plan—will depend on its integration and turnaround of Spirit AeroSystems units. The closing of the long-anticipated deal is expected in the third quarter. Spirit's financial and operational issues have hampered output growth on the A220 and A350 programs.

According to a definitive takeover agreement published in late April, Airbus will buy Spirit sites in Kinston, North Carolina; Wichita; Saint-Nazaire, France; Casablanca, Morocco; Belfast, Northern Ireland; and Prestwick, Scotland. The facilities build A350 fuselage sections; A321 and A320 components; A220 pylons, midfuselage and wings; and A220 and A350 wing components.

Spirit will pay Airbus $439 million in compensation, which should largely cover the negative cash flow the airframer anticipates this year. Airbus Chief Financial Officer Thomas Toepfer expects the Spirit turnaround to take around three years and to cause a "mid-triple-digit-million" negative cash flow during 2026-27.

But the move could be worth the investment. Airbus has committed to building 14 A220s per month starting next year, 75 A320neo-family aircraft per month beginning in 2027 and 12 A350s monthly as of 2028. The company needs to meet these targets to avoid further clashes with a highly frustrated customer base waiting for much-delayed aircraft.

In the traditionally weaker first part of the year (January-April), Airbus delivered 192 aircraft, including a monthly average of just over 37 in the A320neo-family, well below its overall 2024 levels. The A220 came in at a monthly rate of six deliveries, slightly lower than the overall average for 2024. Last year, Airbus also delivered just fewer than five A350s per month. In the first four months of 2025, that number dropped to just over three.



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Preparing What's Next

MARCUS BRANDT/DPA/ALAMY STOCK PHOTO

Airbus CEO **Guillaume Faury** *discussed future commercial aircraft programs, European defense spending, satellite consolidation and more in an interview with Aviation Week Executive Editors* **Jens Flottau** *and* **Robert Wall.**

AW&ST: **What drove the recent change to your senior management team by appointing Rémi Maillard as the new head of engineering and focusing Chief Technology Officer Sabine Klauke on digital projects?** This management team has the unique responsibility to prepare for launching the product that will replace the A320. You know the time frame: launch of the program roughly by the end of this decade and then entry into service in the second half of the next decade. We do not only need the right technologies, partners and architecture, but also the right skills. There are other changes that are maybe less visible but that also go in the same direction. As we come closer to the launch of our new product, we want to be fully digitalized with our design of products, production systems, and support and services.

We want to benefit from what Sabine knows, with her breadth of competencies. She is a manufacturing engineer by background. She is fully concentrating on that part of preparing the next-generation aircraft. And Rémi has an engineering background, has spent time in India and broadened his experience in commercial aviation. We are bringing him back into engineering because of his expertise in product design at a moment when this is what engineering will have to focus on.

Boeing CEO Kelly Ortberg told us in a recent interview that he believes the market and technology are not ready for a next-generation single-aisle—and neither is Boeing (*AW&ST* June 2-15, p. 36). Do you agree with him on the first two points? The market is not calling for a new plane for entry into service now. It is digesting the entry into service of new models including the XLR, certified less than a year ago. The airlines are looking for the on-time delivery of products they ordered a long time ago, and you know we are struggling with the state of the supply chain. Development of a new product would just add complexity.

But if we look at the second half of the next decade, 12-13 years from now, the market will not only be ready for it, but it will be calling for it. The market will be looking for more fuel and cost efficiency. This would be around 20 years after the entry into service of the Neo, so at the right point in time. To be able to launch around 2030, we have to prepare the technologies now—not only the technologies, but also the industrial means, the digitalization. I don't disagree that the

technologies are not ready now; that is why we are working hard on them.

To be able to launch in 2030, you would need to select an engine around 2027. That is a fair assessment. The [CFM International Revolutionary Innovation for Sustainable Engines] RISE studies are moving forward. We need to make sure it is a winning bet. We work a lot, challenging each other in a very positive sense, making sure there is no stone unturned. There is uncharted territory for an engine of that size. You will see prototypes flying, demonstrators validating specific technologies, and the engine will fly before we finally select it. Around 2027 will be when the selection of open rotor or geared turbofan is frozen.

If you went for RISE, it is highly likely you would go for only one engine type. Is that a worry? I'm not sure I would use the word "worry." It is a dimension that we need to fully understand and accept. We prefer a solution with two engine options. But the Boeing 737 has been successful with one engine for a long period of time. We have a very successful A350 program with one engine type. You also have only one on the 777X. So both models can work. You either select one engine for the market or you do a competition in the market where you have two engine options, and airlines select one or the other. If we go for the RISE engine, it would mean we consider its performance will offset having two manufactures competing.

Would you consider an update of the A320 family, such as the proposed A322, a rewinged, reengined stretch? We are really serious about the successor to the A320, and therefore we don't want to be distracted. Never say "never," but it will most likely not be the case, particularly if we stick to our plan to launch the A320 successor at the turn of the decade.

To touch on other parts of your business, how will Airbus need to adjust to benefit from the European defense spending wave that is unfolding? In 2024, both Airbus Defense and Space and [Airbus] Helicopters achieved record bookings, significantly higher than the turnover. We are on the growth path, but relying quite a lot on exports. We have not yet seen the orders connected to ReArm Europe—this trend of the European countries investing significantly more.

NATO will share with member countries their new capability targets somewhere in the middle there. That will give clarity to those nations on their capability gaps and where they will have to bridge. . . . And that's the moment where we expect to have clarity on where it will make sense to invest, in the sense of preparing the production systems or contracting, or maybe investing in some R&D capabilities—either new or existing capabilities.

In other words, we are not yet doing this, but we think that's probably the type of analysis we will be making in the second half of this year.

You have been quite clear that the dwindling A400M backlog is a concern. How long do you have to book more orders? We are delivering 8-10 aircraft a year. We had 48 aircraft in the backlog at the end of last year, so we need to book 8-10 planes per year. I think that's most likely what we will see coming. We have a lot of conversations around the A400M with the partner countries, with export countries in Europe and outside of Europe. And the ones that are NATO members are having those conversations: How many will we need by when? What will the capability targets be? Based on those discussions, I think that will be coming. We have visibility for the next 3-4 years.

So how much time do you have? Sort of a year, which is not a lot. But given the speed at which things are happening, I think it's more than enough.

The U.S. market has been a challenge for you, but you have had some success with the UH-72 and satellites for the Space Development Agency. Is there a way for you to play in the Golden Dome? Not significantly. Let's be realistic: It's very sovereign. And it will be exclusively—or if not exclusively, in its vast majority—going to U.S. manufacturers, even if we would have the capabilities to contribute.

Not to sound impatient, but the talks with Leonardo and Thales around consolidating satellite activities have been dragging on. I'm impatient as well. I would love this to go faster. Those types of things take some time. We have to agree on the frame and the objectives, and then we have to start to be more specific on what the project should look like, what the end result should look like, what the governance will look like. And when we have agreed on the most important high-level things, then we have to go into the details. And the devil is in the details—in those activities, there are plenty of details.

And then we have to engage with stakeholders. There is some sovereign dimension. There's also reaching out to commercial customers. Then you have antitrust authorities. We are mostly consistent with the timeline we had given to ourselves nine months ago.

Do you feel you are on a path to a handshake on a deal? You are not there until the point when you are there. And the last mile can be long. I think the commitment of the three parties is very strong. We share the common understanding that this joint venture will be much stronger than the sum of the parts. That scale in the space business today is a key driver of speed, of competitiveness in terms of capabilities and in terms of cost. The game now is global, with very strong players in the U.S., with very strong players in China. Even if they play mostly on the domestic market, one day they will come to the export market. Therefore, we have no time to lose.

Back to commercial, the [Boeing] 777X has had some considerable sales success in the Middle East in particular. Do you feel the need to offer a further stretch of the A350? I am not sure that they have such a great success with the 777X. They are so late. We have to look at things with prudence in my view. The 777X is a slightly larger product than the A350-1000, so it is a natural question. The -1000 is in service, and we are ramping up production. It serves a large share of the widebody market successfully, and we have more demand than supply. So we don't feel the need to do something more that would create more diversity of products when ramp-up capacity is limited. In the short term, there is no

need to make the product range more complex and not get the benefits because we are limited by supply.

At a later stage, it will probably be a natural evolution of the product line to continue to increase capacity from the -900 to the -1000 to something slightly longer, bigger, with more capabilities that will come close to the 777X in terms of seat count. We always look at the product range with growth potential. In the short term, this could be counterproductive.

Would an A350 stretch be the opportunity to introduce "Neo" versions, too? Honestly, I don't have the answer, but that is sometimes what we do to combine a change of engines with a new variant.

Are you confident about Rolls-Royce's commitment on the Trent XWB-97 upgrades needed for harsh environments that Emirates, among others, has demanded? We have strong demand for the -1000 anyway. Rolls-Royce is in the process of an upgrade for the engine that will respond to the ask of customers, specifically Emirates, that are flying hot, high and sandy. These are the most challenging conditions for the durability of engines, and [the upgrades] would ease that side of the equation. But the world is bigger. We have strong demand for the -1000. Actually, the mix of the -1000 versus the -900 is larger than what we had designed at the launch of the program.

It seems like you are moving closer to making a decision on the A220 stretch. How close are you? Those decisions are not made until they are made. The last mile is sometimes very long, and sometimes you do not reach the destination. Nothing is planned in the short term, and beyond the short term, there is uncertainty. We are ramping up the -100 and -300; we have not commercialized anything else.

Do you think you have a good plan for how to deal with tariffs, or are they changing too often to even have a plan? It is unfortunately more of the latter. You have a plan until you have to change the plan. You have to adapt, be agile, try to understand what is the nature of the game, to engage with the supply chain, the customers, discuss and decide what is best for the moment. And honestly, the most difficult part to appreciate is whether this is a short-term game that will go back to something close to what we had before the 1979 agreement on no tariffs, which was so favorable to aerospace in the U.S. and Europe, or whether the result will be materially different and will structurally change the industry. We are adapting to the short-term changes as they come.

> *"I am a bit worried about what would happen if the tariffs were raised significantly above 10%."*

But you are in favor of retaliatory tariffs if the U.S. sticks to its position. We don't like tariffs, we as an industry. We are a European player, but we are also a U.S. player, to a certain extent, and speaking to our U.S. colleagues, they also suffer from the tariffs. We believe the tariffs are lose-lose for the Western-North Atlantic aerospace ecosystem that we are a part of, and that the endgame should be no tariffs. The way to get there is rather complex. And if there is no reaction on the U.S. side in applying tariffs in Europe, at a point in time, there must be a new status quo to force a negotiation.

What we observed five years ago, when there were tariffs on Airbus planes going to the U.S. against the backdrop of the [World Trade Organization] ruling, it took 15 months for the EU to apply tariffs on Boeing planes, and that was the way to bring the two parties to the table and get to a resolution. I believe, indeed, that if it is not possible to get to an agreement by negotiation and by being rational, there must be a symmetrical response. Nobody can pretend there was imbalance in trade conditions, because there is a trade agreement that says zero tariffs for everyone.

Are you concerned about the impact on the supply chain? I am concerned. As long as tariffs are reasonably modest, it is probably manageable, but it is a lot of work because the supply chain is very complex, deep and cross-border, thanks to the 1979 agreement. I was really worried about the 145% tariffs against China, the 125% retaliation, because that potentially could have stopped deliveries and created bottlenecks, stalling deliveries of certain parts. We are back to levels that are less toxic. We have not identified an area of jamming in the supply chain, and we are working hard to check that there is none. But indeed, with very high tariffs, you might create real problems. I am a bit worried about what would happen if the tariffs were raised significantly above 10%.

How fast will you be able to integrate the Spirit [AeroSystems] sites? We will have turned them around within 2-3 years, but it is a site-by-site situation that we need to manage.

What's your view on mergers and acquisitions (M&A) right now? We need to create scale in certain areas of the business where scale has not yet been achieved. We have scale in Airbus Commercial. We have scale in Helicopters. We have scale in missiles with MBDA. And the priority now is to create scale where we don't have scale. We created scale in combat with Eurofighter. Finding the keys to a future combat air system—what kind of combination of sharing with [the UK-Italian-Japanese Global Combat Air Program] GCAP in Europe moving forward, what is the way of getting there—remains a question. And on space, on satellites, we are working hard to create that scale.

I'm not suggesting we would not do M&A, but these are a more, small tactical bolt on things we can add to our cybercapabilities, to our [command and control] here and there. We did it a bit on helicopters. But the priority is getting scale, especially in the European landscape, where we are very fragmented. Where we create scale, generally speaking, we compete well with our U.S. or non-U.S. competitors. That's the way I'm thinking of the priorities for Airbus.

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Top Exec Parker Previews F-47-Based Turnaround at Boeing Defense

- HYPERSONICS MARKET EXIT FREED UP RESOURCES FOR NGAD BID
- BOEING AIMS TO ALIGN CONTRACTS BETWEEN GOVERNMENT PROGRAM MANAGERS AND SUPPLIERS

Steve Trimble, Brian Everstine and **Robert Wall** Washington

The call came in to St. Louis at 9:34 a.m. CDT on March 21. President Donald Trump was scheduled to announce at 11 a.m. EDT the winner of the U.S. Air Force contract to develop what would soon become known as the F-47, the first U.S.-built sixth-generation fighter.

BOEING



BDS Interim CEO Steve Parker's ambitions for Boeing's combat aircraft portfolio span into uncrewed systems, such as the MQ-28 Ghost Bat.

Both contenders—Boeing Defense and Space (BDS) and Lockheed Martin Aeronautics—knew the rules. A half-hour before the announcement, the Air Force would inform the leaders of both companies privately. The lucky winner would receive the first call at 10:30 EDT sharp. The second call would then be to the loser.

Inside a secure, classified facility on Boeing's St. Louis campus, the anxiety rose as each minute past 9:30 CDT ticked by. Seeking to make a dramatic turnaround by winning a flagship defense program, Boeing had invested billions of dollars in infrastructure, committed a decade's worth of engineering work and abandoned once-promising market sectors in a make-or-break gamble to win the right to deliver the F-47.

Finally, the call came—4 min. late. Surrounded by a crowd of anxious employees, Steve Parker, the BDS interim CEO, answered the phone and heard the news: Boeing had won.

"It'll be the most memorable thing I've ever done in my career—just to tell the team and to feel the shockwave of emotion that came back," Parker told Aviation Week two months later. He recalled how that visceral response from the employees physically knocked him backward.

"I was completely shocked," Parker said. "You've got people blubbering, and grown men and women just absolutely crying because they had put in everything that they've got. There are these things in the aviation [industry]—I don't think the general public understands the stakes."

The Air Force now plans to spend at least $20 billion to complete development of the F-47, aiming to field the most advanced fighter in the world within several years. In a single stroke, the contract vaults BDS over rival Lockheed, whose stealthy and sensor-fused F-22 and F-35 defined the fifth-generation fighter standard for aerial warfare technology.

For BDS, the industrial victory was sorely needed. A string of contract wins for trainers, uncrewed aerial tankers and the next presidential transport in 2018 and 2019 refilled the division's order backlog as decades-old F/A-18E/F and F-15EX assembly lines faced an uncertain future.

But the MQ-25, T-7A and VC-25B—in combination with the Air Force's KC-46 tanker and NASA's Starliner spacecraft—had saddled BDS with thorny technical problems and money-losing, fixed-price development deals, resulting in reach-forward losses totaling more than $18 billion since 2014.

As Boeing ramps up development activity on the F-47, Parker is not yet willing to declare victory over the issues that have plagued execution on the fixed-price programs. In the first quarter, BDS reported no reach-forward losses for the first time in three years, but because of delays, all five programs are still 1-3 years away from completing development. The risk of surprises in flight testing remains.

The first quarter was "a great start, but, you know, it's one quarter," Parker said. "Looking at this from a long-term view, we're going to have discovery from time to time."

Boeing's victory has created another challenge. A new Advanced Combat Aircraft Facility (ACAF) is rising on the southwest corner of Boeing's fighter production complex in St. Louis. Hundreds of personnel will soon fill the ACAF to start building the first F-47s and perhaps the U.S. Navy F/A-XX, the F/A-18E/F replacement Boeing is competing against Northrop Grumman to build. Somehow, Boeing must ramp up staffing at the ACAF while keeping a large portfolio of other military aircraft projects on track.

In addition to the fixed-price development programs, Boeing is also slowly building up production on the F-15EX and upgrading the engine, cockpit and radar on the B-52 bomber. The latter recently suffered a cost overrun that triggered a Nunn-McCurdy review.

At the moment, Parker says he has no concerns about staffing. The St. Louis site has been at peak personnel levels in the engineering department for several years, as Boeing delivered the F/A-18E/F Block III upgrade, EA-18G Block II upgrade, F-15EX, F-15QA and T-7 at the same time. Resignations and attrition in the BDS engineering department are running at industry-leading low levels, Parker noted.

"Staffing is not going to be an issue," he asserted. "We're going to be staffed all the way through this to make sure we can deliver on the promises that we've made."

Parker's use of the past tense to describe fulfilling promises made by Boeing is part of that strategy. To focus resources on existing commitments, BDS plans to be more selective about when and how to take on new minor projects, even if it has to disappoint some customers demanding small upgrades.

"It will force me into a situation where [I focus on] what's really the priority," Parker said. "There are things that I could be doing for customers that will not be the priority. The priority will be these critical programs. So for some minor upgrade, I may choose not to staff that up, and that may go [outside Boeing]."

Those kinds of pressures are part of a wider trend in the defense market. As traditional prime contractors focus on core businesses, smaller defense enterprises, nontraditional companies and startups are looking for opportunities in similar roles. Even if many of these smaller companies are not ready to deliver an aircraft as advanced as the F-47, they are increasingly finding opportunities to be prime contractors at lower levels of technology, especially for satellites, Collaborative Combat Aircraft and munitions.

BDS should learn how to partner with those companies, even if it requires working as a subcontractor to a startup, Parker said. The concept involves finding areas where a nontraditional player can contribute a new technology but still lacks the infrastructure for engineering and manufacturing to scale it up into an operational product.

"I'm very open to working with the nontraditionals," Parker said. "Whether Boeing takes some of its secret sauce—its technology, its ability to scale up or [software] its algorithms—and actually works with the nontraditional, where the nontraditional is the prime and BDS becomes a part of their solution, these are all options we're exploring."

An example of such a partnership might already be in the works behind the scenes. "There's nothing for me to unpack for you all today, but maybe in the future, you'll see some movement there," Parker said. "You'll see some things coming up in the coming months."

At the same time, BDS' strategy will be to avoid getting too far ahead of customer demand on some technologies. That is a lesson from painful experiences in Boeing's recent history. It was only 20 years ago that Boeing was considered a global leader in hypersonic vehicles and strategic missile defense.

In this century's first decade, Boeing designed and flew the scramjet-powered X-43A and X-51A experimental aircraft and deployed the Ground-Based Interceptor. But the company now has no role in the Air Force's Hypersonic Attack Cruise Missile or the Missile Defense Agency's Next-Generation Interceptor or Glide Phase Interceptor.

"I think hypersonics is a really good almost case study in terms of 'We were there and we were ahead,'" Parker said. "But the market wasn't there. [So] we moved and pivoted elsewhere."

That internal pivot away from hypersonics and missile defense a decade ago proved significant. Although Boeing lost its position in two promising areas, a behind-the-scenes shift took place, providing more financial and engineering resources to compete in other high-growth areas, Parker explained. In other words, giving up on those technologies made it possible for BDS to prepare to win the F-47 contract and classified work in the military space domain.

"In the national security space environment, I believe we're the market leader," Parker said. "In the fixed-wing fighter world, . . . we have a transformative capability. Those things just don't happen overnight. They take a great deal of investment, materials and technologies and so forth, and that's what we've done."

Now, Boeing needs to deliver on that transformative fixed-wing capability. Throughout the largely secret competition with Lockheed, Boeing executives emphasized that the Next-Generation Air Dominance (NGAD) program will be different, setting a new tone for a company that wants finally to shed the cost overruns, schedule delays and bungled execution.

An essential part of Boeing's recovery strategy is to align contracts between the prime and the supply chain. In a major defense program, the financial terms of the government deal—whether fixed-price, cost-plus or a hybrid—apply only to the prime contractor, which must then negotiate separate deals within the supply chain. If not carefully managed, the arrangement on fixed-price deals can force such prime contractors as Boeing to absorb the losses of suppliers.

"Sometimes suppliers are not on a fixed-price contract [with us], or we've got some type of not-to-exceed [deal] in which they might exceed," Parker said. "So it's really aligning much more tightly at the offer stage."

Another new feature of the F-47 program is the government management structure. When the Air Force Materiel Command established the Agile Development Office to manage the NGAD program, it set out to follow the example of the Rapid Capabilities Office (RCO), which is responsible for fielding the Boeing X-37 and Northrop B-21 Raider.

"It's very similar to the mindset we have right now in terms of getting risk out of the system early, getting discovery done early and in a much more collaborative, cooperative fashion," Parker said.

"But when it comes to the F-47," he explained, "I'll decline to say too much more there, other than it's really the relationship between the customer and in this case, the post-award Boeing to define risks, to put the right milestones in place, to make sure you have the right elements of schedule margin and technical margin."

Boeing has one advantage on the F-47 program with discovering problems early. In March, DARPA confirmed for the first time that the initial flight of Boeing's secret NGAD demonstrator occurred in 2019. That gives Boeing about six years of hands-on experience with a flying example of the advanced technologies now entering development.

In the competition that led to the F-35 two decades ago, flight demonstrators were available for only a year before full-scale development began. The same timeline applied to the experimental aircraft that informed the selection of the F-22 a decade before.

Asked if the longer lead time for the F-47 demonstrator would pay dividends in the next phase, Parker said: "Absolutely."

Parker has one more tip for managing the F-47—and, possibly, the future of BDS. "Don't screw it up," he said. "That's the plan."

France's Aspiring Space Power



With geopolitics changing fast over the last three years, the French Air and Space Force now has a stronger focus on high-intensity combat and military space. Meanwhile, it also is gearing up to replace lost capacities, such as suppression of enemy air defenses, and defining a doctrine for uncrewed combat aircraft. European Technology Editor **Thierry Dubois** *sat down with Air and Space Force Chief of Staff Gen.* **Jérôme Bellanger** *for a wide-ranging interview.*

FRENCH AIR AND SPACE FORCE

AW&ST: **In April, the French Air and Space Force conducted the Pegase Grand Nord exercise in Sweden, Poland and Croatia. What lessons were learned?** It contributed to our strategic show of force toward Russia and reinforced our partnership with Nordic countries, especially Sweden—a new NATO member. The idea was to deploy swiftly and, at the end of a raid, make some real shooting on the Swedish firing range. And then, after a refueling and rearming stop, take off again and perform another mission. That's what we did as part of a joint exercise with the Finnish, Norwegian and Swedish forces. On the way back, we worked on our agile combat employment (ACE) skills—deploying a few fighters with a small logistics footprint. In the ACE framework, three [Dassault] Rafales made stopovers in Poland and then in Croatia.

In total, Pegase Grand Nord employed six Rafales, three [Dassault] Mirage 2000Ds, two Airbus A400M transports and one A330 multirole tanker transport (MRTT). We have proven, again, we can have a significant strategic impact with few resources.

Over the last few years, French forces have transitioned from counterinsurgency operations in the Sahel region of Africa to preparing for high-intensity warfare. Is that a fair summary, and what does that mean for training and flight hours? We never stopped training for high-intensity [missions]. One of our permanent missions, nuclear deterrence, has always shaped our entire activity. Our Operation Poker exercises, for instance, involve a large part of our resources. We simulate a raid of about 50 aircraft by night, with adverse ground-to-air defenses and aircraft, and we do it four times a year. The mission has shaped us for 60 years, centering on capabilities such as air-to-air refueling, electromagnetic warfare (EW) and deep strikes.

Indeed, our approach in African countries has been less about kinetic operations recently and more about partnerships, typically with Ivory Coast.

And what about flight hours? To be up to the task, and if you want to use all the potential of the Rafale—an omnirole aircraft that can do, in one mission, all the missions from air combat to ground strikes—a pilot needs 180 flight hours and 60 hr. on a flight simulator annually. A sense of flying can be gained in flight only. Meanwhile, in the simulator, you can use the entire potential of the aircraft—which you cannot always do in flight because the airspace is restricted or you do not have the right configuration.

Is the French Air and Space Force at the right size, relative to its missions? Our aviators are fit for the job because they benefit from operational preparations, such as Pegase. Not every air force can fly its nationals out of a country such as Afghanistan, Niger or Sudan.

It is not only about strategic transport; it is about the combination of the Rafale, the A400M, the A330 MRTT and special forces.

We are fit for the job, and our size is consistent, as the Ministry of Armed Forces has announced the Rafale's target fleet is increasing by 30 aircraft. We have benefited from a doubling of the defense budget, and we have been able to modernize. Our fighters will evolve to an all-Rafale fleet around 2030-35.

That said, we have learned lessons from the war between Russia and Ukraine. In the 1990s, we gave up on two capabilities because we were not challenged in the air as we could be today. The first one was suppression of enemy air defenses (SEAD), and the next Rafale standard, the F5, will have a SEAD missile against surface-to-air missiles. It will be decisive in access-denial areas.

The second one was EW. We need to recover some capacities in offensive jamming and deception.

In addition, we want to develop uncrewed air vehicles (UAV) with remotely operated weapons, for EW and for saturation of an airspace. As for counterdrone capacities, we deployed some in quite a remarkable way during the Olympic Games in 2024.

On SEAD, what is the timeline? Against short-to-medium-range systems, the AASF future air-to-ground missile is aiming for 2030. Against long-range systems, we are talking about post-2030. MBDA is developing the RJ10 missile. The development's main focuses are on the homing and targeting systems.

So is that a full-fledged program? It is for after the current military budget programming law, so we will keep pushing. We have specified the targeting and precision performance. We also want to give it a level of resilience against GPS jamming, for the inertial reference system and for the homing system.

What about regaining EW capabilities? Are we talking about a dedicated program? There are several programs at Dassault Aviation, MBDA, Safran, Thales and others. In our own organization, we have reinstated EW in a visible way. We have dedicated officers in operational units, and we have a general in charge of developing EW capacity at our air warfare center. The Rafale F5 will have an upgraded Spectra self-protection system. And we now have the Black Crow exercise, where crews train against electromagnetic defenses.

When you talked about UAVs, were you alluding to remote carriers? Yes, but not only. I am also referring to low-cost UAVs and the entire arsenal, up to the uncrewed combat air vehicle (UCAV) that will accompany the Rafale F5. It will feature capabilities such as stealth, a weapon bay and collaborative combat. Remote carriers will be part of that combat sphere in flight. Then you have low-cost UAVs in the medium-altitude, long-endurance category with electromagnetic, kinetic or observation capabilities. Their role is to wear down adverse defenses and enable the weapon—an expensive one—to reach its target. The combination will enable the mission to be effective.

Can you elaborate on the role of the UCAV flying along with a Rafale F5? It is about having a UCAV in charge of facilitating entry force [the capacity to be the first to enter a disputed area against enemy forces] and possibly the first strike. The Rafale comes just behind, with its own weapons. It can bring along remote carriers with a direct kinetic role.

So it is a major step toward the Future Combat Air System (FCAS)? Yes, a very important one. It will include FCAS bricks. The F5's collaborative combat capability will enable us to be on time on the FCAS. Some sensors and the evolution of the M88 engine will include technologies the FCAS' New-Generation Fighter will use.

Is the FCAS program progressing as you expect? It is making progress, of course with the challenges you can encounter when several partners are involved. We want to work on interoperability, especially with other in-development aircraft in the U.S. and the UK, to avoid what happened with the Lockheed Martin F-35. The F-35's interoperability could be better.

At the government level, NATO has seen ups and downs over the last few months. What have you seen on your end? The activity is unchanged, with excellent synergy at our level. We continue to have the NATO air chiefs conference four times a year, and France will lead the Allied Reaction Force exercise in 2026. With our NATO partners, we have a common legacy, and we share the same vision.

Look at what has been done in preparation for a potential ceasefire in Ukraine and accompanying security guarantees. That would be under a dual France-UK leadership, and we managed to gather 23 nations, outside the NATO framework but with a majority of NATO member states, to discuss those guarantees. When you want to discuss plans at a broader level than NATO, European and NATO air chiefs easily get together.

In space, what are the capacities you would like to add? The militarization of space is a new challenge. It is not just about air and space, in our view. We include the higher airspace, so we are talking about a continuum. Henceforth, an aviator should not just think that Flight Level (FL) 500 [or 50,000 ft.] is the ceiling; they should consider the airspace up to FL 3300 and the space beyond.

I mean, we want to develop capacities in space, as well as from space and toward space, such as overpowering a satellite by jamming or directed-energy weapons. Russia and China already have such anti-satellite arms.

We need such capacities as patrol satellites under the Egide program [preceded by the Yoda demonstrator in geostationary Earth orbit]. Time is of the essence; we want to have such a capacity as soon as possible, even if it is not perfect.

For low Earth orbit, the Toutatis demo is well underway. With the IRIS^2 program [creating a sovereign EU secure communications constellation], we will need such capacity.

What about higher airspace operations? It is quite new, [and] a bit of a Wild West. We want to be able to do what a U.S. F-22 did when it shot a Chinese balloon. We have done trials, and we are carrying on. Our capacities may include balloons or high-altitude platforms comparable to gliders.

Can you elaborate on the Balman maneuvering balloon program? It is taking years, although it is much less sophisticated than a space launcher or a combat aircraft. The difficulty is about piloting the balloon at an altitude of 25 km (82,000 ft.). You do not want to let it drift randomly, and then you have to organize the recovery. The next demonstration flight will take place late this year.

What about responsive launches with smaller rockets? Access to space is a major issue, and I very much believe in responsive launches. They will enable us to be faster than our competitor, whether it be for capacity in the higher airspace or space, in a given period or for a specific theater of operations. Right now, we do not have that capacity.

I see a number of projects, and that is a good thing. You have established players [such as ArianeGroup] and startups, and we need both. It is high time we accelerate if we want to use the increasingly crowded low Earth orbit.

Adaptive-Cycle Engine Eyed To Power European Future Combat Air System



Images of the proposed platform released by airframers indicate that the partners appear to agree on the need for an adaptive- or variable-cycle engine.

AIRBUS DEFENSE AND SPACE

- FCAS NATIONS PLAN TO DECIDE ON SYSTEM CONFIGURATION IN THE THIRD QUARTER OF 2026
- ENGINE IS TO PROVIDE 30-40% MORE THRUST THAN M88 OR EJ200

Tony Osborne and **Robert Wall** London

The Franco-German-Spanish future fighter program may be lagging its biggest Western rivals in development, but there is one area in which the trio is looking to outdo its counterparts: the engine.

The trinational development is embracing adaptive-cycle engine architecture for the next-generation Future Combat Air System (FCAS) fighter. Despite the promise of a leap in performance, other programs—the U.S. Air Force Boeing F-47, U.S. Navy future F/A-XX and the UK-Italian-Japanese Global Combat Air Program (GCAP)—have passed on that option.

The European Military Engine Team (EUMET) joint venture of Germany's MTU Aero Engines and France's Safran—along with Spain's ITP Aero, which is not part of the joint venture—offered program airframers Airbus and Dassault Aviation two engine configurations for the new fighter, which is due to enter service in the 2040s. One of their messages to airframers was: Think long-term.

"This platform is a sixth-generation fighter aircraft that still needs to be able to fight in 2100, so we need to have an engine that is very capable and stretches ourselves in terms of materials, architecture and electrical power supply," Michael Schreyögg, MTU Aero Engines chief program officer, tells Aviation Week.

With that in mind, "I pushed a lot for variable cycle," he says. "We need to provide something which is truly state of the art; it should not just be a better M88 [from the Rafale] or an EJ200 [from the Eurofighter]."

Until now, little information had emerged about the proposed engine apart from a handful of bullet points on the EUMET website that point to a wish list of features.

The engine's development is one of the most important programs for the three companies, Schreyögg says, since each has a 33% share of the program in development and production.

The FCAS next-generation fighter (NGF) is due to replace part of the fleet of Eurofighters flown by Germany and Spain and part of the Dassault Rafale fleet flown by France. Initial operational capability is planned for around 2040.

The engine partners are looking to have development powerplants ready in the early 2030s. More refined prototype engines are then due in the mid-2030s to support flight testing, ahead of the start of production for the aircraft's entry into service in the early 2040s.

As with other next-generation combat aircraft projects in China, Europe and the U.S., the proposed platform is physically heavier and larger in size—up to one-third bigger than fourth-generation combat aircraft such as the Dassault Rafale, Eurofighter Typhoon, Boeing F/A-18 Super Hornet or the Chengdu J-10. All the next-generation aircraft feature extensive low-observability characteristics, including internal weapon bays, and will have much-expanded combat ranges. They are also studded with power-hungry electronics.

All that puts a premium on engines that are more powerful and thermally managed to preserve the platform's infrared signature, while also producing much higher electrical outputs to power new radars, mission systems and—potentially—directed-energy weapons in the future.

How powerful the NGF's engine will need to be will depend on the architecture selected for the system. That decision is due around the third quarter of 2026, say program officials. Three system configurations are in play: one that focuses on the fighter's attributes, another that leans more on the remote-carrier capability and a third balancing the first two.

Of the sixth-generation fighter programs in development, only the European FCAS program has declared plans to use a variable-cycle engine. The architecture's advantage is that the engine can have different modes of operation, allowing fuel-efficient cruise or high power for air combat, Schreyögg said.

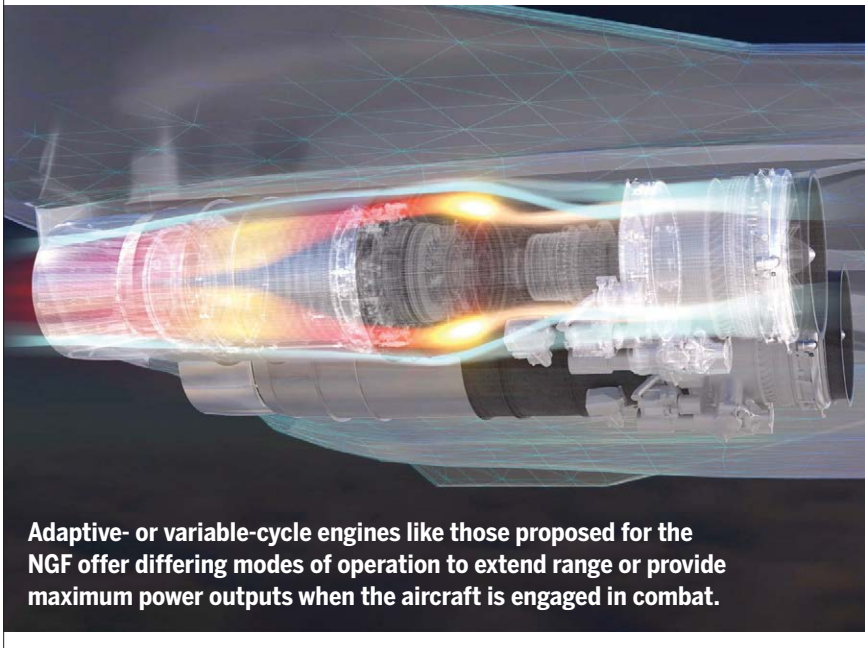
GCAP engine developers Avio Aero, IHI Corp. and Rolls-Royce have opted for a simpler architecture (*AW&ST* May 5-18, p. 53), as has the U.S. Navy's F/A-XX program. Uncertainty surrounds the initial engine choice for the U.S. Air Force's baseline F-47. The platform could receive an adaptive-cycle engine in future batches.

The FCAS engine will need to deliver 30-40% more thrust than current fighter engines, according to Schreyögg, and will require a different architecture. The program, he says, also will take lessons from the U.S. Lockheed Martin F-35 Joint Strike Fighter program, whose Pratt & Whitney F135 has faced deficits in electrical power production as demand from aircraft systems has increased. "We will need to oversize the power management in order to have the margins," Schreyögg explains.

As part of the engine development activity, the three companies have delivered all the milestones from the technology maturation phase—the so-called Phase 1B of the FCAS program—and now have a "technology suite" of about 100 ongoing programs, Schreyögg says. These are focused on advanced materials and powdered metals to support production using additive-manufacturing processes. Targets include lightweight compressor systems and durable turbines produced from ceramic matrix composites, while structural casings will be manufactured additively to secure reduced overall engine mass.

Before work begins on the adaptive-cycle powerplant, trials of some of these new technologies will be performed on a demonstrator engine, an adapted M88, with work beginning in late 2026 and running through to around 2029.

This will be something of a "Frankenstein engine," Schreyögg says, and will test various technology projects developed by the three companies, although it is unlikely to test the variable-cycle element. That is to come in the development engines planned for the 2030s.



EUROPEAN MILITARY ENGINE TEAM

Adaptive- or variable-cycle engines like those proposed for the NGF offer differing modes of operation to extend range or provide maximum power outputs when the aircraft is engaged in combat.

Testing of the demonstrator engine is part of the €4.5 billion ($5.1 billion) Phase 2 of the FCAS, due to begin in late 2026. It includes a flying demonstrator powered by a pair of M88s, a sensor testbed based on a Fokker 100 airliner and trials of remote-carrier uncrewed collaborative platforms. Program officials are exploring five classes of uncrewed adjuncts that provide mass to the force package. These will vary in size, weight and role, and whether they are expendable, attritable or deemed too costly to lose.

Progress on the development has been hampered by industrial disagreements over work allocation and other issues, causing some anxiety among program officials that the timeline for fielding the fighter may be slipping. That has injected a sense of urgency to move forward with the decision-making process.

But Brig. Gen. Philippe Koffi, the head of the FCAS program in France's DGA materiel agency, is upbeat about the effort. Development of the demonstrators follows a two-year effort to mature technologies and architectures.

"We have built a robust and dynamic industrial ecosystem of more than 3,000 engineers and 144 companies, including major players and startups," Koffi said at a Royal Aeronautical Society event on May 21. "This is not just about building momentum." He added that several design reviews have been achieved, along with some "800 deliverables."

Artificial intelligence (AI) will be one of the "main features of the platform," he noted. Linked with the combat cloud network, AI will be essential for the "collaboration and coordination" of the uncrewed remote carriers, he said. AI also will help evolve the command-and-control of force packages, ensure dataflows to the right platforms and act as a virtual assistant, helping them command the remote carriers with "high-level orders" and enhance the capability of the sensors. Koffi even suggested AI could provide a Shazam-like capability for electronic warfare, identifying and classifying electronic signals in the same way the Shazam software identifies music.

Development of remote carriers has

moved up a gear in the last 12 months. Spain's Satnus joint venture, established to develop autonomous remote-carrier technologies for the FCAS, completed its first flight test campaign in January. Satnus' work is focused on the algorithms and systems that will allow the Airbus- and MBDA-developed remote carriers to work with the future crewed fighter.

As part of the trials, they flew converted target drones with new communications and termination systems, and different payloads. Satnus also trialed a multiplatform simulation tool that can integrate real and simulated aircraft in the same test, paving the way for collaborative flights involving multiple converted drones.

MBDA, tasked with development of an expendable remote carrier (ERC) for the FCAS, has conducted flight trials of a testbed for remote-carrier technologies. Its Small Highly Adaptable Remote Carrier System (Sharcs), a remotely piloted jet-powered forward swept-wing fixed-landing-gear-equipped air vehicle with a composite airframe structure provided by Airbus-owned German aerospace supplier Premium Aerotec, began flight trials last summer in Germany.

Sharcs is a platform for testing various sensors, systems and associated algorithms that could be featured in ERCs. These ERCs have been designed to carry different payloads including intelligence, surveillance and reconnaissance sensors, relays, electronic-warfare systems and jammers, and will collaborate with other ERCs and weapons.

Indra, meanwhile, as the Spanish national coordinator for the FCAS, is working with Celestia TTI on satellite communications links and with a company called Idbotic on hardware encryption. Both efforts are expected to support development of the proposed combat cloud, the complex network that ties the various systems together for communications and situational awareness and for collaboration between crewed and uncrewed systems.

But while many of the disagreements among the industrial development partners have been largely resolved, tensions remain. Dassault CEO Éric Trappier has said he continues to have doubts about the future construct of the program as it moves into Phase 2, as well as the involvement of a fourth nation, Belgium, as an observer. The perennial question of whether the two European sixth-generation fighter developments, the other being GCAP, should merge is discussed regularly and subsequently dismissed by industry.

Their view is that the two aircraft need to be interoperable and capable of fighting alongside each other. Jean-Brice Dumont, the head of Air Power at Airbus Defense and Space, told France's National Defense Commission in February the two programs must "work together on the connectivity layer," and "develop weapons jointly." Cooperation between the programs also could extend to the remote carrier realm, with the Trinity House defense agreement between Germany and the UK hinting of collaboration for such platforms as well.

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European Fighter Jet Orders Surge Amid Geopolitical Uncertainty

- MORE F-35 ORDERS FROM EUROPE LIKELY DESPITE TRUMP'S RHETORIC TOWARD NATO
- F-35 OPERATORS STILL AWAIT INTEGRATION OF EUROPEAN WEAPONS



SAAB

Saab is hoping to sign Gripen E contracts with Colombia and Thailand this year.

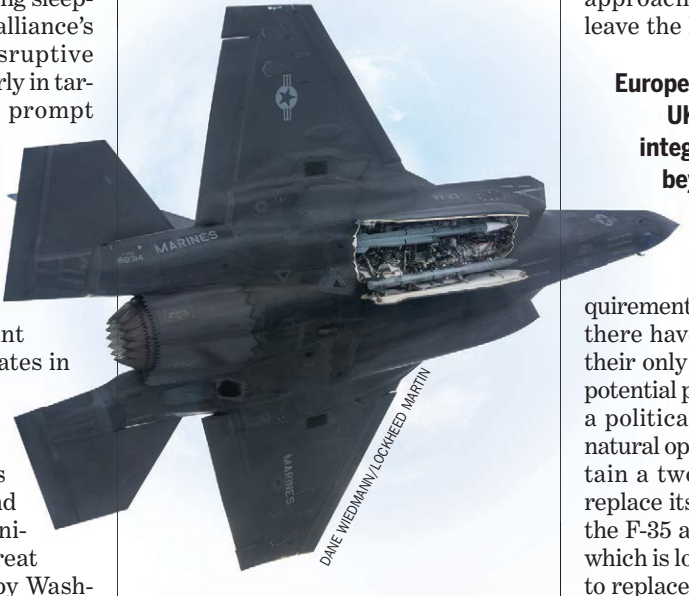
Tony Osborne London

With much of Europe's fighter fleets heavily dependent on the U.S., President Donald Trump's apparent siding with NATO adversaries and calls to annex Canada and Greenland must be causing sleepless nights for some of the alliance's European leaders. His disruptive words and actions, particularly in targeting tariffs, continue to prompt questions about the reliability of the U.S. as an ally and defense supplier.

But when it comes to combat aircraft acquisition, most European nations have made their decisions. Lockheed Martin's F-35 Joint Strike Fighter (JSF) dominates in the region. While larger numbers of the Eurofighter Typhoon are operated now, the F-35 will surpass that as more nations take delivery and bolster their fleets in recognition of both the growing threat from Russia and demands by Washington that Europeans take more responsibility for their own security.

TOP-UP ORDERS

Despite the rhetoric of European leaders following pronouncements from Trump and U.S. Vice President JD Vance, several countries are expected to announce top-up F-35 orders in the coming months. Among them will be Denmark, which, despite the threat of a U.S. takeover of Greenland, wants to grow its fleet from the currently planned 27 aircraft. Others likely to top up include Belgium, Italy and the UK. The Czech Republic, Germany, Greece, Romania and Switzerland are either under contract for the F-35 or selected it for their fighter needs.



DAVE WIEDMANN/LOCKHEED MARTIN

Only Spain's and Portugal's air forces have yet to decide whether to invest in the platform. Portuguese ministers had suggested that Trump's approach to European allies would leave the F-35 out of the running for fulfilling Lisbon's fighter requirements, but air force commanders there have indicated the platform is their only real option. As for Spain, a potential purchase of the F-35 remains a political hot potato—yet the only natural option for the country to maintain a two-type front-line fleet and replace its EF-18 Hornets. Interest in the F-35 also has come from Austria, which is looking to start procurement to replace its Eurofighters next year.

European nations, particularly the UK and Italy, are awaiting the integration of the MBDA Meteor beyond-visual-range air-to-air missile on the F-35.

EXITING CRISIS MODE

Interest in the JSF continues unabated as the wider program emerges from crisis mode. Lockheed is handing over F-35s that had been stored after a delivery pause disrupted the transi-

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Europe's Combat Aircraft Outlook

Operator Country	Aircraft Type	Current Fleet	On Order/ Contracted
Austria	Eurofighter Typhoon	15	—
	Proposed Eurofighter Replacement	—	TBD
Belgium	Lockheed Martin F-16	52	—
	Lockheed Martin F-35	8	26*
Bulgaria	Lockheed Martin F-16	2	14
	Mikoyan MiG-29/35	3	—
	Sukhoi Su-25	7	—
Croatia	Dassault Rafale	12	—
Czech Republic	Lockheed Martin F-35	—	24
	Saab Gripen C/D	14	—
Denmark	Lockheed Martin F-16	38	—
	Lockheed Martin F-35	17	10
Finland	Lockheed Martin F-35	—	64
	Boeing F/A-18	61	—
France	Dassault Mirage 2000 -5/D	88	—
	Dassault Rafale	142	55
Germany	Lockheed Martin F-35	—	35
	Panavia Tornado	82	—
	Eurofighter Typhoon	130	38**
Greece	Lockheed Martin F-16	153	—
	Lockheed Martin F-35	—	20***
	McDonnell Douglas F-4	20	—
	Dassault Mirage 2000	24	—
	Dassault Rafale	24	—
Hungary	Saab Gripen C/D	14	4
Italy	Lockheed Martin F-35A/B	34	56
	McDonnell Douglas AV-8	14	—
	Panavia Tornado	38	—
	Eurofighter Typhoon	91	24
Netherlands	Lockheed Martin F-35	42	16
Norway	Lockheed Martin F-35	52	—
Poland	Lockheed Martin F-16	48	—
	Lockheed Martin F-35	4	28
	Mikoyan MiG-29/35	15	—
	Sukhoi Su-22	8	—
	KAI T-50GF/PL	12	36
	Proposed Air Superiority Fighter	—	36
Portugal	Lockheed Martin F-16	24	—
	Proposed F-16 Replacement	—	TBD
Romania	Lockheed Martin F-16	33	16
	Lockheed Martin F-35	—	48
Serbia	Soko J-22	6	—
	Mikoyan MiG-29/35	14	—
	Dassault Rafale	—	12
Slovakia	Lockheed Martin F-16	8	6
Spain	Proposed F/A-18 Replacement	—	TBD
	Boeing F/A-18	79	—
	McDonnell Douglas AV-8	11	—
	Proposed AV-8 Replacement	—	TBD
	Eurofighter Typhoon	69	45
Sweden	Saab Gripen C/D/E	99	57
Switzerland	Lockheed Martin F-35	—	36
	Northrop F-5	25	—
	Boeing F/A-18	30	—
UK	Lockheed Martin F-35A/B	38	9
	Eurofighter Typhoon	107	—

*Twenty-one expected top-up orders. *Source: Aviation Week Network Fleet Discovery Military*
**Twenty expected top-up orders.
***Twenty order options.

tion plans of several European air forces. However, the defense prime now has other distractions. The awarding of the F-47 contract to Boeing in March produced a new domestic competitor and inspired proposals for a future F-35 makeover, even though the program has struggled to keep up with current obligations.

Aviation Week has not been able to verify Trump's May 15 claim of a new twin-engine variant of the F-35, which he christened the F-55. Lockheed CEO James Taiclet said in April that the U.S. military did not need a next-generation fighter to deliver new technologies, and the company could repackage some 80% of those next-generation capabilities for the F-35 at about half the cost.

Among them could be new stealth coatings, electronic warfare and networking improvements and even making the aircraft optionally piloted, Taiclet said in late May.

Until then, Lockheed has other worries. The 40P02 software tape—a component of the platform's Block 4 upgrade—that would provide full operational capability is still in testing, with no update on its progress. The delay has forced Lockheed to deliver F-35s with the 40P01 software, a truncated version limited to training sorties.

WEAPON FRUSTRATIONS

These delays are holding back the integration of European weapons. MBDA's Meteor beyond-visual-range air-to-air missile—a weapon in high demand with JSF customers—finally flew on the F-35B last November, 4-5 years behind schedule. A delta program to integrate the missile on the F-35A is also late.

The UK government now expects integration of the Meteor to be complete by the end of the decade, along with that of the Spear 3 mini-cruise missile, the development of which has been paced with that of the F-35's Technical Refresh 3 (TR-3) effort. To improve standoff capability, several European customers are acquiring the Kongsberg-Raytheon Joint Strike Missile and the Northrop Grumman Advanced Anti-Radiation Guided Missiles-Extended Range (AARGM-ER).

EUROFIGHTER RENEWAL

Production of the Eurofighter appears assured well into the 2030s, as the platform secured a slew of new orders at the end of 2024. Italy and Spain ordered 49 more aircraft in mid-December, and Germany has another order of 20 in the offing to add to its Quadriga order for 38 in 2020.

Export orders are also close to "crystallizing," Eurofighter CEO Jorge Tamarit Degenhardt told the Royal Aeronautical Society's Future Combat Air and Space Capabilities Summit in London on May 22. He expressed confidence in the prospect of top-up orders from Saudi Arabia and the potential sale of 40 aircraft to Turkey, an effort that has faced on-and-off support from



ALESSANDRO MAGGIA/LEONARDO AERONAUTICS

Leonardo has almost completed Eurofighter deliveries to Kuwait and will build 24 Tranche 4 model aircraft as part of a top-up order for the Italian Air Force.

Germany. Ankara appears to be keen on the Eurofighter in part because it offers airpower parity against Meteor-armed Dassault Rafales in Greece's inventory, keeping airpower over the Aegean in an uneasy balance. Top-up orders could also come from Qatar.

These orders, which Degenhardt's predecessor Giancarlo Mezzanatto described as a "renaissance" for the type, are prompting the industrial partners to raise production rates, targeting 20 initially and later 30 aircraft per year (*AW&ST* Jan. 13-26, p. 17).

Rates are still half of the 60 aircraft assembly lines were producing per year at the height of Tranche 2. Still, the new ramp-up will be challenged by similar pressures facing the commercial aircraft industry, with which Eurofighter production shares many suppliers. The only partner nation that has not yet contracted for additional aircraft is the UK, despite calls from workers' unions to do so. The country's focus will likely be on expanding its F-35 fleet and upgrading its Eurofighters with new active, electronically scanned array (AESA) radars.

RADAR COMPLEXITY

Three variants of the European Common Radar System AESA sensor are under development. The Mk.0 is operational on Kuwaiti and Qatari aircraft. Hensoldt's Mk.1 will equip German Tranche 2, 3 and 4 aircraft as well as new Spanish jets. Leonardo UK's Mk.2—offering electronic attack capabilities—flew on a UK Eurofighter

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France seeks to expand the Rafale's capability by partnering it with a UCAV derived from the Neuron demonstrator that can operate from an aircraft carrier.

last September, and will be retrofitted to Royal Air Force Tranche 3 jets by decade-end. A modified Airbus A320 testbed is supporting Mk.1 radar development (*AW&ST* Feb. 10-23, p. 55).

In addition to radar upgrades, partner nations have agreed to implement the Phase 4 Enhancements (P4E) package, the most complex yet. The P4E includes new weapons integration, suppression and destruction of enemy air defenses (SEAD/DEAD) capability and task-based mission management systems tailored to reduce pilot workload for the AESA radar. Two new weapons will be integrated: the Taurus KEPD 350 cruise missile and AARGM. The latter is to become Germany's main SEAD/DEAD weapon, enabled by Saab's Arexis electronic-warfare suite. Italy also is interested in pursuing this capability. Other updates include cockpit changes and new defensive aid subsystems.

Air forces will be able to apply the P4E upgrade to Tranche 2 and 3 Eurofighters, although how many aircraft will receive the update will be up to the customer nations.

Even though the partner nations are beginning to work on a Eurofighter replacement in the form of either the pan-European Future Combat Air System (page 66) or the Italian, Japanese and UK Global Combat Air Program (GCAP), Degenhardt said at the summit it would be an "oxymoron" to describe the Eurofighter as a legacy platform. With aircraft that are now in production expected to be in service until 2060, Degenhardt said the type "will have an active role in the FCAS environment during its maturation."

RAFALE GUSTING

Dassault's Rafale continues its export momentum. Over the past 18 months, France secured the first Rafale M sale to India, a 12-aircraft deal with Serbia and pledges from Indonesia to increase its buy beyond the 42 it already has on order. The airframer has a backlog of 220 Rafales, equivalent to more than 10 years of production at current rates—21 were delivered in 2024. The first of 80 Rafales for the United Arab Emirates were delivered in January.

An upgrade program, the F4, is being delivered in phases and includes networking improvements, integration of the Safran AASM 1,000-kg (2,200-lb.) bomb kit and the MBDA Mica NG missile. The latter is due in the final F4.4 phase.

UCAV WINGMAN

An F5 upgrade planned for the 2030s will prepare Rafale for France's new nuclear-tipped ASN4G standoff missile and allow it to operate alongside an uncrewed combat air vehicle (UCAV), building on the Neuron demonstrator. The UCAV is intended to penetrate air defenses beyond the Rafale's current reach. The F5 also will introduce Thales' RBE2 XG radar. France's 2025 defense budget allocates €196 million ($223 million) to F5 development and €704 million to UCAV development.

"This stealth combat drone will contribute to the technological and operational superiority of the French Air Force by 2033," Dassault CEO Eric Trappier said.

GRIPEN BOOST

Saab's Gripen family is enjoying success as well. Just this year alone, Colombia and Thailand have selected the new Gripen E; the airframer is hoping to wrap up negotiations and finalize both contracts by year-end. The Gripen E is already in front-line service in Brazil (*AW&ST* Nov. 25-Dec. 8, 2024, p. 37). The type is slated to enter service with the Swedish Air Force's F7 Air Wing this year, although the Swedish Armed Forces' annual report says Saab will slow deliveries of the platform in order to hand over a higher maturity level. Final delivery is planned for 2030.

And with Sweden now planning to hold on to 60 of its 105 Gripen C/Ds into the 2030s, a series of new block updates and systems is planned to address obsolescence. The C/D models also are set to receive the Taurus KEPD-350 cruise missile, giving Sweden a long-awaited standoff strike capability.

Hungary gave the C/D model a boost last year with a top-up order, the first for the type in 14 years. In addition, the Czech Republic will extend its leasing contract for the aircraft until it takes delivery of its F-35s.

Sweden also has contracted with Saab and GKN Aerospace to begin studies and technology maturation work that could pave the way for a third next-generation European fighter project in addition to FCAS and GCAP. This work is designed to support a Swedish government decision in 2030 about whether to pursue the development of a new combat aircraft. Such a program likely would see replacement of the Gripen C/Ds first.

The F-35 is not the only U.S. platform being proposed in Europe. Boeing's F-15EX is being offered to meet a Polish requirement for 32 fighters, with competition from the Eurofighter, F-35 and Block 70 F-16. Small numbers of Block 70 F-16s are arriving in Europe, with deliveries underway to both Bulgaria and Slovakia, which have ordered 16 and 14, respectively. Poland also has initiated plans to upgrade its Block 50 F-16s to the Block 70 standard.

—With Steve Trimble and Brian Everstine in Washington

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Full-Spectrum Intelligence

Heron MK II Brings Integrated COMINT and ELINT to the Front Line

Emphasizes multi-sensor integration and operational deployment.

Real-time intelligence is vital to maintaining strategic advantage in today's complex operational landscape. The Heron MK II, Israel Aerospace Industries (IAI)'s latest generation Medium-Altitude Long-Endurance (MALE) UAV, brings cutting-edge capabilities in Communications Intelligence (COMINT) and Electronic Intelligence (ELINT) to the forefront of modern aerial surveillance. Built on decades of operational experience and hundreds of thousands of flight hours, the Heron MK II is a versatile, robust SIGINT platform capable of delivering high-value intelligence over long durations and vast areas.

The Heron UAS has demonstrated its value tactically and strategically, with the aircraft's capability to collect, process, and disseminate real-time data through IAI's CRISP system. This real-time flow includes raw and processed intelligence, facilitating swift decision-making across multiple command levels.

Close standoff operations with full-spectrum coverage

The Heron MK II is designed for "close standoff" missions, flying nearer to targets than most manned aircraft while remaining outside high-threat zones. This enables effective SIGINT collection without compromising platform safety. This "close standoff" flight profile allows for the effective collection of signals intelligence while minimizing risk to the asset. Furthermore, the Heron MK II can operate as a networked system, distributing sensors data across multiple users. This architecture ensures continuity, even if one platform is compromised, significantly improving mission resilience.

A major advantage of the Heron MK II is its ability to carry and operate a comprehensive sensor suite simultaneously. This includes COMINT, ELINT, electro-optical systems, and radar – all integrated to create a cohesive intelligence picture. At up to 35,000 feet, the platform offers a 360-degree situational awareness capability across hundreds of kilometers, making it ideal for strategic missions such as wide-area maritime surveillance.



Credit: IAI



Credit: IAI

For example, SIGINT sensors work alongside advanced long-range electro-optical cameras such as the new-generation MOSP 5000 to cue visual investigations of targets detected electronically. This fusion of multiple sensors significantly improves detection, classification, and tracking in complex and dynamic environments.

Advanced SIGINT systems and AI integration

IAI's ELTA group currently offers its third-generation SIGINT systems, which now equip the Heron MK II. These include the ELL-8385, ELI-8395 Tacsense, and ELK-7072 – systems capable of rapid, wideband scanning from 20 MHz to 18 GHz. AI-driven processing enhances detection, classification, and analysis of digital signals, enabling rapid extraction of actionable intelligence, including ship identification through AIS signals and detection of covert push-to-talk communications.

The systems are designed to handle dense electronic environments by designating radars & communications-based network and geographic region to create a visual map of active situational picture. These insights are particularly valuable in maritime domains, where detecting brief, low-power transmissions can signal illicit activity or emerging threats.

Latency is a critical factor in SIGINT operations, especially when adversaries use brief transmission bursts to avoid detection. The Heron MK II's persistent airborne presence ensures that even millisecond-long signal emissions can be detected and geolocated. Its highly sensitive receivers enable it to maintain close electronic proximity to threats, providing unmatched coverage and early warning capabilities.

Scalable Intelligence

The Heron MK II can function as a standalone multi-sensor platform or as part of a distributed SIGINT architecture, wherein multiple UAVs share collection responsibilities and fuse data in real time. This distributed model provides optimal coverage over complex terrains and extended maritime zones while enhancing survivability and mission effectiveness.

Following its operational success, the new Heron MK II upgrade with ELINT/COMINT capabilities could enhance long-range strategic intelligence, supporting missions ranging from border security to counterterrorism and maritime route protection. SIGINT capabilities also enable the UAV to identify threats directed at itself and cue defensive measures for self-protection or to safeguard other friendly assets.

The Heron MK II represents a significant advancement in unmanned SIGINT operations. Real-time integration of COMINT, ELINT, radar, and visual intelligence sets the standard for unmanned strategic intelligence in today's contested airspaces.

Meet IAI's UAS experts at Hall 3, Booth B64 – or connect directly: info.malat@iai.co.il

Europe Must 'Think Big'



DPA PICTURE ALLIANCE/ALAMY STOCK PHOTO

Michael Schreyögg, *head of programs at MTU Aero Engines, sat down with Aviation Week London Bureau Chief* **Tony Osborne** *and Executive Editor for Defense and Space* **Robert Wall** *to discuss everything from defense investments to future powerplant pursuits. Excerpts follow.*

AW&ST: **The defense landscape in Europe has changed significantly. Is Europe now doing enough?** The environment is very much different to some years ago. Europe needs more of everything. Our armed forces are understaffed and underequipped. We need more technology, more platforms, more weaponry. That's simply a consequence of the long-term reluctance, especially here in Germany, to invest in our defense.

This has changed since 2022. We see a dramatic move in our procurement organizations to become much faster, much more efficient, much more focused on what they really need. Now it's really much more like a partnership. But we have to do more. If you just look at the upcoming order of Eurofighters, Germany wants to buy 20 more Eurofighters. If I see the threat from the East, my feeling is not 20 Eurofighters but 200. Think big.

How do you see today's geopolitical situation impacting Europe's plans on future programs? In this world in which we are living, you can buy fighters or helicopters from Europe when you develop them and when you launch development programs. If you don't do this, then you can go to Russia, China or the U.S. to buy equipment. And the question is really a strategic and political question. Do you want to have this dependency on Russia and China? I think the answer is easy, but should we be also

more sovereign from U.S. defense equipment? What we see today with today's administration, this might be a good idea.

And then, as a last point, we need volume. To make it sustainable and a profitable business, you need volume. And this means, besides the European demand, we need to be more active in the world. We need more support from our governments in Europe to export equipment.

Exports are definitely not purely commercial business discussions; it is political. And that's something where, at least in Germany, we are lacking the political will and the organization to support exports. Europe, and also Germany, has become much more open to military export, but there needs to be more coming. We need more resources. In the UK, you have basically an export organization. In France, we have DGA [the General Directorate for Armaments]. We need something like this also on a European level, or at least on a national level, where we are really collaborating and supporting industry to make such political deals also happen at the end.

Should that be a German-focused or European organization? For me, it's always preferred if Europe can act together. But at the end, someone has to do it. I'm very impressed by the British government about how they do it in Saudi Arabia, for example; it's really a very professional organization. If we can establish this on a European level without becoming a bureaucratic monster, yes, of course. But I would be happy also if we get support from the core nations, like on Eurofighter—Italy, Spain, Germany and UK—if we get the appropriate support to sell the aircraft.

Everyone is talking about Collaborative Combat Aircraft. What is MTU's plan? I have no clue, to be honest. We just had this discussion here. It ranges from people who come to us that have a startup and say, "I need an engine to power this." However, they want this for a kamikaze drone. This is an engine class where I say, "This is not the size of engines which MTU can do in a cost-efficient manner."

Then you come up with heavier versions: the loyal wingman, which requires an engine that you would see today in a business jet, for example, and that is where it starts to get interesting for us.

The question which I always have then is: "What is the volume of this program?" To develop or modify an engine for 100 units is something that cannot be cost-effective, so I wouldn't do this. And then the heavy, intelligent loyal wingman strategy of Airbus, which requires significant thrust, could be considered.

When I take a look at what is happening in Ukraine today, I think low-cost drones of high volumes are also very effective. And then you have the question: Where do you find the place for this kind of loyal wingman?

> *"Why is Brussels not buying 20 [A400M] aircraft for their mission?"*

Or would you just say, you have more fighters than today and then also these low-cost weapon systems?

To develop a new system, I think it's an effort. It takes time. And the question is, where do you spend your money? In the end, we will follow the customers. We will not place our own product in this market segment.

You are working with Safran on the European Military Rotorcraft Engine Alliance (EURA). Why? The strategy and the thinking are simple: We have the option to sit and wait if Airbus or others will develop something or if the customers will tell us something, or we become a bit more noisy and proactive and try to create this market.

We saw this with the heavy-lift helicopter. We had a future transport helicopter and engine aircraft program in about 2010. The development cost at the time was overseeable. But nobody was launching this program. And the end of the story is that our [Sikorsky] CH-53Gs are now close to 40 years old. To get this aircraft to fly is more restoration than maintenance. And all of a sudden, our government realized that if they want to have heavy lift and comply with NATO requirements, then they need to replace these helicopters. And you had two options—the [Boeing] CH-47, which is as old as me, or you go with the CH-53K. Both are U.S. products, and nothing was available in Europe.

This was an eye-opening moment for us. So we decided we need to try to create this market demand. Let's be more proactive. Let's create a joint venture and market this idea of a next-generation helicopter, which will need a next-generation engine. We are speaking to the European helicopter manufacturers and trying together to create this demand. Because it's obvious the [Airbus] Tiger has reached now a certain age. In 2040, the [NHIndustries] NH90 will have reached a certain age. And from 2040 onward, the European nations will need a replacement in terms of helicopters. And then we are back to square one if we are not starting this now, 15 years ahead, because that's about the time frame for technology and the project development and testing and military equipment application. I hope that the airframe side will put such a proposal together.

What is the technology plan for that turbine? Hybridization will be one of the paths—lightweight materials, additive manufactured parts. And then we have to speak to the customers. Do they want the highest performance of the engine, or do they want to have a mass product, which could be a different development stream? Do they want a mass product with the lowest cost of procurement and [to] procure more systems? In the past, we always looked to the extreme side in terms of technology and performance. But if you look now at the threat, there could also be a different customer specification, going for cheaper helicopters, cheaper engines, but buying more of them.

Germany is retiring its [Eurocopter] Tiger helicopters. Do you see a need for attack helicopters in the future? I think Europe needs an attack helicopter. The question is, how much can it be a common platform with a transport helicopter? The engine should be the same. The gearbox could be the same. The cockpit could

be the same. But this is exactly the discussion where we need also the airframers, and then we need the end customer. But we are far away from a specification. But we know there's a need for rotorcraft, attack and transport, and this is what we want to address with the EURA consortium.

Industry is getting anxious about the dwindling Airbus A400M backlog and the risk of a production shutdown. When do you need customer commitments to assure the future of the line? These decisions need to be taken in 2025, and half the year is gone. What we could do is pull in orders from Spain and France, which had been pushed out in the past years. This can buy you another 12 months. And then it really comes to export orders. Why is Brussels not buying 20 aircraft for their mission? Brussels wants to become a player in defense. Europe needs to provide more airlift NATO requirements anyway. So why not buy, on a European level, 20 more aircraft, which is another two years of production? But we need to act; otherwise, Airbus is right: They need to close down. And then there is no option to open such a line again. There are 3,000 people in Seville, [Spain], and if you are not employing them, they are gone, and the experience is gone. The engine is performing very well. It's a good aircraft, so it needs to find its place in the market.

> *"You have to have a stock of spares, which we had in the Cold War, but this is an experience which we lost in the last 30 years."*

What Ukraine war lessons are you taking? We learned that a war lasts not three months, but it can be three years. You have to have a stock of spares, which we had in the Cold War, but this is an experience which we lost in the last 30 years.

We need to ramp up our capacities for maintenance. And maintenance is nothing if I don't have the spare parts on hand. I cannot go to my supplier with a lead time of six months, 12 months for the raw material, and then we have a manufacturing lead time of six months again. So this means 1 year or 1.5 years until I've got this part available. We need to have stocks available again. And this is something which is not yet implemented in the system. It needs better integrated planning, in my view, so you are not just looking at weapons, people and platforms, but also, how do you support this over a wartime of three, four or five years?

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Is Europe Leading the Way on Aviation Decarbonization?

- EUROPEAN AIRLINES SOUND THE ALARM ABOUT SAF VOLUMES
- NATIONAL INTERESTS RISK DEPRIORITIZING DECARBONIZATION



WAHAV/ALAMY STOCK PHOTO

Helen Massy-Beresford Paris

With clear targets for alternative fuel and a framework in place for monitoring the non-CO_2 effects of aviation, European legislators are keen to show the world that the region is leading the way in decarbonizing the sector. However, those concrete steps toward net zero are not immune to uncertainties and external pressures.

Through a resolution adopted at the International Air Transport Association's (IATA) annual general meeting in 2021, the global airline sector committed to achieving net-zero emissions by 2050, but the path to achieving that ambitious goal is far from simple. Even IATA Director General Willie Walsh warned earlier this year that there is likely to be a reevaluation of the target, although at IATA's annual general meeting in Delhi in June, he insisted industry still has time to meet the target, if all parts of the value chain step up their efforts.

Meanwhile, geopolitical shifts are casting a shadow on decarbonization efforts in different parts of the world, and national governments are weighing sustainability ambitions against macroeconomic and political pressures.

Sustainable aviation fuel (SAF) is a prime example. SAF is widely acknowledged as the most useful tool in aviation's decarbonization toolkit for reaching its 2050 net-zero goal, but volumes are not growing fast enough.

The global airline industry held up regulatory support by the Biden administration as a model for getting the fledgling SAF production sector off the ground, with just the right amount of carrot in incentives and not too much stick in mandates.

But SAF production announcements have declined dramatically since the climate change-skeptical Trump administration took over in January. Initiatives such as the SAF Grand Challenge and the Blenders' Tax Credit included under the 2022 Inflation Reduction Act boosted project announcements under the Biden administration, but uncertainty over funding is now the order of day—and bad news for capital-intensive projects.

While Asia's SAF industry has huge growth potential, with considerable production underway and many new facilities planned or under construction, many government mandates or targets remain in the planning stages.

While industry players find plenty to criticize in Europe's strategy for aviation decarbonization, 2025 is a year of transition and new beginnings. A new European Commission (EC) took office for its five-year mandate at the end of 2024, keen to set out broad policy objectives.

The transition coincided with two important pieces of sustainability legislation coming into effect. First and most high-profile, the ReFuelEU Aviation mandates delineating SAF requirements out to 2050 went live at the beginning of January, specifying an initial requirement for 2% of jet fuel to come from SAF.

In February, the new EC presented the Clean Industrial Deal aimed at making industry competitive as it decarbonizes. Although airlines praised the package's focus on green fuels, the sector wanted more concrete action to support its competitiveness amid

Europe's airlines have had to monitor their non-CO_2 effects since January.

decarbonization and more clarity on funding for the steep ramp-up of SAF production in the region.

That, industry hopes, will come with the presentation of the Sustainable Transport Investment Plan (STIP) due later this year.

European airlines say they are committed to decarbonization. However, at a time of heavy macroeconomic pressures and rising geopolitical tensions, they are all too aware that extra decarbonization costs may put them at a disadvantage compared with international peers. Carriers want strong support from the European Union and from their national governments.

"With global competitiveness, sustainability and strategic autonomy all at stake, the EU must act now, and it must act decisively," Airlines for Europe (A4E) said in an April position paper. "The European Commission must use the [STIP] to align Europe's decarbonization ambitions with industry realities—unlocking investments in SAF and hydrogen, enabling SAF offtake agreements while keeping air travel accessible to all and European carriers and destinations competitive."

A4E added the STIP "should deliver a level playing field not only for EU fuel producers but also for aircraft operators and must prevent business leakage to non-EU competitors."

With SAF representing 56% of aviation's decarbonization pathway, the paper continued, the "STIP must provide funding, prioritize feedstock access and support all SAF technologies equally."

In a speech to A4E members at the association's summit on March 27 in Brussels, the new European Commissioner for Sustainable Transport and Tourism Apostolos Tzitzikostas put forward the EC's vision for balancing sovereignty and regional competitiveness with decarbonization goals.

"To keep aviation strong, we must reduce our reliance on fossil fuels," Tzitzikostas said. "Because dependence makes Europe vulnerable." He added that ReFuelEU Aviation would "not only help aviation decarbonize but also strengthen its energy independence."

But at the same A4E event, airlines cast doubt on whether the mandates could be met and even warned, controversially, that they may need to be pushed back. While many see the 2025 mandate as feasible, the rise to 6% in 2030 is raising doubts. Some of the region's biggest airlines said the 2030 mandate for SAF uptake may need to shift.

"We don't have enough SAF, and the SAF we do have is very expensive," International Airlines Group (IAG) CEO Luis Gallego said. "The only realistic solution is to move the 2030 SAF mandate date to the right."

Lufthansa CEO Carsten Spohr said it was "science, but not rocket science, to say that this target is probably not realistic."

Air France-KLM CEO Ben Smith agreed: "We don't see a path toward the amount we need to reach the mandate."

ReFuelEU contains further mandates out to 2050: 20% in 2035, 34% in 2040, 42% in 2045 and 70% in 2050, as well as smaller submandates for e-fuel.

A December report by the European Union Aviation Safety Agency (EASA) highlighted another big stumbling block for airlines when it comes to SAF uptake: the price. The EASA report put the price for conventional jet fuel at €816 ($933) per metric ton in 2023, with SAF (excluding synthetic fuel) at €2,768 per metric ton and synthetic SAF at €7,500, which is an estimate because synthetic fuels were not available in the market.

So far, no details of the STIP have been released. "We expect some measures in order to increase the SAF production in order to comply with these mandates," Gallego said. He also called for an expansion of SAF allowances as part of the European Emissions Trading System (ETS) and their extension beyond 2030 to provide long-term certainty.

"I recognize that public intervention is necessary to drive the adoption," Tzitzikostas said. "More effort and investment are needed to scale up e-SAF, which is a key part of our ambition."

Europe is also a trailblazer in another area of sustainability legislation that could have a big effect on aviation's environmental impact. Since Jan. 1, airlines have been required to monitor their non-CO_2 emissions through the monitoring, reporting and verification requirement that is part of European ETS regulation. Airlines' data on non-CO_2 effects should provide the basis to define potential changes to the region's aviation climate legislation in 2027.

Researchers, politicians and industry want to see more momentum in the non-CO_2 space.

"Avoiding contrails is an unprecedented opportunity for aviation to reduce its climate impact in a much shorter time frame than for CO_2 emissions," French Parliament member Christine Arrighi said May 22 at a conference she organized with climate nongovernmental organization Transport & Environment at the French National Assembly.

Arrighi's Haute-Garonne constituency in southwest France includes Toulouse, where Airbus is headquartered.

"European regulation is absolutely fundamental on this subject," said Jérôme du Boucher, T&E's head of aviation for France.

Du Boucher urged more action on contrails without delay. "We are at the precise moment where there is enough scientific certainty to move from research into practice," he said. "That does not mean there are no more uncertainties and we can stop research. It means that we know that contrails have a climate-warming impact of the same order of magnitude as CO_2 emissions and that avoiding contrails is a promising method of action with an interesting potential to reduce this impact."

The conference participants also highlighted the importance of action at a national level. Du Boucher pointed to rapid contrail research advancements in the UK and Germany. Arrighi noted that healthy competition among European member states could help drive progress on contrail avoidance.

"There is a diplomatic issue at stake vis-a-vis our European neighbors," du Boucher said. "We need to show that France is also in the race. It's possible that the UK or Germany wants to be the first country avoiding contrails on a grand scale. We need to be aware of what that would mean for the reputation of our players."

While overarching European targets set the tone for the region's climate efforts, airlines facing varying tax regimes and SAF requirements know that national pressures risk diverting governments from the broad goals.

Renewable energy is vital to large-scale production of e-SAF, which is key to boosting SAF volumes beyond what biomass-based fuel can offer. However, in Germany, heavy dependence on energy imports pits meeting renewable energy targets against increasing energy independence at an acceptable price.

It is not just about SAF. Member states' inability to agree on Single European Sky airspace reforms that go far enough to improve efficiency, saving fuel burn and emissions, is another stumbling block for European sustainability efforts.

While the long-awaited reforms took a step forward in 2024, the region's airspace remains fragmented, depriving airlines in Europe of the opportunity to cut emissions in a straightforward way by flying more efficient routes.

Member states are not aligned on aviation taxation, either. After Sweden abolished an air-ticket tax at the beginning of this year, France introduced a new, higher one within a matter of weeks.

European lawmakers face a dilemma as they strive to lead the world in aviation decarbonization while juggling their own national challenges and airlines' calls to protect their competitiveness.

Europe's SAF and e-SAF Mandates

	Percentage of SAF Used in Air Transport	Submandate for Synthetic/e-Fuel
2025	2%	—
2030	6%	0.7%
2032	6%	1.2%
2035	20%	5%
2040	34%	10%
2045	42%	15%
2050	70%	35%

Source: European Union Aviation Safety Agency

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> ELECTRIC AVIATION ASPIRANTS LOOK TO REGIONAL AIR MOBILITY AS A MORE VIABLE OPTION

Ben Goldstein Boston

Europe may have lost its pole position in the race to develop and certify electric vertical-takeoff-and-landing air taxis, but electric aviation aspirants continue to push forward with more conventional tube-and-wing designs.

It was not long ago that Europe was considered a world leader in the advanced air mobility (AAM) scene. The European Union Aviation Safety Agency (EASA) was the world's first civil aviation regulator to craft rules for electric vertical-takeoff-and-landing (eVTOL) operations when it issued its Special Condition for VTOL rule set in 2019. The German market in particular showed tremendous promise, with Volocopter seeking to be the first Western startup to certify with its two-seat VoloCity, and Lilium aiming to follow in its footsteps with the six-passenger Lilium Jet.

Now, following the collapse of Lilium and the sale of Volocopter to China's Wanfeng Group for pennies on the dollar, UK startup Vertical Aerospace appears to be the sole remaining credible air taxi startup in Europe. And considering Vertical Aerospace's persistent financial struggles, some industry-watchers see such U.S. companies as Archer and Joby Aviation as poised to dominate Europe's AAM market, raising the specter that the continent's domestic manufacturers will be shut out of their own air taxi market.

Recriminations have swirled among proponents of AAM in Europe following the collapse of Lilium and sale of Volocopter. Some suggest the venture capital market in Europe is far too risk-averse to support the cash-intensive, highly speculative air taxi industry. Others critique the region as overregulated, observing that EASA had set the design assurance level for eVTOL to 10^{-9}, or one catastrophic failure in 1 billion flight hours, while the FAA adopted a flexible, performance-based standard.

Some commentators also note that Europe has less need for urban air mobility (UAM), given its far more developed ground transport and public transit networks compared with the U.S.

"These [eVTOLs] are so expensive that I don't think Europe has the wherewithal in their market to support them," says Sergio Cecutta, founder and partner with SMG Consulting. "There's always been more appetite for risk in the U.S. when it comes to funding startup companies. You could say the U.S. takes a glass-half-full mentality, and the Europeans are glass-half-empty. . . . But the other thing is that the business case for urban air mobility is tougher in Europe for the simple reason that they have a lot more transportation options than the U.S."

Vaeridion is developing a nine-passenger electric aircraft called the Microliner.

Robin Riedel, an analyst at McKinsey who specializes in AAM, echoes those sentiments. "Europe is tough," he says. "The environment here [in the U.S.]—getting the right engineers, getting the mindset to build new things, getting the funding, getting the government support—is just stronger than it is in Europe."

Despite the turmoil, European industry has hardly budged from its efforts at electrifying aviation, even if it may have backed away from the eVTOL race. A host of startups developing runway-based, electric conventional-takeoff-and-landing (eCTOL) aircraft say they can target a more viable mission set than the eVTOL-makers—and at a fraction of the price.

These include Vaeridion, a German startup developing a nine-passenger electric regional aircraft called the Microliner; Aura Aero, a French company developing a family of hybrid electric aircraft, beginning with a two-seat trainer; Germany's Maeve, developing a hybrid airliner in the 80-seat class (page 90); and Elfly, a Norwegian company developing a nine-passenger electric seaplane, among many others. Heart Aerospace, formerly of Sweden, was Europe's best-funded eCTOL startup, but the company defected to the U.S. this year, in part for the more advanced technology and venture capital ecosystem.

While the U.S. industry is most excited about UAM, these European aspirants are instead targeting regional air mobility (RAM). Phrased differently, they see a major opportunity to connect underserved airfields with point-to-point routes using smaller

electric aircraft with lower operating costs, revitalizing markets and routes that were not commercially viable with conventionally powered aviation.

Europe's RAM momentum appears to be boosted by a confluence of factors, such as political schemes to disincentivize conventional aviation, a greater familiarity with small turboprops and a cultural aversion to long-distance driving compared with the U.S.

"Regional air mobility seems to have more traction in Europe than urban air mobility and even more traction in Europe than in the U.S.," Cecutta says. "And more and more, these companies are becoming practical. Now they are talking about rightsizing a specific route or reopening a route that existed before. . . . It's becoming more about developing a replacement for existing aircraft that really don't do their job well today—and that's something with a lot of appeal."

Other European startups are continuing to pursue eVTOLs, such as Ascendance and VoltAero in France, Sirius Aviation in Switzerland, and Lyte Aviation and Sora Aviation in the UK. But these cash-strapped companies will face an uphill climb in raising the estimated $1-2 billion needed to certify an eVTOL, according to SMG Consulting.

To be sure, even the eCTOL hopefuls will struggle to raise the cash for certification. SMG Consulting estimates that certifying an eCTOL would cost around $350 million for a nine-passenger aircraft and $700 million for 19 passengers—dwarfing the relatively meager sums that the upstarts have raised to date.



VOLOCOPTER

China's Wanfeng Group acquired Volocopter for just €10 million ($11.4 million).

Despite the downbeat mood among industry-watchers, Europe's handful of surviving eVTOL players insists plans remain firmly on track. Even Volocopter, under its new ownership as a private company, says it still intends to certify the VoloCity, although its target has been pushed back to 2026.

The paucity of credible eVTOL startups also means regulators, such as the UK Civil Aviation Authority and EASA, should have plenty of available bandwidth to devote to type certification efforts, Vertical Aerospace CEO Stuart Simpson says.

He also notes that Vertical has been able to hire more than 100 engineers from Lilium, Volocopter and other defunct European startups.

"We're really the last man standing," Simpson says. "We were the only focus in the UK; we now have the only focus in Europe, as well. That's a good thing. The regulators in Europe have the capacity, knowledge and a massive desire to certify these aircraft. That desire is still there, and we're capitalizing on it."



'We Need To Expand'

Embraer CEO **Francisco Gomes Neto** *arranged time for an Aviation Week interview on the sidelines of the International Air Transport Association Annual General Assembly in New Delhi. He brought team members* **Arjen Meijer**, *CEO of Embraer Commercial Aviation, and* **Raul Villaron**, *head of Embraer's Asia-Pacific business, to the meeting with Executive Editor for Commercial Aviation* **Jens Flottau**.



Arjen Meijer

Raul Villaron



MATEUS BONOMI/AGIF/SIPA USA/ALAMY STOCK PHOTO

AW&ST: **We are doing this interview in India, one of the markets on which you are putting a lot of hopes. What are your concrete plans?** **Gomes Neto:** We just opened a subsidiary. We will have government relations, communications, procurement, engineering, sales and marketing for defense and commercial as well. We have 50 aircraft operating in India. In defense, we are participating in the MTA [Medium Transport Aircraft] program, which is an opportunity for between 40 and 80 [C-390] aircraft. We are really working very hard on that program. We also expect to increase our business and commercial jet sales. In the short term, the opportunities are in defense, but we also see them in commercial and business jets. We believe it will be a good market for our eVTOLs [electric vertical-takeoff-and-landing aircraft].

Isn't a lot of the opportunity gone in commercial, given that IndiGo and Air India are going into a lot of secondary markets with narrowbodies? **Villaron:** Traditionally, the market was always addressed by large narrowbodies and turboprops. IndiGo is a good case. It is now growing more into [Airbus] A321s, which increases the gap to the turboprops. There was always a gap for something in the middle that could reach longer distances. It was difficult for Embraer to penetrate that market over the years because we did not have a product that delivered the seat cost needed for India. Here, the yields are very low, so to really enter the market you need the right product. While the E1 [series] really had good trip costs, it did not deliver the seat costs. Now we have the E2. We see an opportunity for around 300 aircraft. We just need someone to grab it and we are talking to the different airlines.

Strategically, you seem to target establishing another big base outside of Brazil. **Gomes Neto:** Absolutely. Our aircraft already are very international. Our commercial jets are assembled in Brazil, but we buy the wings in Portugal, we buy parts in Poland, a lot of equipment in the U.S. The same for the C-390. But yes, with the opportunities ahead, we need to expand our production capacity, and we want to connect that with new business opportunities.

Poland is a good example. We are talking to them in terms of partnerships. If we win business there in commercial and defense, we can do a lot more things with them. We can use Poland as a hub to increase production of the C-390 and the E2 to supply the European market.

India is another example. As part of the MTA requirement, we need to make at least 50% locally, and we are now working on that plan.

But how many of these projects can you do in parallel? Gomes Neto: For assembly, we won't have many facilities, and it all depends on the volume. We have to invest more in production, and we don't want to do that in Brazil. We want to connect that investment with strategic partnerships.

Do you see any weakening of demand because of the slowdown in the world economy? Meijer: We don't see that yet. Globally, there is still more demand. Airlines are getting more concerned about their available capacity between now and the early 2030s, and where that will come from. The Embraer segment is actually protected even in downturns.

Villaron: There is a fundamental change in the market, which is inflation, and that has a huge impact on low-cost carriers. The paradigm of [having a single type] fleet for [low-cost carriers] is being challenged. How can they make money and grow if a huge part of the market is being eaten up by inflation? A flexible fleet brings a lot of value. We are seeing a segment open up for our aircraft that we have never really been able to penetrate.

Meijer: In the past, the thinking was a lot about complexity, but now people see that 25% lower trip costs give you a lot of operational benefits and yield upside.

And risks are spread with more than one type. Meijer: The point you are making, we hear that from more and more CEOs. Ten years ago, it was all about simplicity and cost. Now it is about putting your eggs in different baskets and resilience against potential risks.

How deep is the impact of the Azul bankruptcy on Embraer? They have 52 more E2s on order. Meijer: This is very fresh. They have been very vocal about new technology and the E2 being the backbone of their fleet. We have to wait to see what the impact is going to be. We have aircraft going directly to Azul, but we also have a delivery stream through the leasing arm. The direct orders are further out, we may have to slide a little bit, but they have time to get through Chapter 11 before we have that discussion.

Is the supply chain still such a big worry or is it getting better? Gomes Neto: We do see improvements. Our first-quarter deliveries were almost 30% higher than last year, more concentrated on business jets. It shows that we are getting parts that we need earlier. We are implementing an initiative we call production leveling, and we could see the first results in the first quarter. We are still struggling with some parts and a few suppliers, but we expect to have a strong second and third quarter and not such a high concentration in the fourth quarter. And next year, we expect to see the first quarter already stronger, with more linearity.

> *"We had a fantastic 2024.... We are rated at investment grade by the three agencies."*

How do you view the impact of tariffs? Gomes Neto: This tariff issue is bringing complexity and costs. The aviation industry has not been used to this in 45 years. We now have to calculate, understand the rules and how they work, how we can mitigate the tariffs. We have people working on that and I'm sure our suppliers are doing the same. We see some impact for this year, but believe we can mitigate it.

Embraer has always been more cautious with regard to hydrogen and electric propulsion. Seeing the delays that have been announced, do you feel your schedule is still right? Gomes Neto: At Embraer, we are focusing a lot on electric propulsion and eVTOLs. We have almost 1,000 people working on that project. We expect to enter into service at the end of 2027. The next step could be hybrid-electric. Hydrogen is more into the future. We are working to certify 100% of our products for SAF [sustainable aviation fuel] for 2030.

Meijer: We have talked about Energia, [the company's project to explore sustainable designs to carry up to 50 passengers] and at some point people were seeing Embraer as being a little bit conservative on the timeline. I think now we may be a little bit too progressive. I like the Embraer statement that we have been sharing with the market, which is that the mission drives the architecture. We keep our work on Energia going, and it is taking longer than everyone was hoping five years ago.

Gomes Neto: The strongest focus is on the eVTOLs.

A while ago, you said you could decide on a new commercial, defense or business jet project in 2026. Today, you are not saying that anymore. What happened? Gomes Neto: Our main focus now is to sell the products that we have. But we are studying what could be the next step for Embraer. The teams are making studies—the marketing team, the engineering team—on executive jets, commercial jets and military variants. We try to understand technology development, we invest a lot in fuselage and cockpit technology and so on, to be prepared to decide which way to go.

Meijer: There are a lot of variables to be looked at. You picked it up well that we mentioned 2026, but we need a bit more time. We really believe there is a huge opportunity and shifting momentum on the E2. Historically, we have had several challenges with the Boeing merger and then COVID-19. The commercial aviation market is now seeing what the E2 can contribute.

Gomes Neto: We had a fantastic 2024: [earnings before interest and taxes] above $700 million. We are rated at investment grade by the three agencies, our net debt is close to zero, and we generated $600 million in cash. Financially speaking, we are stronger than ever. We have a plan for the next years. We are focusing a lot on efficiency, so

profitability should improve and we should create more cash with the products that we have. In parallel with these studies, we are ensuring that we have more financial muscle.

Is there a new timeline? Gomes Neto: We don't have a timeline defined because it will not only depend on us, but also on technology development. We don't want to go with a product that will become obsolete in 10 years. Our situation is not different from that of the other manufacturers.

What technologies do you mean? Gomes Neto: Engines are one of them. In the case of executive jets, which we are studying as well, it is not only the engines. We need a product that is faster and more comfortable.

You are studying a variety of new defense products. Has any one become more concrete? Gomes Neto: We recently signed the partnership with the Portuguese and Brazilian air forces for a new variant of the KC-390. We are also working on a midlife upgrade of the Super Tucano for the Brazilian Air Force. We continue to sell the C-390. The product is new. It is getting traction in many different countries—Europe, Asia, India, U.S. It is a big opportunity for Embraer to grow in that segment.

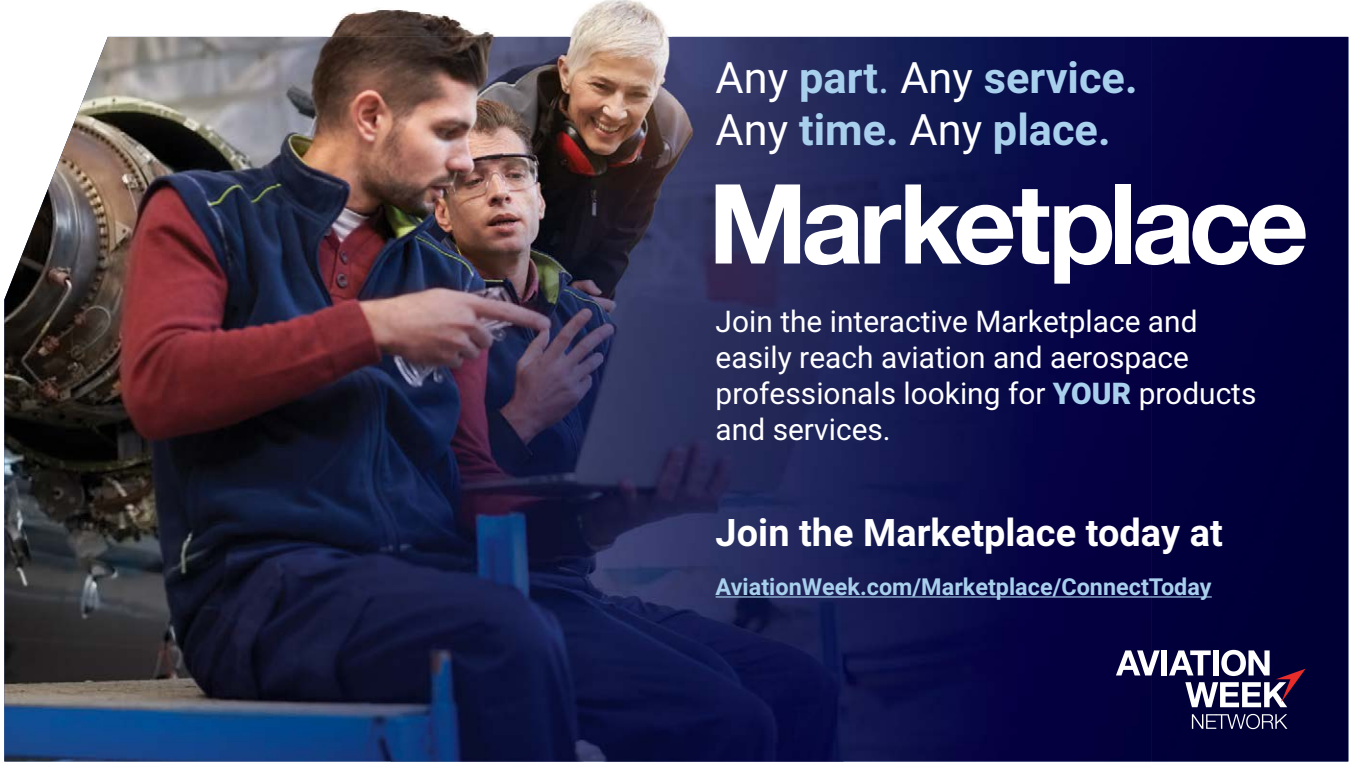
Do you really believe you can sell it in the U.S.? Gomes Neto: Yes, we do. We know it is difficult, but we had a really nice and interesting tour there—Las Vegas; Tampa, [Florida]; Washington. We have increased our workforce in the country and that it is a product that will be assembled in the U.S. We really believe that this product will revolutionize the productivity of the U.S. Air Force, starting with the tanker, but also for other missions.

Are you comfortable with really only having two products in the defense business? Gomes Neto: We have more products. In India, all the air traffic management was supplied by Embraer. Implementation happened in 2019. In Brazil, the same. Its Army surveillance system is also provided by Embraer. We are supplying the system that controls the platforms of the Brazilian Navy frigates. We have other products in defense; they are not as big as the KC-390.

Are your hopes to sell the C-390 to Saudi Arabia still alive? Gomes Neto: Yes, we are still working with them, with Saudi Arabia and many other countries. The decision will not come quickly, but we are in contact with them.

For all of these new projects, you would need partners, be it defense or commercial. Gomes Neto: Absolutely. We have what we call the One Embraer approach, which is interesting for some countries because they can connect business opportunities with development of the local aerospace industry.

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REGIONAL REDEFINED

> MAEVE REPOSITIONS HYBRID-ELECTRIC MJ500 AS RJ REPLACEMENT

> AIRCRAFT WAS REDESIGNED AROUND OPEN-ROTOR/STATOR ENGINES



The MJ500 is designed to carry 76-100 passengers 1,000 nm at Mach 0.75 and 35,000 ft.

MAEVE AEROSPACE IMAGES

Graham Warwick Washington

Much of the motivation behind electric aviation startups is the belief that lower operating costs, and therefore fares, will unlock pent-up demand for regional connectivity using aircraft that are within reach of today's battery and fuel cell technology. But first the companies have to convince airlines.

Feedback from those prospective customers has led Dutch startup Maeve Aerospace to redesign its planned hybrid-electric aircraft to match more closely the characteristics of the regional jets (RJ) it is intended to replace, while still promising a 30-40% reduction in fuel burn.

Delft-based Maeve has been assisted in its rebranding by Mitsubishi Heavy Industries RJ Aviation (MHI RJ), which acquired the legacy CRJ program from Bombardier in 2019. Under an agreement announced in November, Maeve is paying MHI RJ to provide engineering and marketing services.

The result of that collaboration is the newly unveiled Maeve Jet Series 500 (MJ500), a CRJ-inspired 76-100-seat aircraft with five-abreast seating and hybrid-electric propulsion. Gone are the propellers mounted regional-turboprop-style on a high wing that marked Maeve's previous concept, the 80-seat M80. The MJ500 has a low-set swept wing and aft-mounted open-rotor/stator propulsors.

When configured as a 76-seater to comply with U.S. pilot scope clause limits, the MJ500 is designed to fly 1,200 nm, cruising at Mach 0.75 and 35,000 ft. while burning 30-40% less fuel than the CRJs and Embraer ERJs and E175-E1s it is designed to replace. Operating cost is reduced by about 20%.

This is the third redesign for Maeve, which was founded in September 2020 to develop a 44-seat all-electric regional airliner with a range of up to 300 nm. In December 2023, the start-up switched to a hybrid-electric 80-seater, and Pratt & Whitney Canada joined the program in July 2024 to supply the powertrain.

"Optimization of the aircraft configuration is driven by customer feedback," Maeve Chief Technology Officer Martin Nüsseler says, explaining the latest design changes. "We are not changing the proposition of a high-economic-value regional aircraft, but we received two key pieces of feedback."

One concerned internal noise and customer perception that passengers do not want to see propellers next to the cabin. The second concerned aircraft productivity and the need to match the cruise speed of today's RJs. Together they necessitated a change in propulsion architecture.

The engine is unchanged, but the propulsor is new. "We still have this advanced thermal hybrid engine from Pratt, which gives us a unique efficiency at altitude versus normal turbine engines," Nüsseler says. "In combination with a new propulsor, we have a step change in overall engine performance."

Maeve needed to replace the M80's propellers with something smaller in diameter to enable rear-fuselage mounting to remove noise from the cabin. "This is not possible with a normal propeller because the diameter is too big," he says. "The installation challenges are too high."

Instead, Maeve is planning to develop an unducted propulsor with a rotor swirl recovery system, similar to the open fan that CFM International is developing under the Revolutionary Innovation for Sustainable Engines (RISE) program. "And rear-mounting the engine was driving opportunities to improve the aircraft configuration," Nüsseler says. "We changed from a high-wing to a low-wing configuration, which is a natural effect.

"We have this open-rotor and stator combination, similar to the RISE concept from CFM but with a much better engine behind it," he continues. "Typically, the rear-engine configuration gives you a weight challenge because

you have a longer pylon. We compensate for this with the clean wing."

The MJ500 has a parallel hybrid configuration, with both the advanced thermal-cycle engine and an electric motor driving into the propulsor gearbox. "It's a mild hybrid because batteries are not born to fly," Nüsseler says.

The aircraft is optimized for performance at altitude. "This is why we are flying at Flight Level 350 like a jet," he notes. "We have an engine with the power of four PW150s at altitude, but on the ground, we do not have more power [than Pratt & Whitney's big turboprop]. Takeoff power from the thermal engine is 5,000 shp, and at altitude it's nearly the same—it's 4,800 shp."

The electric motor provides 300 kW (400 hp) to the gearbox, which can be used to boost power for takeoff if required by field performance. "We are optimizing the thermal engine completely for cruise, and the remaining gap for takeoff and initial climb performance we are covering with hybridization by the electric motor," Nüsseler explains.

"We can with full payload start at a 4,900-ft. runway, and the engine does not have the typical thermal stress with a higher power setting," he notes.

The thermal engine runs at constant output, and power is set with the electric motor. "We don't have an impact on the ground infrastructure at airports because the batteries will be charged during cruise flight," he says.

Six battery modules are housed under the floor, behind the avionics bay, in a fire compartment separating them from the cargo. "The batteries are not huge," Nüsseler says. "And we're targeting a life of 1,800-2,000 cycles for one year of operation. The minimum target is to exchange the batteries during yearly maintenance."

The level of hybridization is limited to providing takeoff boost and powering the aircraft's 800-volt more electric systems. "We are not taking bleed," Nüsseler says. "We have an electric environment control system, no auxiliary power unit, and we have electric anti-icing. This combination of hybridization to boost takeoff with a more electric aircraft gives us an overall system benefit and also a weight benefit versus just implementing a more electric system in a traditional aircraft architecture."

Maeve took the opportunity of the redesign to reconsider the cabin. "There was clear feedback to future-proof the platform for the coming decades," he says. "This needs a wider, five-abreast cabin because four-abreast is too squeezed for the passenger."

Passengers do not like the change when moving between a regional and a narrowbody. Neither do the airlines. "Today, everybody is coming into the cabin with a trolley, and only a five-abreast cabin with the same size bins provides room to reduce the increasing lead times for boarding," Nüsseler says.

A five-abreast cabin also provides more space for below-floor cargo. "The wetted area is not significantly increased with the five-abreast," he says. "With four-abreast, you are pushed to a double bubble to give you room for underfloor cargo and the right cabin height."

With a completely circular five-abreast cross-section, the lower weight penalty for pressurization offsets the drag penalty from increased wetted area, Nüsseler says. The wider fuselage also results in a shorter aircraft, which is better for weight and balance with rear-mounted engines.



Smaller-diameter propulsors allow engines to be relocated to the rear.

Key to the redesign was producing a single aircraft that can seat 76 in a three-class configuration, 90 in two classes and in a 100 single class. "The aircraft will be able to achieve the weights required by U.S. scope clauses," says Ross Mitchell, MHI RJ senior vice president for strategy and business development. "It will be able to make 76 seats and 86,000 lb. We also believe the aircraft we're designing will be able to meet 50 seats and 65,000 lb., the weight limit for small regional jets with a CRJ550-type interior."

Maeve is primarily targeting the replacement market for the U.S. fleet of scope-compliant CRJ550s, -700s and -900s, ERJs and E175-E1s. "With the 76-seat configuration, we can fly 1,200-1,500 nm," he says. "For the 100-seater, it's more like 900 nm. We are not targeting a 2,500-nm range because we think it's not necessary. What is the benefit of it? Because with longer range, you increase the aircraft weight.

"The design target is around a 1,000-nm range, which gives us a lighter aircraft," Mitchell continues. "We can go down to 50 seats and still maintain the scope-clause requirements. This gives high flexibility to the MJ500 family and a big opportunity for customers to have one aircraft and reduce the diversity of their fleets."

Beyond the U.S., Nüsseler says the MJ500 will be more economical than flying Airbus A220s and Embraer E2s when their longer range is not required. "Five-abreast gives you this narrowbody feeling, and what we are doing is stretchable to 150 seats," he says.

Maeve and Montreal-based MHI RJ are in the concept design phase, which is planned to be completed by early next year. "We will then start the preliminary design phase," Nüsseler says. "PDR [preliminary design review] will be from the end of 2026 to mid-2027. We will fly at the end of 2029. Entry into service is targeted for the end of 2032, beginning of 2033."

As a startup, Maeve does not expect to take the MJ500 to production on its own, but to assemble a consortium of industry partners. "It is important to demonstrate the customer acceptance and concept robustness, that we have a business case," he says. "The plan is to take the aircraft to PDR, then someone takes over." Supported by initial investors, Maeve aims to tap public grants and loans to reach PDR.

"The reason MHI RJ is helping us is to ensure we have a consortium to take over the program," Nüsseler adds. "Such a program cannot be financed by a startup. We only can complete the predesign and make sure the main supply chain is complete. We are starting those discussions now."

Critical Minerals Are Front and Center in Trump Administration Agenda

> WHITE HOUSE TARGETS DOMESTIC CAPABILITIES

> MINERALS AGREEMENTS HAVE BEEN SIGNED WITH UKRAINE, SAUDI ARABIA AND THE UAE

Matthew Fulco Washington

In its first 120 days, the second administration of U.S. President Donald Trump has fast-tracked efforts to strengthen critical mineral supply chains on which the aerospace and defense industry relies, but China continues to dominate.

Beijing has weaponized that dominance—60% of global production and 85% of processing—to gain leverage in what it sees as a long-term techno-industrial competition with the U.S. that will outlast the current trade war. China has curbed exports of least 16 minerals to the U.S., including a ban on shipments of gallium, germanium and antimony.

The flurry of actions by the Trump administration—from executive orders to boost domestic production to ambitious bilateral deals with allies—underscores Washington's sense of vulnerability about a paramount node of its defense industrial base. Virginia-based defense acquisition software company Govini estimates that China's export controls affect more than 1,000 Pentagon weapon systems and more than 20,000 individual parts.

If China does not ease recent critical mineral export restrictions, "a risk factor for U.S. defense is the impact on production schedules in 2025-26," Capital Alpha Partners Managing Director Byron Callan wrote in a May 27 client note. The U.S. has no domestic suppliers for 12 of the 50 metals considered critical and is more than 50% reliant on imports for 29 others, according to the Paris-based International Energy Agency, an intergovernmental organization.

"President Trump is committed to ending American dependence on hostile foreign powers for critical minerals," a March 20 White House executive order states.

The Trump administration launched a Section 232 investigation—used to determine the effect of imports on national security—in April that is expected to result in recommendations to boost domestic mineral production and reduce import dependency. Yet, out of necessity, the White House is also searching the globe for new mineral suppliers.

"'America First' does not mean 'America Alone,'" Treasury Secretary Scott Bessent said at an Institute of International Finance event in Washington on April 23. "To the contrary—it is a call for deeper collaboration and mutual respect among trade partners."

In the following three weeks, the U.S. signed mineral deals with Ukraine, the United Arab Emirates (UAE) and Saudi Arabia. All three countries are important markets for the U.S. defense sector.

Mahnaz Khan, vice president of policy for critical supply chains at the Silverado Policy Accelerator, tells Aviation Week that "this administration has been very intentional" in its approach to strategic metals. "Attacking on both fronts [domestic and international] makes sense if enough investors are interested," Khan adds.

Saudi Arabia aspires to become a global mineral hub. The Saudi government estimates its mineral reserves are valued at $2.5 trillion. Washington and Riyadh signed two mineral agreements during Trump's trip to the kingdom in May,

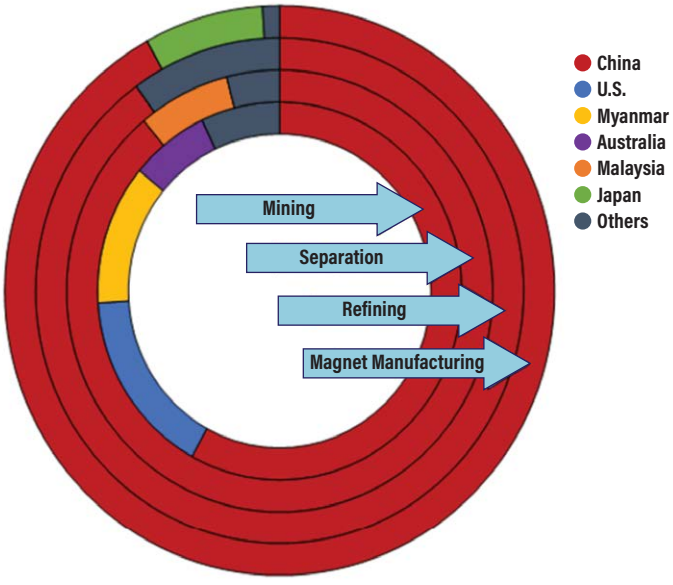
Critical Minerals Used in the F-35 Fighter



Source: NATO Science and Technology Organization

VDWI AVIATION/ALAMY STOCK PHOTO

Geographic Concentration of Supply Chain Stages for Neodymium Magnets



Source: U.S. Energy Department

including a memorandum of cooperation aimed at creating a framework for secure mineral supply chains.

Additionally, Nevada-based MP Materials, which owns and operates the U.S. only large-scale rare-earth production source—the Mountain Pass mine in California—signed a memorandum of understanding with Saudi state-owned mining company Maaden. The agreement stipulates that the two companies create a complete rare-earth supply chain in Saudi Arabia encompassing mining, separation, refining and magnet production.

Lockheed Martin F-35 Lightning II aircraft, General Atomics Predator drones and Raytheon Tomahawk missiles all use permanent magnets made with rare-earth elements.

"We need American champions domestically, but we also have to compete abroad and help develop projects abroad in ways that align with America's national and strategic interest," Matt Sloustcher, MP Materials' executive vice president of corporate affairs, tells Aviation Week. With a large industrial base for chemical processing, "you see the right sort of pieces in the Middle East" to build new mineral supply chains, he says.

To that end, RTX announced in May plans to produce gallium in the UAE with Emirates Global Aluminum and Tawazun Council, the defense and security acquisitions authority for the UAE Armed Forces and Abu Dhabi Police. The agreement "puts us on a path toward a reliable supply of gallium, needed for production of critical aerospace and defense solutions," Paolo Dal Cin, senior vice president for operations and supply chain at RTX, said in a statement.

Gallium-nitride semiconductors—which outperform silicon chips in speed, power handling and resistance to extreme temperatures—are used in a wide array of military radars and systems. These include Raytheon's Patriot, GhostEye and SPY-6 as well as Lockheed Martin's TPY-2, the primary radar in the Terminal High-Altitude Area Defense system.

The RTX initiative aims eventually to produce enough gallium to make the UAE the world's No. 2 supplier of the metal. "With China so completely dominant, the bar for second place is low," Cory Combs, head of critical minerals and supply chain research at the consultancy Trivium, tells Aviation Week. "The real challenge for becoming No. 2 is the willingness to put up the necessary capital for an investment with questionable [return-on-investment] prospects."

With vast wealth derived from oil and gas reserves, the UAE has sufficient capital. And unlike private investors, "it has the potential to sway demand through industrial policy and by strategically slotting outputs into other assets it is seeking to build up," Combs says.

Analysts are more circumspect about the U.S.-Ukraine mineral agreement, which establishes a joint investment fund for the reconstruction of the country devastated by Russia's full-scale invasion. Ukraine has sizable deposits of titanium, uranium and graphite as well as the rare earths neodymium and yttrium.

The Center for Strategic and International Studies (CSIS) sees the deal as a positive step for U.S.-Ukraine relations but cautioned that its effectiveness will depend on enduring peace and stable investment conditions. About 19% of Ukraine's main critical mineral deposits are in Russian-occupied territory, according to the Institute for the Study of War.

"I don't know many exploration geologists that would elect to do fieldwork under wartime conditions," says Mark Smith, CEO of Nebraska-based critical mineral project owner NioCorp.

Smith adds that "a great deal of work remains to quantify what's actually in the ground," from mineralization types and resource size to ore grade and infrastructure support.

Sometimes the Trump administration's trade policies conflict with its mineral security objectives. Canada is a case in point. The U.S. imported $47 billion in minerals from the country in 2023, considerably more than the $28.3 billion it purchased from its No. 2 supplier, China. Yet the administration's 25% duties on aluminum and steel imports will cost Canada $7.5 billion annually, according to Columbia University's Center on Global Energy Policy.

Australia, another close American ally and key mineral producer, faces a 10% baseline tariff. The International Monetary Fund estimates the levies and their ripple effects will cost the Australian economy $13 billion this year.

A multilateral supply chain could complement bilateral deals and domestic capabilities that are growing but remain limited. While the U.S. has abundant natural resources, it has few operational mines. The CSIS estimates that globally, it takes 18 years to develop a mine—and $500 million to $1 billion to build both the mine and separation plant.

"To my mind, it's Canada and Australia on minerals, and add Japan and South Korea for [upstream] intermediate goods," Combs says. "That's in terms of resources, tangible assets and production capacity."

The Silverado Policy Accelerator has proposed a mineral trade policy framework, MinSec, as a road map for securing vital resources with trusted partners and breaking China's tightening grip on global supply chains. "China is going to continue using rare earths and other critical minerals as a bargaining chip—it is a pervasive pattern now," Khan says.

She recommends that the U.S. continue investing in domestic mineral capabilities while increasing cooperation with trusted partners, "many who are in the same boat we are." Khan notes: "We have to do both because we are 40 years behind China in mining and processing."

TECH TAKE

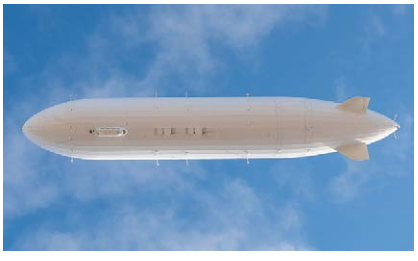
By **Graham Warwick**

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Pathfinder 1 Large Airship Ventures Out

LTA Research's Pathfinder 1 large rigid airship has conducted its first test flight away from its base at NASA Ames Research Center in Mountain View, California.

LTA RESEARCH



LTA's Pathfinder 1 large rigid airship flew over San Francisco Bay on May 15.

The 407-ft.-long, helium-filled, piloted hybrid-electric airship completed the 11.5-nm flight over San Francisco Bay on May 15, reaching an altitude of 1,125 ft. and a top speed of 18 kt., according to a LinkedIn post by LTA, which is funded by Google co-founder Sergey Brin.

Built in Hangar 2, leased by Google from NASA Ames, the proof-of-concept airship began outdoor tethered testing in October 2023 and made its first untethered flight over Moffett Field in October 2024.

The flight over San Francisco Bay focused on evaluating the performance of the Pathfinder 1's lidar helium level sensor and thrust-vectoring propulsion system.

The airship has generators and batteries that power 12 electrically driven propellers that can swivel through 180 deg. between vertical and forward flight. Controlled from the crewed gondola via a fly-by-wire system, the thrusters and four fin rudders provide flight control.

The lidar system tracks helium levels in 13 gas cells inside the airship envelope. To ensure helium is retained, an air ventilation control system manages internal pressure and temperature. When pressure builds inside the airship, air escapes through vents, reentering when pressure drops.

Mixed-Reality Simulator Wins EASA Approval

Switzerland's Brunner Electronik has received the first European Union Aviation Safety Agency (EASA) qualification for a mixed-reality flight simulation training device. Deployed by Lufthansa Aviation Training and qualified as a flight and navigation procedures trainer, the device replicates the Diamond DA42.

The simulator uses a Varjo VR-4 Focus Edition virtual reality headset to provide a mixed-reality (MR) training experience in which the trainee is provided with an immersive, photorealistic out-the-window visual environment while still being able to use the physical controls in the cockpit.

Switzerland's Loft Dynamics has already received EASA qualification for virtual reality (VR) helicopter training devices, in which both the out-the-window view and the cockpit are presented virtually on the headset.



Brunner's mixed-reality training device combines a virtual-reality headset with physical cockpit controls.

"The key difference is that this is the first-ever mixed-reality simulator qualified to EASA standards, whereas Loft Dynamics' systems are based on virtual reality with the Varjo Aero headset," Finland-based Varjo says.

"In a mixed-reality setup, pilots can see and interact with their actual physical cockpit and controls with their own real hands while immersed in a high-fidelity virtual environment," the company says. "While VR devices are extremely valuable and serve a purpose well, this hybrid approach provides greater realism and, while not backed by research yet, we believe better training outcomes."

While MR devices are widely used in military training, this marks the first time that MR-based training has been formally recognized for civil flight hours in Europe. The level of immersion and visual precision of the headset was critical in meeting the standards required for EASA qualification under special conditions, Varjo says.

Piasecki Develops Damage-Tolerant Flight Control

Piasecki Aircraft has selected Germany's Volz Servos to supply redundant electromagnetic actuators for a program to demonstrate damage-tolerant flight controls for autonomous rotorcraft.

Volz will supply actuators for the Adaptive Digital Automated Pilotage Technology (Adapt) program, under which Piasecki is modifying an EDM Aerotec CoAx 2D ultralight helicopter to flight-demonstrate an advanced automated flight-control system.

Launched in 2016 in response to a U.S. Joint Aircraft Survivability Program Office study documenting high rotorcraft losses in Afghanistan and Iraq in 2001-13, the U.S. Army-funded Adapt program is intended to reduce mishap rates through intelligent flight control and autonomy.

Adapt's core capabilities—including return-to-base, leader-follower and safe landing area determination—enable aircraft to continue flying after suffering significant damage or pilot incapacitation, Piasecki says. The system automatically optimizes control allocation, lift and thrust to improve survivability and enhance maneuverability across a range of mission profiles.

Volz's actuators provide dual-channel redundancy and feature an electromagnetic clutch for manual override. "Volz's actuators provide the perfect mix of capability, reliability and redundancy needed for our optionally piloted aircraft," says Chris DiMarco, Piasecki's Adapt program manager.

Adapt already has demonstrated fly-to-optimal maneuvering, vehicle maneuvering optimization and damage-tolerant control in simulations. Piasecki also is flying two subscale testbeds, one representing the Bell V-280 tiltrotor, which will be used to test the flight-control software.

Damage-tolerant control automatically reallocates effector functions to enable continued safe flight in degraded mode or to conduct an emergency land-

ing with a higher probability of survival. Fly-to-optimal maneuvering automatically selects the optimal combinations of control effectors to maximize performance based on a selected objective. Vehicle maneuvering optimization maximizes performance and minimizes exceedance limits by automatically selecting the optimum combination of control effector settings.

EDM AEROTEC



Piasecki's Adapt damage-tolerant flight controls will be flight-tested in a CoAx 2D ultralight helicopter.

The CoAX 2D is scheduled for flight testing this year, Piasecki says, followed by continued development of advanced autonomy features to further expand safety and flexibility. "Our work not only supports military applications but also lays the foundation for next-gen commercial rotorcraft," DiMarco says.

Sodium Fuel Cell Could Transform Electric Aviation

Researchers at the Massachusetts Institute of Technology (MIT) have developed a new type of fuel cell that promises to cross the 1,000-Wh/kg energy density threshold for viable electric regional aviation.

In a typical fuel cell, hydrogen and oxygen flow on either side of a membrane that enables an electrochemical reaction that produces electricity, with water and heat as the byproducts.

In the new device, the fuel is liquid sodium metal, which is inexpensive and widely available. The other side of the cell is air. In between is a layer of solid ceramic electrolyte that allows sodium ions to pass through and a porous air-facing electrode that helps the sodium react with oxygen and produce electricity.

In experiments with prototype devices, MIT researchers say they achieved more than three times the 300-Wh/kg energy density typical of current lithium-ion batteries. "The threshold you need for realistic electric aviation is about 1,000 Wh/kg," says team member Yet-Ming Chiang, a professor of materials science and engineering.

While similar in concept to a metal-air battery, the device can be refueled quickly rather than recharged. Lithium-air and sodium-air batteries have proved difficult to make fully rechargeable because the discharge products are solid, but in a fuel cell, the energy-carrying materials flow in and out of the device, making it more practical.

In tests of two different small-scale prototype cells, using an air stream with a carefully controlled humidity level produced an energy density of more than 1,500 Wh/kg at the individual stack level, which translates to more than 1,000 Wh/kg at the full system level, Chiang says.

In an aircraft, fuel packs containing stacks of cells would be inserted into the fuel cells. The sodium metal inside those packs is chemically transformed as they generate electricity. A stream of chemical byproduct would be emitted, but there would be no CO_2 emissions.

Instead, a cascade of reactions would help remove CO_2 from the atmosphere. The cells would emit sodium oxide, which would quickly combine with moisture in the air to make sodium hydroxide. This readily combines with CO_2 in the atmosphere to form a solid material, sodium bicarbonate. If that final byproduct ends up in the ocean, MIT says, it would help deacidify the water.



The Massachusetts Institute of Technology's liquid-sodium fuel cell promises an energy density of more than 1,000 Wh/kg.

The envisaged power system would use a refillable cartridge, which would be filled with liquid sodium metal and sealed. After depletion, the cartridge would be returned to a refilling station and loaded with fresh sodium. Sodium melts at 98C (208F), making it easy to refuel the cartridges, the team says.

Members of the research team have formed a startup, Propel Aero, to develop the technology. The initial plan is to produce a brick-size fuel cell that can deliver enough energy to power a large drone in order to prove the concept. The team is aiming for a flight demonstration within a year.

Moya Expands Cargo eVTOL Family

Brazilian startup Moya Aero is to develop a second, larger uncrewed cargo aircraft as it adopts a platform strategy intended to improve modularity and scalability in aerial logistics.



MOYA AERO

Both of Moya's uncrewed cargo aircraft share the same tandem-wing tilt-body eVTOL configuration.

The 30-kg-payload (66-lb.) Moya 256 now in flight testing is being joined by the 190-kg-payload Moya 760, a prototype of which is under development. Both aircraft share an all-electric tilt-body eVTOL architecture. The family of tandem-wing uncrewed cargo aircraft is planned to enter service in 2027.

With a span of 5.2 m (17.1 ft.) and length of 3.5 m, the Moya 256 is designed to carry its 30-kg payload 160 km (100 mi.) at a cruise speed of 130 kph (81 mph). The larger Moya 760, at 5.1 m long with a span of 7.4 m, is designed to fly faster and farther, carrying its 190-kg payload 190 km at 160 kph.

Ground software, battery modules and flight systems are common to both aircraft. A family of vehicles provides fleet interoperability and simpler maintenance as well as enabling quicker deployments across different environments, Moya says.

"By creating a family of drones that share common features, we enable our customers to scale their operations without incurring additional costs or needing extensive training," Moya CEO Alexandre Zaramela says.

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Sept. 9-10—AeroEngines Europe. Hamburg, Germany.

Sept. 9-10—CAPA Airline Leader Summit – Latin America & Caribbean. Lima, Peru.

Sept. 16-18—MRO Asia-Pacific. Singapore.

Sept. 24-26—Routes World. Hong Kong.

Oct. 14-16—MRO Europe. London.

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A Different Paris Air Show



"The Americans are playing a strong technical game across the whole aerospace spectrum, and the Europeans are going to have to streamline their management, organize their resources better and cut through the national bureaucracy if they are to have any hope of keeping up the pace," Aviation Week's editor-in-chief wrote from the Paris Air Show—50 years ago.



YURIKO NAKAO/GETTY IMAGES

The 1975 show was an acrimonious affair, with American pilots chafing over stringent flying rules imposed by the French government. The "hit of the show" was the F-16 prototype, built by General Dynamics, proclaimed Aviation Week. Serge Dassault, the air show's commissioner general, countered that the prototype was not a true combat aircraft, like the Dassault Mirage F1E, but merely "an aircraft only for an air show."

A half-century on, there is still plenty of transatlantic sniping as we head into Le Bourget. But today the stakes are much higher. The Trump administration's skepticism toward defending Ukraine and its ambiguity about the NATO alliance have raised the question of whether Europe can still count on Washington to defend the continent against Russian aggression. This year's air show is going to feel different.

As Aviation Week's data analysts recently calculated, Europe is on pace to outspend the U.S. in the procurement of military equipment for the first time since World War II. After years of missing NATO spending targets, most European members have fallen in line. And a number of collaborative projects could help Europe achieve military independence from the U.S. if they come to fruition, including a tactical airlifter, next-generation rotorcraft, air-to-air missiles and hypersonic interceptors (*AW&ST* June 2-15, p. 45).

However, a robust defense industrial base cannot be created overnight after years of underinvestment, which means a European military buildup will offer plenty of opportunities for U.S. contractors at the air show. The continent still relies heavily on North America for military aircraft, C4ISR platforms and other equipment. Witness all those Lockheed Martin F-35 fighter sales, which no doubt irritate Dassault as much as the F-16 once did.

There is an argument to be made that, 80 years after the end of World War II, it is time for Europe to stand on its own feet. We are once again in a bipolar world, except that the old Soviet Union has been replaced by a technically ascendent China. Talk of the U.S. needing to pivot its military focus to the Asia-Pacific goes back to the Obama administration, around the time that many European leaders were turning a blind eye to Russian President Vladimir Putin's land grab of Ukraine's Crimea region.

But it would be incredibly foolish for the U.S. to throw away its alliance with Europe, which has been a reliable strategic and economic partner for longer than most of us have been alive. America's security umbrella has given Washington sway over the nature of the transatlantic relationship. The two sides historically have shared common commitments to democracy, stability and the rule of law, and their economies—especially in aerospace—are intertwined.

Aviation Week guest columnist Richard Aboulafia opines that concerns about the upcoming NATO summit on June 24-25 and U.S. President Donald Trump's threat to impose 50% tariffs on EU imports next month will cast a cloud over this year's air show (page 10). But with NATO now raising military spending targets to levels on par with the U.S., perhaps it is time for U.S. Vice President JD Vance to tone down his anti-European rhetoric. The military spending for which his boss has long called is finally starting to flow.

—Joe Anselmo, editor-in-chief and editorial director

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