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AVIATION WEEK

& SPACE TECHNOLOGY



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C-390 MILLENNIUM

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MISSION-READY WITH THE PORTUGUESE AIR FORCE

We're delighted to announce the Portuguese Air Force now joins the Brazilian Air Force as a C-390 Millennium operator. Two aircraft are already in service with 506 Squadron, located at Beja Air Base, with three more aircraft to be added in the future. A growing number of countries are choosing the C-390 Millennium (including Hungary, Netherlands, Austria, Czech Republic and South Korea) attracted by its unbeatable combination of technology, speed, performance and multi-mission capabilities. Hungary will take delivery of their first C-390 Millennium in 2024 – another milestone for an incredible aircraft that has already achieved 10,000 flight hours with the Brazilian Air Force.

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DEPARTMENTS

- 5 | Editors' Letter 12 | Airline Intel
- 6 | Feedback 13 | The Launchpad
- 7 | Who's Where 62-63 | Tech Take
- 8-9 | First Take 64 | Marketplace
- 10 | Up Front 65 | Contact Us
- 11 | Leading Edge 65 | Aviation Week Events

FEATURES

- 14 | Compromising Redundancy**
Jamming and spoofing events involving commercial aircraft triple in three years as conflicts grow
- 16 | Chasing Air Dominance**
Silicon Valley startup Anduril hopes to land the Collaborative Combat Aircraft market
- 32 | Small Change**
The U.S. Space Force takes the Rocket Systems Launch Program back to its customer-funded roots
- 42 | Weather Woes**
Recent disruptions spur airline tech upgrades and collaboration to improve delay mitigation
- 52 | United in Opposition**
Pilot groups are stepping up their campaign against reduced-crew and single-pilot concepts
- 58 | On Hold**
The U.S. Air Force's NGAD uncertainty pressures adaptive engine-makers to "adapt"

DEFENSE

- 17 | Scaled Composites' multirole Model 437 enters flight testing**
- 19 | Barracuda seeks a bite of the low-cost cruise missile market**
- 20 | U.S. Air Force is considering a V-22 airworthiness overhaul**
- 22 | U.S. Navy aviation goals are competing against budget realities**
- 24 | Tokyo invests in more missiles amid regional security concerns**
- 25 | Leonardo remains only bidder for UK medium helicopter program**
- 26 | Poland primes new round of defense procurements**

SPACE

- 28 | Star-crossed Starliner flight test comes to a close**



48

Volocopter recently flew the 2X prototype in Versailles, outside Paris.

- 30 | Startups push to introduce metal propellants for spacecraft**
- 31 | Boeing to test quantum entanglement-swapping on satellite**
- MILITARY SPACE**
- 34 | Pentagon's marquee LEO constellation prepares to go operational**
- 36 | U.S. Space Development Agency preps for critical tech demos**
- COMMERCIAL AVIATION**
- 38 | Pursuing change, Southwest shareholders spur board refresh**
- 39 | U.S. flight attendant contract negotiations push for improvements**
- 40 | Europe's airlines fear new border system will cause delays**
- 41 | Boom Supersonic demonstrates XB-1 flight control fixes**
- 45 | Malaysia Airlines tackles operational headaches and trims frequencies**
- 46 | Aura Aero's hybrid-electric aircraft design effort is in full swing**
- ADVANCED AIR MOBILITY**
- 48 | Departing Volocopter CEO Hoke: VoloCity to be certified in early 2025**
- SUSTAINABILITY**
- 50 | Carriers delve into contrail-avoidance practicalities**
- AUTONOMY**
- 54 | How a small USAF unit will shape the service's autonomy goals**
- ROTORCRAFT**
- 56 | Robinson adds hydrogen-powered helos to its innovative ventures**
- PROPULSION**
- 60 | China is stepping up its adaptive combat engine research**
- VIEWPOINT**
- 66 | How Russia will continue to shape Western defense**

ON THE COVER

Anduril Industries has unveiled the first prototype of the jet-powered Fury, a new breed of armed and autonomous Collaborative Combat Aircraft funded by the U.S. Air Force's Next-Generation Air Dominance program. Our report by Defense Editor Steve Trimble begins on page 16. Anduril photo.

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FROM THE EDITORS

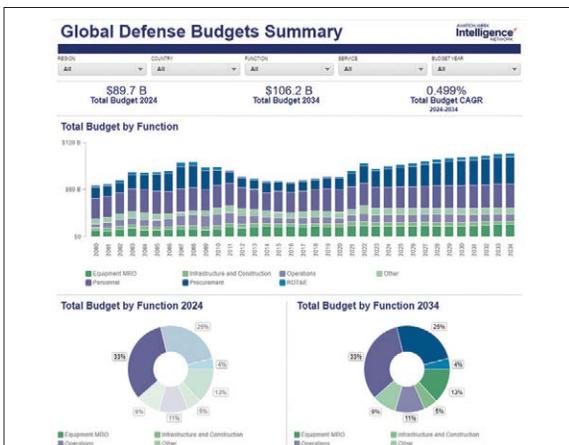
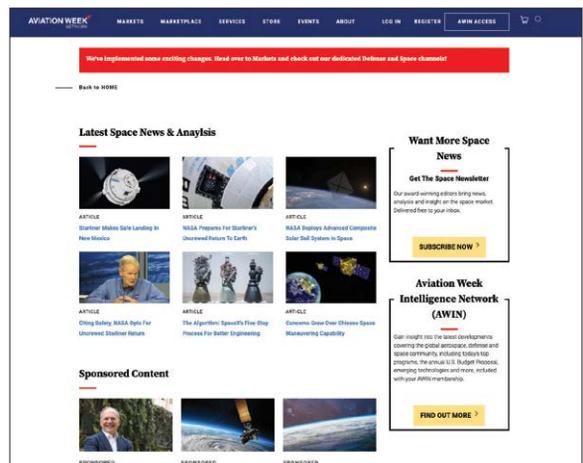
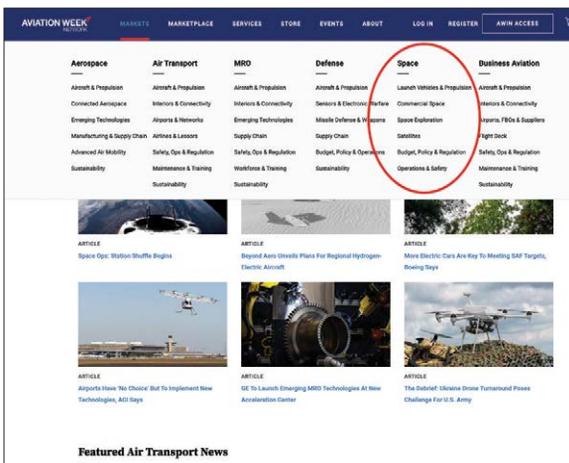
Expanding Our Horizons

Aviation Week Network has long been committed to delivering integrated intelligence to connect defense and space professionals worldwide. The execution of this vision has exceeded expectations by enhancing and combining timely insight with the critical linkages between policies, programs, operations and procurement, all within a framework of technology development.

Aviation Week Network continues to deliver on this promise with sustained investment in our people,

to bolster our team of reporters and data and analytics specialists.

In May, we hired Vivienne Machi as our military space editor to provide fuller coverage of the huge investments the U.S. military and others are making into this field. This adds to the work of Senior Space Editor Irene Klotz and Space and Emerging Technologies Editor Garrett Reim, allowing us to provide even more comprehensive coverage of the new space economy. We also hired veteran aerospace journalist



channels and community—and with recent enhancements to our defense and space portfolio. We wanted to share with you what is driving some of these exciting enhancements and what more you can expect from our award-winning content team.

To keep pace with the robust increases in defense spending globally and the boom in commercial space activity, from launch services to on-orbit data gathering, Aviation Week Network has invested significantly

Robert Wall as our Executive Editor for Defense and Space, based in London, to help guide this expansion.

As we bulk up our content channels with more business intelligence and data, we have increased the frequency of our Defense Digest and Space Digest newsletters. You will also notice a new dedicated Space channel alongside our Defense channel on both the Aviation Week Intelligence Network (AWIN) and AviationWeek.com, designed for you to access the most current news in both sectors more easily.

In our market intelligence and data portfolio, we have launched the Defense Market Analyzer to complement our expanded defense and space coverage, fleet data and forecasting models. This new service supports informed decision-making and helps navigate the intricate defense landscape by identifying the key political, economic, budgetary and strategic trends shaping and driving the global defense and space markets.

We are working on many more exciting developments in both defense and space to serve you better. For now, we hope you enjoy the enhanced space and defense content and remain an engaged participant in the Aviation Week Network. 🌐

—Joe Anselmo, Editor-in-Chief

Robert Wall, Executive Editor for Defense & Space

SKINS AND SNIPERS

Among the various upgrades discussed for the Lockheed Martin F-22 Raptor in “Raptor Reprise” (*July 29-Aug. 11, p. 18*), I was surprised that nothing was mentioned regarding increasing fleet availability by reducing flight costs. Probably the biggest move toward doing so would be to replace the radar-absorbent materials. It would be easiest to use the same materials as found on Lockheed’s F-35 Lightning II, although the new ceramic-based materials and/or mirror-like materials that have been spotted on some test aircraft would also work.

But if the Raptors will be outfitted with stealth pod-based infrared search and track systems, why not do the same with something like the Sniper ground targeting pod? I’m no expert, but at the very least it would seem pretty easy to just take the existing system and put it into a new stealthy pod to allow the Raptor to have greater ground pounding capability. My understanding is that the main reason Lockheed’s F-117 Nighthawk was deployed to the Middle East in 2016 was due to the Raptor’s lack of ability to engage moving targets. A pod like this would have made this unnecessary. Or better yet, make a podded version of the F-35’s electro-optical targeting system and distributed aperture system to allow targeting of both airborne and surface targets at the same time.

Other upgrades I would like to see implemented include: gallium-nitride-based radars such as the APG-85, F-35-style head-down displays (both for reduced maintenance costs and increased pilot capability), multidimensional fluidic thrust vectoring, a Northrop YF-23-style V-tail (to help lower maintenance costs and increase stealth and agility/maneuverability), F-35-style wingtip hardpoints to allow the stealthy external carriage of air-to-air missiles and quite possibly Chengdu J-20-style side weapon bay doors that open, extend the launch rail, close and then allow the missile to launch. Not to mention adding an open architecture system and separate mission and flight control computer systems to ease upgrades. If the Raptor is going to soldier on in light of the Next-Generation Air Dominance delays, some if not all of these upgrades will be needed.

Jacob Katz, Norfolk, Virginia

BEHIND THE SCENES

Aviation Week was invited to present an update on sustainability research and technology underway in China and the Asia-Pacific region at the 34th Congress of the International Council of the Aeronautical Sciences in Florence, Italy. Senior Editor **Guy Norris** (right) delivered the address on Sept. 9.



RICH WAHLS



U.S. CHAMBER OF COMMERCE

A fireside chat between Aviation Week Network’s *Air Transport World* Editor-in-Chief **Karen Walker** (left) and FAA Administrator **Michael G. Whitaker** kicked off the U.S. Chamber of Commerce’s 2024 Global Aerospace Summit on Sept. 10 in Washington. Whitaker assumed the FAA helm last October and is leading the agency through challenging times.

SPACESUIT STANDARDS

The misadventure of Boeing’s Starliner (*“Coming Home Crewless,” Sept. 2-15, p. 13*) shows the importance of standardization in astronauts’ spacesuits, at the least. Having to await a second suit for a return to Earth in a SpaceX vessel is inconvenient at best. It will also leave no spare suit at the International Space Station (ISS).

In the future, spacesuits will need adapters pre-staged aboard the ISS so that suits may be used in alternate vehicles if necessary. SpaceX seems to have set the standard other allied space travelers must meet. As of now, that is the U.S., Russia and a distant China. That standardization should include docking ports. Until standards for all spacesuits and orbital stations are set, the situation remains needlessly perilous.

Peter J. Peirano, Ridgewood, New Jersey

Space Editor Irene Klotz replies: Under the terms of NASA’s Commercial Crew Program partnership agreements,

SpaceX and Boeing are responsible for designing, developing and operating the Crew Dragon and the CST-100 Starliner, respectively, including the pressure suits astronauts wear for launch and reentry.

FOLLOW THE MONEY

It is well past time for you to publish at least year-by-year the money that the Boeing C-suite has taken home since the move to Chicago. Including a breakdown for the CEO and chief financial officer would be revealing and instructive.

John C. Bauer, Manotick, Ontario

CORRECTIONS

“Taking Charge” (*Sept. 2-15, p. 60*) should have identified the energy density of lithium iron phosphate batteries as 160 kWh/kg.

“MagniX Unveils Hybrid Testbed” (*Sept. 2-15, p. 70*) should have identified the pack-level energy density of the MagniX Samson battery system as 300 kWh/kg.

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

Jason Kim has been named CEO of space transportation startup *Firefly Aerospace*, effective Oct. 1. He succeeds Bill Weber, who has left the company. Kim was CEO of Boeing-owned satellite manufacturer Millennium Space Systems and before that held roles at Raytheon and Northrop Grumman.



Wheels Up has promoted **Eric Cabezas** to interim chief financial officer and appointed **Matthew Knopf** chief legal officer and secretary, succeeding Todd Smith and Laura Heltebran, respectively, who have left the company. Cabezas was senior vice president of finance, with a past stint as interim chief financial officer in the spring of 2022. Knopf was senior vice president and deputy general counsel at Delta Air Lines.

Clay Mowry has been appointed CEO of the *American Institute of Aeronautics and Astronautics*, effective Oct. 1, succeeding Dan Dumbacher. He remains president of the International Astronautical Federation and was chief revenue officer at Voyager Space. Before that, he held executive roles at Blue Origin and the U.S. subsidiary of Arianespace.



Avion Express Brasil, a subsidiary of Avia Solutions Group, has named **Esteban Jauregui Lorda** CEO. He was fleet director at Colombian carrier Avianca and before that worked at GOL and Aerolíneas Argentinas.

Vivek Upadhyaya has been appointed chief financial officer at *Defcon AI*, an artificial intelligence-based software developer serving military clients, bringing deep experience in financial management. He was chief financial officer and vice president of mission systems at defense electronics developer Mercury Systems. Before that, he held executive positions at Leonardo Electronics US, Northrop Grumman and Orbital ATK, among others.



Lufthansa Technik (LHT) has announced changes to senior manage-

ment. **Michael Kirstein** has become vice president of the Transformation Office, overseeing the Ambition 2030 growth program. In the engine services segment, **Derrick Siebert** has been promoted to vice president of operations from vice president of commercial and **Georg Fanta** to vice president of commercial from vice president of aircraft component services. **Berit Plewinsky** has been promoted to succeed Fanta; she was senior director of product sales and fulfillment for single events and closed loop for Europe, the Middle East and Africa (EMEA). **Tim-Oliver Fedeler** has been promoted to managing director of component services and senior director of product sales and fulfillment for the Asia-Pacific region from head of digital innovation in the component segment. **Jens Michel** has been promoted to vice president of sales for Northeast Asia from head of legal affairs for EMEA and **Fabian Nagel** to vice president of sales for VIP and special aircraft services from senior director of procurement for engines and airframe.

Mike Gallagher has joined *Palantir Technologies* as head of the defense unit, succeeding founding head Doug Philippone, who remains at the company as an advisor. Gallagher was the Republican U.S. representative from Wisconsin's eighth congressional district from 2017 until his resignation in April.



Alexander Sixt has become managing director of *Lufthansa Technik Intercoat*, a joint venture with Intercon Holding. He was head of the global competence center for warehouse and aircraft maintenance solutions at LHT Logistik.

Lufthansa Technik Component Services has named **Thomas Illner** managing director and head of the Americas region. He was CEO of LHT subsidiary BizJet.

Global Jet Capital has hired **Tom Kacin** as vice president of sales for the Northeast and Midwest U.S. He brings

a strong background in market-facing sales, most recently at Webster Capital Finance, and before that worked at



Citibank and Terex Financial Services. **Glenn Farnar** has joined the *Metropolitan Nashville Airport Authority* as a board commissioner, serving out the rest of

Bill Freeman's term after Freeman retired. Farnar is the longtime business manager and secretary-treasurer of the Southeast Laborers' District Council, which represents workers in the Laborers' International Union of North America for the U.S. Southeast.

Mike Suffredini is transitioning to the board of directors at *Axiom Space* from his position as CEO, with fellow company co-founder and Executive Chairman **Kam Ghaffarian** taking over as interim CEO. Suffredini had a long career with NASA, including as program manager at the International Space Station. Ghaffarian has founded and co-founded numerous companies in the space sector and emerging technology field, including IBX, X-energy, Intuitive Machines and Quantum Space.

The *Corporate Angel Network*, a nonprofit that provides cancer patients free transport on business aircraft to receive treatment, has appointed **Michael Amalfitano** to its board of directors. He is president and CEO of Embraer Executive Jets and has held positions at Stonebriar Commercial Finance, Bank of America Merrill Lynch and GE Capital.

HONORS & ELECTIONS

The National Aviation Hall of Fame has awarded the *Congressional Leadership Award* to Reps. **Rick Larsen** (D-Wash.) and **Mike Turner** (R-Ohio) in recognition of their work advancing aerospace and aviation industry initiatives. Larsen is the ranking member of House Transportation and Infrastructure Committee, while Turner's congressional district includes Dayton, of which he was mayor from 1994 to 2002. ☼

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.

FIRST TAKE

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HEART AEROSPACE

COMMERCIAL AVIATION

Swedish hybrid-electric regional aircraft startup Heart Aerospace unveiled its X1 full-scale demonstrator Sept. 12 and plans to fly the electric-only aircraft in second-quarter 2025 in the U.S.

Machinist union members at Boeing planned to vote Sept. 12 on a tentative four-year agreement that, if approved, would keep new commercial airplane production in the Pacific Northwest.

Responding to pressure from activist investor Elliot Investment Management, Southwest Airlines Executive Chairman Gary Kelly is among seven board members retiring to make way for new leadership (page 38).

Malaysia Airlines found a defect in fuel hoses on an Airbus A350-900, a variant not covered by a Sept. 5 emergency airworthiness directive requiring checks on Rolls-Royce Trent XWB-97s powering A350-1000s.

With deliveries still lagging 2019 levels, Airbus must hand over more than 320 aircraft in the last three months of 2024 to reach its target of around 770 for the full year.

Low-cost carrier EasyJet has joined Alaska Airlines in a planned 12-airline customer focus group to be established by blended wing body aircraft developer JetZero.

PT Dirgantara Indonesia has agreed to the sale of five N219 turboprop aircraft to the Democratic Republic of the Congo. If firmed up, the order would constitute the 19-seater's first major export.

Russian government-backed lessor GTLK has committed to ordering 238 airliners from state-owned United Air-

craft Corp., including 132 Sukhoi SJ-100 regional jets, 65 Ilyushin Il-114-300 turboprops and 41 Tupolev Tu-214 narrowbodies.

Russia's import-free Yakovlev MC-21 narrowbody airliner variant cannot operate at its design range due to heavier locally made components and may need shortening to restore performance.

KLM cautiously welcomed a revised noise reduction plan for Amsterdam Airport Schiphol submitted by the Netherlands government that calls for a less drastic cut in aircraft movements.

GE Aerospace unit Aerospace Carbon Solutions has acquired Satavia, a UK-based company specializing in preventing the formation of contrails by using flight plan changes.

DEFENSE

The U.S. Navy has reaffirmed L3Harris' award for the Next-Generation Jammer-Low Band system following a series of protests, giving the company a \$587 million development contract.

U.S. startup Anduril Industries unveiled the Barracuda family of cruise missiles, aiming to undercut competitors Lockheed Martin and Raytheon with promises of lower prices (page 19).

A U.S. Air Force report investigating the November 2023 fatal crash of a Bell Boeing CV-22B recommends the service obtain airworthiness authority for the tiltrotor, now the responsibility of the U.S. Navy (page 20).

Airbus and Lockheed Martin have pulled the plugs on their efforts to supply the UK Defense Ministry with a new fleet of medium rotorcraft, leaving Leonardo as the sole bidder (page 25).

The Indian government has approved the purchase of 240 locally assembled Saturn AI-31FP engines to power its Sukhoi Su-30MKI fighters.

Piasecki conducted the first tethered hover flights of the Ares tilt-duct vertical-takeoff-and-landing uncrewed aircraft on Sept. 6 in Essington, Pennsylvania (page 11).

VIEW FROM WASHINGTON

FAA Head: No Reduced Crew

FAA leadership has no intention of changing the agency's longstanding position that reduced crew operations will not be permitted in any update to rules mandating two pilots on the flight deck during all routine flight operations, Administrator Michael G. Whitaker says. "It's the law of the land, and I intend for it to stay the law of the land," he said at the Air Line Pilots Association, International (ALPA) Safety Forum Sept. 11.

The FAA's position contrasts with that of the European Union Aviation Safety Agency (EASA), which is studying two concepts in response to requests from Airbus and Dassault (page 52). In late 2023, EASA issued a rulemaking task on extended minimum crew operations, which would permit one pilot at the controls during "noncritical" segments of cruise. EASA has received at least one formal application from an OEM to approve the concept.

That work, beginning this year, could pave the way for a pilot to sleep without being relieved by a reserve pilot—seemingly a cost-saving opportunity for airlines. Some regulators allow one crewmember to take a short rest on the flight deck while the other acts as pilot flying. The FAA is not among them.

The work in Europe prompted ALPA to unite in opposition with two other pilot groups, the European Cockpit Association and International Federation of Air Line Pilots' Associations.

The U.S. has seized a Dassault Falcon 900EX business jet used by Venezuelan leader Nicolas Maduro, alleging it was delivered in violation of U.S. export controls and sanctions.

TECHNOLOGY

Volocopter CEO Dirk Hoke will leave the company in February 2025. Chairman Stefan Klocke is stepping down and being replaced by Dieter Zetsche, former CEO of Daimler-Benz (page 48).

Germany's Bavarian state government has approved a €50 million (\$55 million) loan guarantee for Lilium that is expected to rise to €100 million as the federal government has pledged to match the aid package (page 48).

UK regional airline Loganair plans to collaborate with Swedish startup Heart Aerospace to develop use cases for its ES-30 hybrid-electric regional aircraft.



SPACE

The Polaris Dawn mission on a SpaceX Crew Dragon conducted the first spacewalk by private citizens on Sept. 12 after breaking the record for the most distant Earth-orbiting crewed spacecraft.

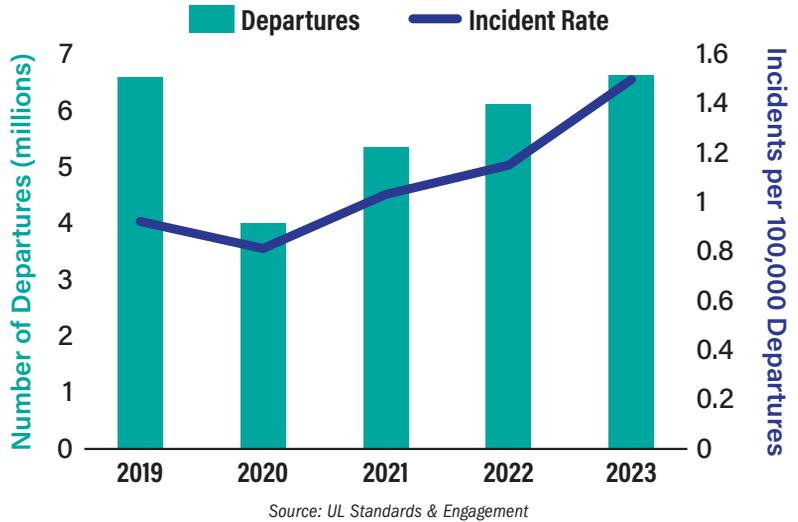
NASA has pulled two small Mars probes from the first launch of Blue Origin's New Glenn rocket over concerns that the booster would not be ready for the Oct. 13-21 launch window (page 13).

Chinese private startup LandSpace on Sept. 11 completed a vertical-takeoff-and-landing test of its ZQ-3 reusable rocket testbed, including a midflight engine reignition.

China's mysterious reusable spacecraft returned to Earth on Sept. 6 after 268 days in orbit, with a total of about 545 days spent in space over three missions.

Boeing's CST-100 Starliner spacecraft returned to Earth without its crew on Sept. 6 after an extended three-month stay at the International Space Station caused by propulsion system safety concerns (page 28). 🌐

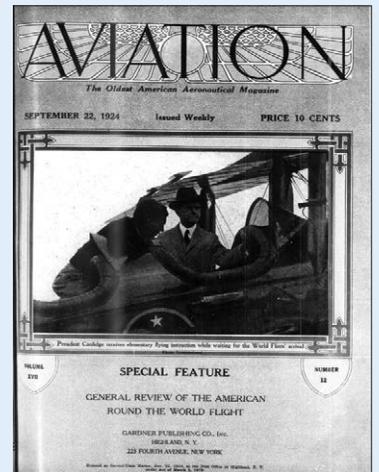
On the Rise: Lithium-Ion Battery Incidents Onboard Aircraft



Thermal runaway incidents involving lithium-ion batteries in personal devices on aircraft increased 28% from 2019 to 2023, a report by nonprofit UL Standards & Engagement says. E-cigarettes accounted for 35% of incidents in 2023, followed by power banks at 16%. The report recommends improved passenger education, flight crew training and standards for baggage handling.

100 YEARS AGO IN AVIATION WEEK

Nearly three years before Charles Lindbergh flew solo across the Atlantic Ocean, the cover of our Sept. 22, 1924, edition showed then-U.S. President Calvin Coolidge being briefed as he awaited the return of the first “around-the-world” flights. Organized by the U.S. Army Air Service, the sensational endeavor sent four single-engine Douglas World Cruiser biplanes westward from Seattle. One crashed in the Alaskan wilderness—its two crewmen rescued 10 days later—but the others reached Tokyo after a grueling 47-day trip. “The spanning of the Pacific, which had never before been accomplished, was perhaps the most difficult part of the flight,” Aviation Week reported. “At times great gales blew, which held the fliers up for weeks at a time.” From Japan the fliers skimmed the coastline of Southeast Asia, crossed India and Turkey into Europe, and then flew from London to Boston on a circuitous route via Iceland and Greenland. An oil-pressure failure over the freezing North Atlantic took out a second biplane, but weary crews of the last two aircraft landed before a huge crowd in Boston on Sept. 6. The approximately 22,000-mi.



flight took about 300 flying hours but required 153 days, thanks to impassable weather that grounded the airplanes for long periods. After a victory tour across the U.S., the fliers finally arrived back in Seattle on Sept. 28 to complete their groundbreaking mission.

Subscribers can access every issue of Aviation Week back to 1916 at: archive.aviationweek.com

UP FRONT

KEVIN MICHAELS



BOEING'S LONG-OVERDUE LEADERSHIP transition to Kelly Ortberg as the new CEO provides the rare opportunity to take a fresh look at its business portfolio and organization. The new leadership team has a long to-do list, including exiting noncore businesses, improving its deteriorating balance sheet and increasing its responsiveness and accountability. Phasing out Boeing Global Services—one of the three major business units reporting to the corporate CEO—would contribute to all these goals.

Boeing Global Services (BGS) was created in 2016 by then-CEO Dennis Muilenberg with the goal of tripling Boeing's services revenue to \$50 billion from \$15 billion. Following in the footsteps of companies such as IBM and GE, it sought to diversify beyond manufacturing and strengthen its services. A separate services business would place a greater emphasis on the value of its aftermarket products and services, which were too often bartered away to win fleet campaigns. The new BGS business took over myriad services and aftermarket activities—military sustainment contracts, parts distribution, modifications, training, digital services and its lucrative proprietary parts—the most profitable part of Boeing. In 2023, it earned \$3.3 billion on more than \$19 billion in revenue.

With these results, why phase out BGS? Recent history has shown that Boeing needs to return to its core work of developing and producing world-class aircraft. Boeing is not a services company and generally does not create value when stretching beyond its core—especially when providing services for non-Boeing aircraft. Its 2006 acquisition of Aviall, the largest independent parts distributor at the time, is a prime example. Known as BDI today, it is losing market share to more nimble competitors. The same argument can be made for Boeing's acquisition of KLX (now called BDSI), an independent inbound logistics supplier to manufacturers, or ForeFlight, a flight-planning software supplier to business and general aviation pilots.

Some of these activities are not accretive to shareholders. Parts distribution, for example, typically has a mid-to-high-single-digit profit margin. Adding BGS' considerable overhead (it has some 20 vice presidents and associated staff) means that distributing other OEMs' parts is not creating shareholder value. In full disclosure, I am a board member at Proponent, a distributor and competitor to BDI. Boeing also misstepped

in the belief it could offer cost-per-hour maintenance and logistics services for its commercial aircraft; after many years of investment under a team of 600, it abandoned the money-losing initiative. It learned a similar lesson with aircraft financing and so recently closed Boeing Capital, whose activities were absorbed into the Commercial Airplanes unit.

A second argument for eliminating BGS is business focus. Every minute its leadership is not focused on fixing its well-documented quality issues, ramping up production, certifying the MAX 7/10 and 777X, turning around its money-losing military programs and planning its next commercial aircraft is a huge opportunity cost. The BGS CEO post has been a revolving door, appearing to be a "finishing school" for more important roles elsewhere in the company. Customers recognize this.

A third argument is financial. Slimming down its top-heavy organization and selling noncore services will allow Boeing to shore up its balance sheet and pay down its net debt of \$45 billion. What could be sold? BDI would attract interest as the industry's largest aftermarket parts distributor; freed of Boeing's overhead and bureaucracy, it could thrive. KLX would attract considerable interest as a well-positioned inbound logistics specialist. Other disposal candidates are ForeFlight and navigation software and services specialist Jeppesen. Selling noncore service assets could raise \$10 billion or more.

After slimming down to two divisions, where would the BGS businesses move? Boeing's defense services—Contractor Logistics Support and Performance-Based Logistics programs (including the C-17, AH-64 and F-15), modifications and military proprietary parts—would move back to their natural home in Defense, Space and Security. Passenger-to-freighter conversions, interior products and modifications, training and commercial proprietary parts would shift back to Boeing Commercial Airplanes. These reintegrated businesses would need strong leaders to ensure outstanding product support, a historical strength for the company.

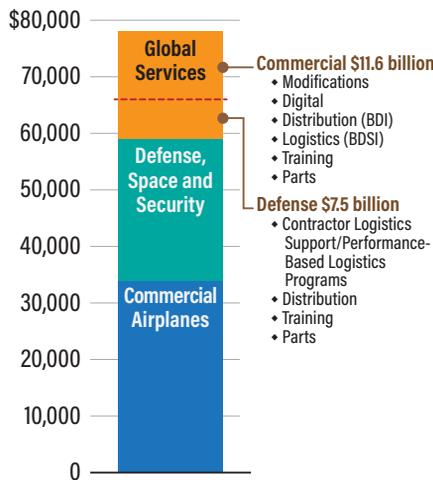
Bold decisions will be required to reboot Boeing. Phasing out BGS would simplify the organization, raise cash and, above all, signal that Boeing is returning to its roots of aircraft development and manufacturing. 🗳️

Contributing columnist Kevin Michaels is managing director of AeroDynamic Advisory in Ann Arbor, Michigan.

Reboot

Why Boeing Global Services should be phased out

2023 Boeing Revenue (U.S. \$ Millions)



Source: Boeing



LEADING EDGE

GRAHAM WARWICK

PERSEVERANCE IS AN ESSENTIAL quality for any aerospace company, especially one trying to bring a new technology to market. For a small company specializing in vertical flight research and development like Piasecki Aircraft, perseverance is as much an art as a necessity.

Piasecki conducted the first tethered hovers of the Ares tilt-duct vertical-takeoff-and-landing (VTOL) demonstrator on Sept. 6, first with the uncrewed air module alone and then with its modular mission pod attached. Each hover lasted about 1 min. The flights came almost a decade after DARPA awarded the contract to build the demonstrator for a program that was later canceled.

The Ares' first flights also came almost a quarter-century after Piasecki first started experimenting with ducted propellers. Founded in 1955 by helicopter pioneer Frank Piasecki, the company flew the PA-59 Airgeep in 1959, its two horizontal ducted rotors providing lift, propulsion and control.

The 16H-1 Pathfinder compound helicopter followed in 1962, its Ring-Tail ducted propeller providing thrust as well as anti-torque directional control. Work on the Airgeep concept continues today with the Air Scout ducted-fan VTOL uncrewed aircraft, while the 16H-1 led in 2007 to the X-49A Speedhawk, a modified Sikorsky SH-60F with Piasecki's Vectored-Thrust Ducted Propeller replacing the tail rotor.

The Ares has its origins in the TX Transformer project DARPA launched in 2010 to demonstrate a military roadable aircraft, a four-seat tactical vehicle able to lift off from a road to fly over obstacles, terrain, ambushes and roadside bombs.

Teamed with Lockheed Martin's Skunk Works, Piasecki proposed a small-footprint, tilt-duct VTOL flight module that could connect to and carry different types of mission modules and fly autonomously or optionally piloted.

In 2014, the team was awarded a contract to build the Ares demonstrator. But DARPA and the U.S. Marine Corps ended investment in the program in 2019, before flying the completed aircraft, citing significant cost overruns and delays.

Lockheed withdrew from the partnership, taking with it the vehicle's flight control hardware and software. But Piasecki continued to seek funding from elsewhere while Honeywell stepped in to supply its commercial Compact Fly-By-Wire system.

Piasecki kept the project going and eventually se-

cured funding from the U.S. Air Force and Army to fly the demonstrator. In November 2023, the company was awarded a Strategic Funding Increase (Stratfi) contract worth \$37 million, including matching private investment, to advance development of the Ares and work on hydrogen fuel-cell propulsion.

"The Air Force was hugely helpful in funding the development of a new flight control system," CEO John Piasecki told Aviation Week in January. "We've spent the past three years in doing that on a shoestring and so the award of the Air Force Stratfi program was a big deal because that gives us the resources to take the aircraft to flight."

"I have to give credit to the Air Force for being perseverant," says Ashish Bagai, who led the Transformer program while at DARPA. "I'm glad it has continued because I don't think we have an uncrewed logistics, runway-independent transport aircraft at this point in time that would serve the kinds of opportunities and environments that Ares was intended for."

The Ares is powered by a pair of 1,000-shp-class Honeywell HTS900 turboshafts mounted in the center wing section and

driving the tilting ducted fans mechanically via shafts. Outboard wing sections tilt with the ducts and provide lift in forward flight.

The tilting ducted fans provide lift in vertical flight, propulsion in forward flight and control in all phases of operation. The Ares is tailless, and vanes in the duct exhausts are used to vector fan thrust for flight control. Longitudinal-only, cyclic control of fan-blade pitch is used to trim the module in pitch.

Piasecki says the tethered flights at its West Helipad in Essington, Pennsylvania, demonstrated the ability of the Ares flight module's Honeywell triplex fly-by-wire controls to sustain a stable hover in multiple configurations and a dynamic ground environment.

Under the Stratfi contract awarded by the Air Force's AFWerx innovation unit, the Air Force Research Laboratory and Army Medical Research and Development Command, Piasecki plans to expand the Ares' flight envelope, then modify the aircraft to enable demonstration of autonomous casualty evacuation and logistics resupply capability.

It has taken a protracted effort to get the Ares airborne, but in that time the uncrewed logistics requirements for which the vehicle as developed have only become more relevant, Bagai says. "I always likened it to Charlie Brown wanting to kick that football," he says. "I think he finally did." 🏈

Staying the Course

Persistence pays off as Piasecki flies its Ares



PIASECKI AIRCRAFT



AIRLINE INTEL

JENS FLOTTAU

LUFTHANSA CEO CARSTEN SPOHR made a quick trip to Lisbon, Portugal, in early September. He went there at the request of the Portuguese government, which was seeking to explore Lufthansa's interest in buying TAP Air Portugal.

While the conversation remains confidential, it is safe to assume that Spohr has signaled interest in picking up TAP. He has said so publicly before, just as his colleagues Luis Gallego and Ben Smith of major European rivals International Airlines Group (IAG) and Air France-KLM, respectively, have done as well. The informal meeting implies that the formal beginning of the privatization process is nearing, which industry sources say will happen in late September. A decision on the preferred bidder could be made early next year.

smaller Airbus A330-900s. That is an important aspect, as Lufthansa has lost alliance partners in Brazil twice (TAM, now part of LATAM Airlines, and Avianca Brasil) and needs to find better ways to serve destinations beyond Sao Paulo and Rio de Janeiro.

Of course, obtaining regulatory approval also could be a big hurdle, as Lufthansa Group has just received clearance for the ITA deal from the European Commission after a lengthy and painful process. The Air France-KLM and SAS Scandinavian Airlines tie-up could be instructive: The group has acquired a 19.9% stake in SAS, below the threshold that triggers a review. The current agreement says Air France-KLM can move to a majority stake after two years at a minimum, which would then lead to action by the competition authorities.

Industry sources say Lufthansa could move in a

Liaising With Lisbon

How TAP Air Portugal privatization could shift European and Latin American market shares



MARKUS MAINKA/ALAMY STOCK PHOTO

TAP, based at a constrained, uncomfortable airport on Europe's periphery, is still highly sought after. It is all about the Europe-Latin America market. Whoever gains control of TAP will be able either to solidify a leading market position or to catch up market share to better compete with much larger rivals.

Of all the major players, Lufthansa Group clearly has the most pressure. According to data from CAPA – Centre for Aviation and OAG, Lufthansa Group (Lufthansa, Discover and Swiss combined) has 4.6% share of the Europe-Latin America market. ITA Airways, in which Lufthansa now holds a 41% stake but not yet a majority, has a further 2.8%. The three airlines combined reach roughly half the share of market leader Iberia (14.4%) and have considerably less than Air France's portion (10.2%). Of course, the picture is even worse on a group level. Even without the failed acquisition of Air Europa, IAG (Iberia, British Airways, Vueling, Level and Aer Lingus) has a 19.1% share, closely followed by Air France-KLM (17.3%).

Taking control of TAP (6%) would enable the Lufthansa Group to grow its share to 13.4%—still substantially below the two rivals but at least a bit closer than before. While the Lufthansa Group is focused on flying large-capacity aircraft (mainly Boeing 747-8s and 777-300ERs) into large markets such as Sao Paulo, TAP has a much broader network into secondary destinations, most of which are in Brazil, using its fleet of

similar fashion, buying less than 20% in a first step, avoiding in-depth regulatory scrutiny and allowing time for those involved to digest the ITA deal—then go for a majority stake later. Lufthansa hopes it can convince the Portuguese side of the merits of its model, which maintains relative independence of the airlines, brands and management.

With Air France-KLM possibly seeking regulatory clearance of the SAS takeover at some point, the timing might work in Lufthansa's favor, should it be chosen in the first place. However, that is by no means a done deal. IAG has just given up pursuing the planned Air Europa takeover because of the regulatory price. Air Europa alone has almost 8% of the Europe-Latin America market and around 20% of Spain-Latin America, which would have boosted IAG's already-dominant position.

With Air Europa no longer in the mix for IAG, TAP is the obvious next target. It might be easier for IAG to obtain approval to take a TAP stake, as the Portuguese carrier at least partially taps into different traffic flows than Iberia on the European side and would give IAG much better access to Brazil.

In that context, it is also worth noting that Lufthansa appears to have been in touch with Air Europa about its perspective. The airline could be a fallback option in case a TAP deal does not happen. And it certainly does not hurt Lufthansa's negotiating position if alternatives are on the table. 🌐



THE LAUNCHPAD

IRENE KLOTZ

IT CAME AS A SURPRISE TO NO ONE that Blue Origin called off plans to launch its first orbital-class rocket during a narrow planetary window opening on Oct. 13.

The stakes are high to make any planetary launch window, the limited period of time when planets' orbits align for optimal interplanetary flight. Blue Origin was hoping to thread that needle with the first flight of the New Glenn (NG-1), which was to send a pair of small science satellites toward Mars for NASA.

But five weeks before lift-off—with NG-1 engine hot-fire testing, refurbishment and integration work still ahead—NASA announced it was halting preparations to launch the satellites, which were about to be fueled for an 11-month cruise followed by an 11-month mission to measure Mars' magnetosphere. Instead, the spacecraft will be returned to manufacturer Rocket Lab's complex in Long Beach, California, and put into storage.

"The decision was made to avoid significant cost, schedule and technical challenges associated with potentially removing fuel from the spacecraft in the event of a launch delay, which could be caused by a number of factors," NASA said in a Sept. 6 statement.

The agency made the call after a review of New Glenn launch preparations and discussions with Blue Origin, the FAA and Cape Canaveral SFS Space Launch Delta 45 Range Safety Organization, as well as NASA's Launch Services Program and Science Mission Directorate.

The agency added that it was looking for another opportunity to launch the Escape and Plasma Acceleration and Dynamics Explorers (Escapade) mission, including possibly in the spring of 2025, although that would entail a circuitous flightpath. The next optimal Mars transfer window will open in November 2026.

"We're committed to seeing Escapade safely into space," said Nicola Fox, NASA's associate administrator for the science mission directorate.

In a separate statement, Blue Origin said it was moving up New Glenn's second launch to November from December—an oblique reference that NG-2 would become the first flight. Instead of Escapade, the company

will fly technology in development for its planned Blue Ring space platform.

In the week leading up to the cancellation of Escapades' flight, Blue Origin shared pictures and updates of the New Glenn upper stage being moved out to Space Launch Complex 36 at Cape Canaveral SFS for a hot-fire test, the date for which has not yet been announced. The Glenn Stage 2 would then need to be refurbished and mated with the first stage ahead of an integrated vehicle hot-fire. Blue Origin now plans to complete that work in time for a November launch.

Taking the Mars mission off NG-1's manifest bought Blue Origin some time, but it is not out of deadline jail yet: The company has until year-end to achieve a successful New Glenn launch in order to compete for missions under the U.S. Space Force's National Security Space Launch (NSSL) Phase 3 Lane 1 program.

The service selected Blue Origin, United Launch Alliance (ULA) and SpaceX for a multiple-award, firm, fixed-price, indefinite-delivery/indefinite-quantity contract in June worth a combined \$5.6 billion, covering a minimum of 30 launches in 2024-29, with an option to extend the agreement to 2034.

Blue Origin also is expected to join ULA and SpaceX as a vendor for the Space Force's NSSL Phase 3 Lane 2 contract, awards for which are anticipated this fall. A Lane 2 award would include additional launch vehicle certification requirements for the New Glenn.

NASA awarded Blue Origin a \$20 million contract in February 2023 to launch the Escapade spacecraft. Escapade originally was to fly as a secondary payload with the agency's Psyche asteroid mission in August 2022. Escapade was removed due to problems with the required trajectory to Mars, after the Psyche mission launch vehicle shifted to a SpaceX Falcon Heavy from a Falcon 9.

Blue Origin is among more than a dozen vendors eligible to bid for small satellite launches and rideshare missions under NASA's Venture-Class Acquisition of Dedicated and Rideshare program, which is designed to provide a broad range of commercial launch services capable of delivering Class D, cubesats and higher-risk-tolerant payloads to a variety of orbits. 🌐

Escapade Slip

Mars probes are pulled from the New Glenn debut flight



BLUE ORIGIN

COMPROMISING REDUNDANCY

- > JAMMING AND SPOOFING EVENTS TRIPLE IN THREE YEARS AS CONFLICTS ESCALATE
- > UKRAINE AND MIDDLE EAST ARE MAJOR HOTSPOTS

Jens Flottau Frankfurt

The Russia-Ukraine war continues to cause profound disruption to international air transport. Airlines flying between Europe and Asia in compliance with Western sanctions have to make long detours avoiding Russian airspace. Competitors from China and the Middle East take the shortest route and gain a big advantage. Networks have thus been adjusted, business models revisited and bilateral traffic rights discussed.

But commercial disruption is not the only unwanted side effect. The war also has at least an indirect impact on aviation safety. No commercial aircraft has been hit since the full-scale war began in 2022 and commercial aviation is generally not the target of military forces at this time. However, jamming and spoofing to confuse enemy receivers about military aircraft positions have become almost routine issues for any commercial crew flying in the region. Onboard systems such as GPS, the enhanced ground proximity warning system (EGPWS), Automatic Dependent Surveillance-Broadcast (ADS-B) Out or basic instruments like the GPS-based clock can malfunction, forcing pilots to use fallback options.

Redundancy, a key enabler of aviation safety, has been compromised. Most systems recover to operate normally once the interference ends, but some do not, often forcing commercial aircraft to operate without some key navigation aids for hours on long-haul flights.

Global Navigation Satellite System Radio Frequency Interference (GNSS RFI) is a growing problem—and not only because of wars in Ukraine and elsewhere. Private devices that can cause jamming or spoofing are much more easily available than they were only a few years ago. Jamming is the loss of the GNSS data when it is

blocked. Spoofing is the fabrication of erroneous data—meaning, in the aviation context, that aircraft can show wrong positions.

According to Airbus data, the number of RFI events is rising sharply: 21,000 were recorded in 2021, and the number tripled to 60,000 last year. In 2019, jamming and spoofing primarily happened only in the Middle East and on a much smaller scale. Now large parts of Eastern Europe, the Baltic Sea, Northern Finland and Russia are affected. But the events are not limited to active conflict zones; they also arise in Southeast Asia, China, India and Pakistan. Jamming has also occurred in the U.S. and Mexico. Spoofing has risen exponentially since the end of 2023, one European Union paper suggests.

“We all experience it,” a senior pilot flying for a European legacy carrier says. “It starts near Istanbul.” Spoofing events can be particularly confusing. Once, on approach to Tel Aviv, the pilot explains, the aircraft’s “reported” position on the flight display map remained over the Mediterranean Sea when it had already crossed the shoreline and was about to land at Israel’s main international airport.

While long-haul overflights of the region can be managed more easily under these conditions, flying to destinations in affected areas is much

more tricky. “The biggest impact is the loss of EGPWS,” the pilot says. “The impact on safety is massive on approaches to destinations surrounded by mountains.”

One additional problem is that the flight management system (FMS) saves the wrong position information after landing if it is not fully reset. And even if the wrong information has been deleted, the system will likely be spoofed again after takeoff, leading to inaccurate FMS inputs. In one case, a crew initiated a go-around on approach to a major European airport because they had received a ground proximity warning and did not realize quickly enough that the alert was the result of spoofing—even though they had left the affected region hours before.

For airlines and pilots, the learning



curve has been steep and led to updated operational guidance about when navigation signals are jammed or spoofed. One practical solution is shutting off affected systems and relying on traditional navigation aids such as the instrument landing system (ILS), VHF Omnidirectional Range (VOR), nondirectional beacons (NDB) and inertial navigation to define the aircraft’s position.

However, Egon Rinderer, chief technology officer at onboard data specialist Shift5, points to another risk. As a

pilot, when you discover spoofing, “you need to immediately cut the breaker on your GPS so as not to infect your inertial nav[igation],” he says. Rinderer describes spoofing in particular as “an arms race,” noting that “12 years ago was the first known incidence of GPS spoofing.” Of late, Russia and China in particular have become much more sophisticated, he believes.

Protecting aircraft has become a lot harder with the emergence of drones, Rinderer notes. Aircraft have antennas on the top and at the bottom of the fuselage, but simply rejecting signals coming from the ground to preserve data integrity is no longer the solution, as drones could send the wrong signals from above.

The European Union Aviation Safety Agency (EASA) covered the

EASA lists several possible symptoms of spoofing, including incoherence in navigation position, abnormal differences between ground speed and true airspeed, time and date shifts or spurious terrain warnings even during cruise at high altitude.

As a consequence of spoofing, GNSS can no longer be used for navigation, sometimes even after aircraft have left the affected area.

“Repeated or widespread disruptions of the GNSS signals can lead to increased workload of both flight crews and air traffic controllers that can cause cognitive overload or confusion and increase the risk for errors,” EASA warns. For instance, a terrain warning has to be dealt with no matter what. Pilots will, at the very least, have to deliberate and decide that at long-

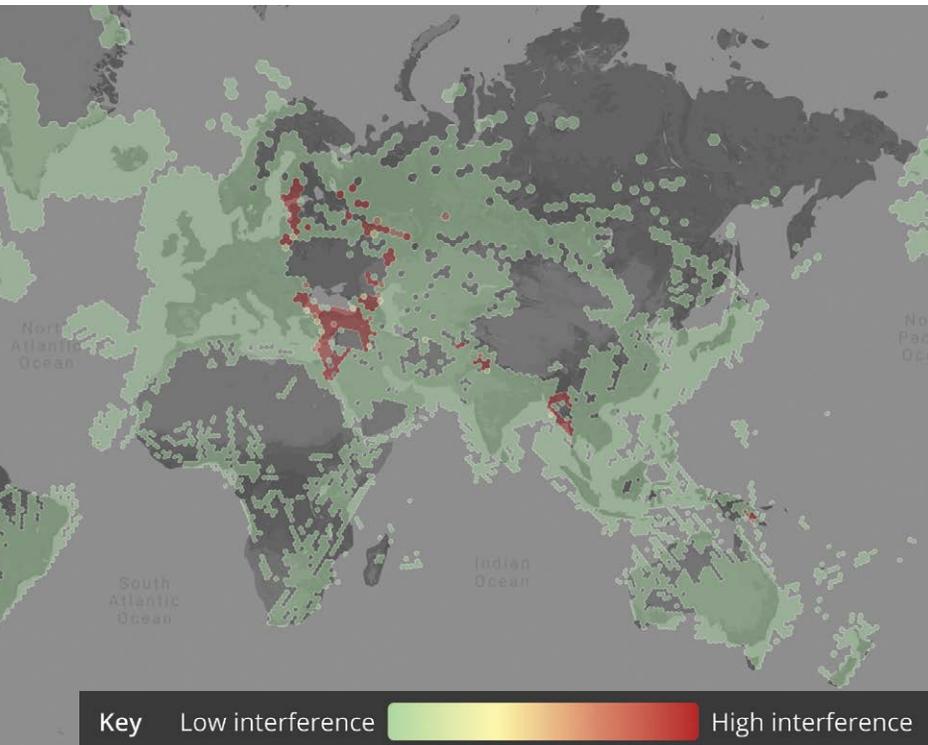
against military attacks and have no interest in sharing information about what they are doing and how. Side effects on civil aviation have low priority.

Yet more and more states are voicing serious concerns. “In Southeast Asia, like in other regions with a significant volume of over-water flights, GNSS-dependent procedures have become key enablers to safely facilitate essential air connectivity with the rest of the world,” Singapore wrote in a working paper for the ICAO conference. “In turn, this connectivity results in significant increases in traffic volume, which brings great opportunities for economic development and growth in the region.”

With “heavy reliance on both space-based ADS-B aircraft separation and GNSS-based navigation performance, especially in areas which have high volume of traffic . . . air traffic control must remain vigilant to detect positional drift, as manual intervention may be necessary to prevent any potential loss of separation, which significantly increases controller workload. Inaccurate aircraft position information caused by ‘spoofing’ may also compromise aircraft automated conflict alerting systems and navigation performance. As a result, separation distances have to be significantly increased to maintain safe operations, which severely restricts the traffic flow rate.”

The European Union warned in its own ICAO conference working paper: “Most GNSS interferences affecting civil aviation are being reported in geographical areas close to conflict zones and are linked to the recent escalations in military drone, anti-drone and electronic warfare. However, a large amount of interference also exists in locations where there is no evident proximity to a zone of conflict. In recent months, a number of spoofing cases have been reported in locations where there is no recognizable link to a state security or defense activity.”

There are no quick fixes, but there are at least some mitigation methods. Claude Pichavant, Airbus’ executive expert for communication, navigation and surveillance, says the decommissioning of VORs, ILS and NDBs should be slowed down. In the longer term, he hopes that antennas could use military technologies for better protection. Dual-frequency solutions for GNSS and GPS are a “very long-term” prospect, in his opinion. ☉



broader issue in an extensive July safety information bulletin. “EASA has analyzed recent data from the network of analysts and open sources and has concluded that GNSS jamming and/or spoofing has shown further increase in the severity of its impact, as well as an overall growth of intensity and sophistication of these events.”

While jamming is relatively easy for crews to detect, doing so for spoofing “is more difficult and not immediate for the flight crew, thus posing more safety risks than jamming,” the agency wrote.

haul cruise altitudes the warning makes no sense.

The industry is far from being able to improve defenses against such attacks. Even initiatives to encourage states simply to share information about spoofing and jamming—brought forward again at the 14th International Civil Aviation Organization (ICAO) Air Navigation Conference that ended Sept. 6 in Montreal—have stalled. It is obvious and to a degree understandable why. In conflict zones, countries use jamming and spoofing to protect

ANDURIL



Anduril's Fury is fighting to move the startup into the ranks of air dominance prime contractors.

Can Upstart Anduril Land the CCA Market?

> LANDING GEAR DECISION OPENS WINDOW INTO DESIGN APPROACH

> USAF LEADERS ARE INTRIGUED BUT ARE WAITING FOR RESULTS

Steve Trimble Washington

Compared to the wing, sensors and other major features, the landing gear likely will be an afterthought on the day Anduril Industries rolls out the first Fury, a jet-powered autonomous fighter selected by the U.S. Air Force to compete in the first round of the Collaborative Combat Aircraft program.

But the design and manufacturing approach to the Fury's landing gear offers a revealing glimpse into the decision-making process that a seven-year-old, Silicon Valley-backed company brings to a new kind of combat aircraft.

As a safety-critical component, landing gear design and manufacturing often are delegated to a small club of specialized suppliers by defense companies. But Anduril decided to design and build the gear in-house.

"While it sounds a bit zany, the better thing to do is start from scratch and build cheaper, commercially sourced, mass-producible landing gear that is actually a better fit for the platform it is going on," Anduril Chief Strategy Officer Christian Brose tells Aviation Week.

Anduril's sudden rise as a new player with a \$14 billion valuation in the exclusive air dominance market rests as much on a few sweeping, strategic decisions as on hundreds of smaller tactical choices, including how to build the landing gear for one of the Air

Force's first two Collaborative Combat Aircraft (CCA) prototypes.

So far, the Costa Mesa, California-based company's fast-moving and fresh approach has worked. In April, the Air Force selected Anduril and General Atomics Aeronautical Systems Inc. (GA-ASI) to build the Fury and a variant of the XQ-67, respectively, for the first increment of the CCA.

In the process, the Air Force passed over bids by three aerospace giants—Boeing, Lockheed Martin and Northrop Grumman—for the first contract of a loosely planned family of autonomous partners for crewed combat aircraft.

Anduril's unusual approach to the Fury's landing gear has caught the attention of Air Force leaders.

"That's going to be a really interesting thing, to see how they succeed at that," Andrew Hunter, assistant secretary of the Air Force for acquisition, technology and logistics, said on The Merge podcast in August. "We are not going to dictate to them how they do that. They're going to figure it out, and they're going to succeed or fail, and it's probably a key benchmark for success—how they succeed or fail at that."

As Hunter's comments suggest, Air Force leaders regard Anduril's design choices with an equal mixture of hope and concern.

"Maybe they'll break 1,000 landing gears before they get the design exactly right," Hunter added. "But if they do that, and if they get it right, that's probably going to be a really good landing gear. That might be better than what we would have generated using the traditional defense process."

An Air Force official declined a request for elaboration. "Mr. Hunter used this as a general example. We aren't planning to provide additional information on this topic," the official said.

Internally, Anduril executives are satisfied that their landing gear design for the Fury uncrewed aircraft system (UAS) complies with Air Force certification requirements, even if their approach differs from the traditional process.

"We have landing gear ready to go on the airplane, and we've done the testing on it that the Air Force is looking for," says Andrew Van Timmeren, Anduril's director of air dominance systems.

For a traditional aircraft, landing gear represents one of a handful of never-fail components, as any fault constitutes a crash risk with no backup system. But the CCA program is seeking to build a different type of aircraft. The Air Force wants the aircraft to be reusable, but not necessarily at the same level of other large UAS, such as

the Northrop Grumman RQ-4 Global Hawk. Conversely, the Air Force also wants each to be affordable enough to be lost on its first mission, but preferably not at the same rate as a disposable system, such as a cruise missile. The design requirement falls somewhere in between, defining a new category for attritable systems.

That distinction informs a different approach to the CCA design across the defense industry. Anduril's competitor, for example, unveiled a separate cost-saving approach. GA-ASI built the XQ-67 under an Air Force Research Laboratory contract with a common chassis. This approach adopts a common structural keel and avionics system, along with a modular, mission-specific approach to the design and placement of the engines and wings.

But Anduril's approach seeks to maximize the savings from simplifying the design enough for the CCA's supply chain to bypass higher-priced and capacity-constrained specialists in the aerospace industry.

The philosophy aims to "reduce the complexity of everything to the greatest extent possible so that it can be manufactured easily and cheaply by the largest number of people," Brose says. "That, I think, is ultimately how we're going to do this differently, how we're going to bring costs down and still meet the requirements of the program."

Another feature of Anduril's approach is reuse. Although founded only in 2017, the company has built up and acquired a portfolio of capabilities that can be applied to the CCA design. The company now builds launched effects systems for the Army, loitering and reusable drone interceptors for other military customers, and a wide range of avionics and sensors. Some of those internal capabilities are finding their way into the Fury design.

"One easy place is just the software baseline, so basically, either a vehicle management system [or an] autopilot system," says Jason Levin, Anduril's senior vice president of the air dominance and strike division. "We're also trying to get a lot of reuse on specific components, so avionics that we develop, actuators and things like this."

In February, Anduril revealed the new Iris family of airborne imaging and targeting sensors, featuring computational pixel imager technology to identify and track objects autonomously.

Although not developed specifically for Fury, the sensor payload could become a candidate for the CCA market.

"Iris is capable of going on a lot of different platforms, but we would obviously agree that a CCA application would make a lot of sense," Brose says.

Mission systems, such as sensors and weapons, remain a source of controversy in the CCA market. A CCA equipped with fighter-like sensors and survivability systems could be more effective but bring higher costs. As the price tag for each CCA rises, the aircraft become less attritable.

"If you're assuming that traditional mission systems from manned aircraft are going to get ported over to a CCA, you blow your cost out of the water," Brose says. "Once you get into sensors, [communications] and weapons, [the CCA] actually creates a market for a totally different class of those mission systems that hasn't existed before, because we've never had something like the CCA that requires low-cost mission systems."

There are limits to Anduril's approach to supply chain decisions.

Seeking to break into the market for loitering munitions, the company developed its own turbojets. But the Fury will be powered by the Williams International FJ44-4, a 3,600-lb.-thrust engine developed for business jets, such as the Cessna Citation CJ4 and Pilatus PC-24. The Air Force's plan to field the first increment of the CCA family drove Anduril to select a certified off-the-shelf option.

Anduril's business strategy also is intended to be self-limiting. An attritable CCA fits the company's model perfectly. New concepts for uncrewed air refueling and mobility aircraft might be possible as well. An advanced crewed fighter or bomber, however, falls beyond Anduril's capabilities now and in the future.

"We're never going to work in those types of programs," Brose says. "I actually think our process of working through something like CCA was a process of realization that this is actually more of an Anduril-shaped program than it is something that traditional industry is well-tooled to go after." ☒

Scaled Composites' Multirole Model 437 Enters Flight Testing

➤ THE PROTOTYPE BUILDS ON THE 401 LOW-COST DEMONSTRATOR

➤ THE PROJECT AIMS "TO STRESS" THE DIGITAL ECOSYSTEM

Guy Norris Colorado Springs

The latest in a long line of experimental Scaled Composites-built aircraft, the single-engine, V-tail Model 437 prototype, is set for further envelope expansion tests after making its first flight from Mojave Air & Space Port, California, on Aug. 29.

The Model 437's names—it was dubbed the Vanguard by Scaled Composites and the Digital Pathfinder by parent company Northrop Grumman—reflect its dual testbed role. Not only is the new aircraft a real-life development test case for Northrop's evolving digital ecosystem, it is also proving out a design targeted at the emerging autonomous collaborative platform (ACP) and manned-unmanned teaming (MUM-T) aircraft markets.

The prototype, with the call sign SCAT17, took off from Mojave at

7:20 a.m. PDT. Accompanied by an Aero Vodochody L-39 chase aircraft, the Model 437 climbed to 16,000 ft. to conduct initial flying and quality assessments while navigating a race-track pattern around the airfield. Flown by Scaled Composites Test Pilot Brian Maisler, the prototype returned to land at 8:36 a.m., completing a 1-hr. 16-min. initial sortie.

"Rotation was smooth, and the aircraft readily lifted off and accelerated," Maisler says. "During the evaluation of flying and handling qualities, both closed and open loop were generally good. Flying in formation with the L-39 chase aircraft was smooth. The aircraft was stable on approach and easy to land with a soft touchdown."

Derived in part from Scaled's Model 401 low-cost technology demonstrator,

which first flew in 2017, the Model 437 Vanguard is larger with an overall length of 41 ft. and wingspan of 41 ft. It also has several enhancements including a deeper and more capacious fuselage, revised lambda wing planform, scarfed dorsal inlet and smaller, lower-drag V-tailed ruddervators. The aircraft's single-seat cockpit is enclosed by a one-piece canopy and set forward of the swept wings, which are set at a shallower dihedral than those of the 401.

Powered by a single 3,400-lb.-thrust Pratt & Whitney PW535 engine, the Model 437 has a gross takeoff weight of 10,000 lb. The revised fuselage

measure adoption and get feedback from users?"

The Model 437 therefore forms part of what Miller calls a "tremendous" investment by Northrop Grumman over the past three years to develop a digital ecosystem. This, he says, "includes a single source of truth that goes all the way from concept of operations and requirements through analysis of alternatives, requirements decomposition [to] build, test, deliver, validate and sustain."

The program involved using the system to design and build a set of wings at Scaled's facility in St. Augustine, Florida, which were then mated with

digital thread extends through verification and validation, so as we are flight testing and ground testing, we can trace those results all the way back through the design to the requirements and see if, for example, that particular test step or activity does not pass, then what requirement that impacts. Then to fix it, you would also know how that would affect the build and the retesting."

From a product perspective, the Model 437 is aimed at the U.S. Air Force's Collaborative Combat Aircraft (CCA) program, as well as other low-cost ACP initiatives, Miller says. Although Anduril and General Atomics have received options with existing awards for preliminary CCA designs, the production decision in 2026 is still competitive. Concept refinement contract awards for a second increment of CCA are expected in 2025.

As the CCA and other ACP programs are uncrewed, the appearance of the Model 437 with a cockpit appears to have taken some observers by surprise. "The design of the vehicle to include having a cockpit is purpose-built for our strategy," Miller explains. "Part of our strategy involves manned-unmanned teaming and advanced autonomous aircraft.

"Autonomy is one of our core competencies," he continues. "It's something that we've been doing for a long time and that we are industry-leading in. So that's a market that we fully intend to continue to be a major player in, and the 437 is intended to compete in that market in a variety of roles. I can say that there's already ideas for other applications and a lot of interest, much like the Model 401. There's a lot of interest in applications for it that we're going to consider going forward."

Beyond CCA, "there's a lot of other applications that are compelling," Miller says. "There appear to be large opportunities in that space for years to come, both domestic and potentially even internationally."

Through the Pathfinder, the digital ecosystem initiative has also led to the creation of a team to "operate in this environment, to rapidly build and test things," he adds. "And I believe that's going to be critical to what happens with being able to not only compete but also adapt to the changing environment on things like ACP and others that are autonomous or optionally piloted." 🗨️

SCALED COMPOSITES



The Model 437 test pilot reported that the aircraft's flying and handling qualities were good on the first flight.

cross-section is designed for multi-mission roles and capable of including a side-looking radar, AIM-120 missiles or other payloads.

Originally planned as a follow-on to the Model 401, the 437's timing has enabled "an opportunity, really, to stress and develop not so much an airplane, but our digital ecosystem," says Colin Miller, aeronautics sector vice president of engineering at Northrop Grumman.

"We continue to evolve that system, which started on the B-21 but is also ready to implement on several new big programs—some of them just starting," Miller says. "The Digital Pathfinder was a way to stress that system with a very fast, small project to figure out what's working and what's not working. What's the best way to use that system concept of operations to

the remainder of the airframe at the Mojave site. "That really fleshed out our digital tools and techniques, and it was very successful," Miller adds.

"The primary objective was to demonstrate the effectiveness of our digital ecosystem to design, build and test rapidly and accurately, and reduce schedule and reduce costs," he says. "We could iterate on the design and rerun the model to get the results within hours or days instead of months. And so we rapidly got to our mature design, and then when we built it, we found that our engineering rework was less than 1% where, historically the industry average is over 15-20%." He notes that the cost and time savings potential for "much larger" programs are "really compelling."

Flight tests will represent an extension of the Digital Pathfinder. "The

Anduril Barracuda Seeks a Bite of the Low-Cost Cruise Missile Market

- > MANUFACTURER TARGETS THE PALLETIZED MUNITION ROLE FOR MILITARY CARGO AIRCRAFT
- > LOW-COST METHODS USE KAYAK-LIKE MATERIALS

Steve Trimble Washington

Armed with a back-to-basics approach to design and manufacturing, Anduril Industries wants to break the grip of defense industry heavyweights on the growing market for air-launched cruise missiles.

The Silicon Valley-backed startup unveiled a family of Barracuda-branded cruise missiles, seeking to undercut competitors Lockheed Martin, MBDA and Raytheon with promises of achieving unit prices that will be drastically lower than their \$1-2 million alternatives.

The Barracuda series emerges as U.S. military officials seek an array of cheap, long-range, air-delivered weapons. In the past year, potential requirements have emerged in the 250-nm-range segment for the U.S. Air Force's Extended-Range Attack Munition and the Navy's Multimission Affordable Capacity Effector as well as in the 120-nm-class for the Coalition Affordable Maritime Strike missile.

Anduril officials stopped short of committing to submit Barracuda-based bids for each of those programs but acknowledged they are aware of them and that the programs reflect rising interest in low-cost, long-range weapons.

"There's a lot of interest in the capabilities that we're going after with Barracuda," Diem Salmon, Anduril vice president for the air dominance and strike division, told reporters on Sept. 11.

A relatively low-cost cruise missile costing around \$300,000 has eluded the military despite several attempts. In the past decade, the Northrop Grumman Gray Wolf entered flight testing on an Air Force Research Laboratory-funded contract to challenge the Lockheed Martin AGM-158 Joint Air-to-Surface Standoff Missile, but the program ended after a brief demonstration phase.

Anduril says the absence of a low-cost standoff missile opens a capability gap that is uniquely suited to its strategy to produce high volumes of cheap weapon systems.

"Our contention is that the American weapons magazine is off by an order of magnitude," said Christian Brose, Anduril's chief strategy officer.

Making a low-cost cruise missile partly means accepting certain performance trade-offs, counting on greater numbers to offset any performance shortfalls.

Anduril, for example, plans to use the same pressed composite materials found in kayaks and canoes for the body of the 500-nm-range Barracuda-500, Jason Levin, senior vice president of the air dominance and strike group, tells Aviation Week.

"There's a weight penalty, but you're getting a huge cost reduction and producibility increase," Levin says. "So maybe we could have gone 10% further in range, but let's just make the thing a little bit bigger."

Another cost-saving measure brings production in-house for some scarce components in the supply chain. Anduril designed small turbojet engines for the previ-

ously announced Roadrunner, a reusable interceptor for shooting down uncrewed aircraft systems and one-way attack drones. The same basic design could be adapted and scaled up for the Barracuda series.

Anduril also faces the same bottlenecks as its competitors in the long path between development and fielding of new munitions. This includes multiyear backlogs to enter the Air Force's Seek Eagle certification process for new air-launched munitions and the refresh cycles of at least two years for integration into the Operational Flight Programs (OFP) of each launch platform, such as fighters, bombers and helicopters.

But Anduril hopes to move faster than the current process allows by bypassing Seek Eagle and OFP integration on the first application. The Barracuda-500 is being offered as a palletized munition that could be released from the hold of a cargo aircraft, then power up in free flight and fly toward a preselected target.

"Cargo-launched is the mission set that they're going after, so [that's] not necessarily requiring aircraft integration," Salmon said.

But not every member of the Barracuda family can escape the requirements of aircraft integration. The 250-nm-range Barracuda-250 cruise missile is being sized to integrate into the weapon bay of a Lockheed Martin F-35, Salmon added. The specifications for the Barracuda-100 show that the smallest variant of the family is being offered for the Boeing AH-64 and Bell AH-1Z—two platforms now searching for a Long-Range Precision Munition and a Launched Effect-Long-Range. ☞



The Barracuda-250 is designed to be carried by an F-15 (background) or in the internal weapon bay of an F-35.

OSPREY

- > INVESTIGATION PRESSES USAF ON CV-22 AIRWORTHINESS
- > THE REPORT HIGHLIGHTS DEFECTS IN MANUFACTURING
- > THE NAVY HAD STUDIED A FULL CLUTCH REPLACEMENT

Brian Everstine Washington

Years of increasing frustration within the U.S. Air Force on oversight of the Bell Boeing V-22 Osprey fleet—culminating in a recent accident investigation that placed some blame on the program office for failing to share safety information adequately—have led to a new recommendation to overhaul the airworthiness process for the tiltrotor.

Specifically, an Air Force nonpublic safety report into the Nov. 29, 2023, CV-22B fatal crash off the coast of Japan is recommending that the service should have the final say on the type's airworthiness. Since the beginning of the Osprey's development, this has been the responsibility of the U.S. Naval Air Systems Command (Navair).

That recommendation comes after the service has twice grounded its CV-22s ahead of an airworthiness decision by Navair. The first coincided with a push by Air Force Special Operations Command for Navair to increase data collection on the fleet to improve safety decisions.

"Data importance notwithstanding, safety assessments and their findings were given insufficient treatment at the program level and have been inadequately communicated to the military services, creating lack of comprehensive awareness of [proprotor gearbox (PRGB) risks] and limiting opportunities to impose mitigation measures at the service or unit level," states the public Air Force Accident Investigation Board (AIB) report on the November crash, which killed eight airmen.

Nonpublic Safety Investigation Board (SIB) documents obtained by Aviation Week expand on this disconnect and the subsequent recommendation. The report, which is deemed controlled unclassified information, states that the airworthiness and risk management of the Air Force's own CV-22B fleet are executed in accordance with U.S. Navy policies and processes, "which creates a gap in knowledge and understanding within the U.S. Air Force technical and risk management communities." The report recommends updating the airworthiness memorandum of agreement with Navair to require risk acceptance and coordination



OVER

in accordance with the Air Force's own safety and mishap prevention guidelines.

Additionally, the report advises updating the agreement "to require the V-22 [Joint Program Office] to obtain USAF Technical Airworthiness Authority approval on airworthiness actions and coordination on serious and high-level risks."

Navair's role resembles the FAA's authority over commercial aircraft, deciding whether an aircraft is safe to fly. The command's authority on the V-22 Osprey extends beyond Air Force CV-22Bs to Navy CMV-22Bs and Marine Corps MV-22s.

Investigators state in the AIB report that they found the V-22 Joint Program Office accepted material failure risk to the PRGB and failed to implement sufficient mitigation measures. The subsequent pages outline a long list of institutional and manufacturing issues that ultimately doomed the CV-22B that flew under the call sign "Gundam 22" on the day of the crash.

During about 1 hr. of flight, the CV-22B received multiple warnings of chips inside the gearboxes. Crewmembers largely dismissed the alerts based on experience with chips burning off or false warnings. They eventually received a more serious alarm concerning the chips, which under Air Force guidance advised landing as soon as possible. Following the guidance, the pilot diverted to an airport about 60 mi. away even though other divert locations were closer. When the CV-22B approached the sole runway on Yakushima Island, another aircraft was preparing to take off, so the pilot flew a holding pattern to allow the traffic to clear.

On final approach, the Osprey's left-hand PRGB catastrophically failed, causing sudden asymmetric lift and forcing it to roll twice before crashing into the water.

The November 2023 crash of a U.S. Air Force CV-22B off the coast of Japan sparked a new look at manufacturing issues inside the Osprey's gearbox.

SIGHT



YASUO OSAKABE/U.S. AIR FORCE

Investigators determined that the failure of the left-hand PRGB's high-speed planetary section likely resulted from a crash in high-speed planetary pinion gears and fatigue cracking of the pinion gear's bearing cage. This fractured through the high-speed planetary carrier assembly, causing a failure of the gearbox, failure of the aircraft's interconnected drive system and overtorque in the right-hand PRGB.

The public AIB placed blame largely on the crew for continuing to fly amid multiple chips warnings and then choosing a long divert. While this contributed to the accident, the crew had followed Air Force guidance.

The nonpublic SIB provides more detail, noting that the crew were unaware of the coming catastrophe because of years of inaction within the program and lack of V-22 systems providing real-time information to the cockpit.

Investigators determined that the Universal Stainless X-53 steel used for manufacturing V-22 gears has been susceptible to failure, with seven low-speed pinion gear failures documented since 2006. However, Navair never required manufacturing or acquisition changes for the components. Documents state that Universal Stainless manufactured the alloy in the high-speed planetary gears, which failed in the crash, while Carpenter Technology produced material for the bull gears in the gearbox. The SIB recommends updating contracts for the component to require triple melt processing, enhanced ultrasonic inspection and reduction in acceptable flaw size.

The Osprey is currently outfitted with a V-22 Vibration, Structure Life and Engine Diagnostic System, which in part monitors the complex gearbox. Its data, however, is available only to maintainers on the ground. The SIB states that while the system functions as intended, "its design is

inadequate as it does not provide real-time vibration indications to aircrew that could accelerate precautionary landing conditions."

The nonpublic investigation report states that the aircrew lacked secondary indications of potential problems outside the chips warnings they received. If those had been in place, they could have declared an emergency to land earlier.

"[The aircrew] did not consider their emergency to be severe enough to disregard the advice from [Yakushima airport's Automatic Flight Information Service] and executed what they believed to be the more reasonable course of action by allowing traffic already on the runway to depart," the report states. "Given what the crew knew about their situation, it is unlikely they would have chosen the latter option. The SIB concluded the [crew] unknowingly exposed themselves to additional [left] PRGB deterioration by delaying their approach and landing."

The V-22 program is developing the Osprey Drive System Safety and Health Information (Odsshi) under a January 2023 award to Bell Boeing for 20 kits. The SIB recommends improving the Odsshi design with real-time alerts in the cockpit and monopole sensors in each PRGB to increase the frequency range capability and thereby capture all component vibration data within the gearbox.

The Odsshi is one of a few new efforts underway to improve the V-22's PRGB. Most are focused on the long-standing issue of hard-clutch engagements (HCE), a separate problem from that addressed in the Gundam 22 investigation. The fleet has seen several HCE, including a dual instance that caused the June 2022 crash of an MV-22 in Southern California, that killed five Marines. A similar incident in August 2022 in Norway spurred an Air Force-led grounding of the type.

Since the investigation into the June 2022 crash, the services have been replacing the V-22 fleet's input quill assembly for each PRGB every 800 hr. Officials say that since this change was implemented, there has not been another HCE.

A long-term acquisition forecast from Navair released in June outlines a series of ongoing efforts to address the HCE. This includes an expected contract for an analytics, controls and modeling study to determine the root cause. The command's leading theory blames an out-of-phase engagement in the gearbox.

Navair expects to award a new contract for the PRGB Input Quill Clutch Upgrade, a second step following a December 2022 award to Bell Boeing.

In addition, the Navy's fiscal 2025 budget request includes \$48 million in 2026 to procure 45 kits of an improved design, as well as \$138 million for 328 kits over the following four years.

The acquisition outlook also details a previously unreported plan to replace the V-22's clutch completely. Navair had awarded an undisclosed contract for a trade study to look at installing a Synchro-Self-Shifting clutch instead of the existing sprag overrunning clutch into the fleet, but it was unsuccessful, as the contractor found that the design could not be applied to the Osprey. Specifically, the contractor determined that it could not develop a mechanism to compensate for changing forces under different loads and operational conditions. 🗣️

Check 6 Aviation Week editors discuss the SIB report and the V-22 saga: [AviationWeek.com/Check6](https://www.aviationweek.com/Check6)



The sunset of the Navy's Boeing EA-18 and F/A-18 fleet might be pushed back amid funding questions surrounding the F/A-XX program.

U.S. Navy Aviation Goals Compete Against Budget Realities

- > F/A-XX AWARD EXPECTED IN 2025
- > TRAINER COMPETITORS AWAIT NEW REQUIREMENTS

Brian Everstine Reno, Nevada, and Washington

The U.S. Navy's aviation enterprise has big goals over the coming years, with plans to replace its Boeing F/A-18 Super Hornet and EA-18G Growler combat fleet, T-45 Goshawk trainers and Sikorsky MH-60 Seahawk helicopters for its future carrier air wings. But one thing has not become clear: Where will the funding emerge from the fog of budget planning?

The Navy's carrier fleet in the mid-2030s and beyond is expected to include the F/A-XX fighter, a sixth-generation combat aircraft performing both the strike role of the Super Hornet and the electronic attack role of the Growler, bolstered by uncrewed Collaborative Combat Aircraft (CCA). The Future Vertical Lift (Maritime Strike) platform is planned to take over the search-and-rescue and anti-subma-

rine role from the Seahawk helicopters. Next-generation pilots are to be trained on a new Undergraduate Jet Training System (UJTS) that is awaiting the formal start of competition.

At the same time, the Navy is facing a dramatic backlog in building delayed Ford-class carriers, combat ships and submarines—a reality that is eating the service's budget. Leaders in the Naval Aviation Enterprise (NAE) have over recent years said soon it will be the aviation community's turn to take on increased spending, albeit probably not in the coming years, as Congress and the bulk of the Navy are likely to prioritize the nation's shipyards over aircraft factories.

"The Navy doesn't have a coherent plan for the next recap cycle, when it will have to deal with the aging MH-60, [Boeing] P-8, F/A-18 and EA-18G," says

Bryan Clark, a senior fellow with the Hudson Institute and an expert on the service's strategy and budgeting. "The Navy could replace them with improved versions of similar platforms to avoid a big [research and development bill], but that may only be viable for F/A-18."

This uncertainty about the F/A-XX is unfolding within current budget debates. In its fiscal 2025 request, the Navy called for just \$453 million for the program for that year, a considerable cut from the prior year's \$2.1 billion. The Senate's version of the fiscal 2025 policy bill slashed that to \$53 million, although the simultaneous appropriations spending measure would increase the figure to \$954 million.

The disconnect has not yet been rectified as Congress appears headed to a likely long-term continuing resolution ahead of elections in November.

Clark argues that a further delay will probably occur in the next budget cycle, which is expected to be flat and deal with increasing Columbia-class ballistic missile submarine costs.

"The Navy's original plan was to essentially develop FA-XX now and then move into procurement during the 2030s, after Columbia is fielded and a normal recap cycle for aviation would begin (the last one being from the mid-2000s to about 2015)," he says. "The problem is cost growth in shipbuilding and flattening budgets prevent investing in the amount of R&D needed for highly advanced aviation programs."

Despite the funding uncertainty, the Navy is still expected to award an engineering and manufacturing development contract for the F/A-XX in fiscal 2025. The major primes—Boeing, Lockheed Martin and Northrop Grumman—are competing and in concept refinement, as the program overall is in a source selection phase. If the Navy is able to keep to its schedule for a contract award, it should leapfrog the U.S. Air Force Next-Generation

Air Dominance program, which has been put on pause amid a review of requirements.

While the Air Force has charged ahead on the CCA, selecting Anduril and General Atomics Aeronautical Systems Inc. in April for its first increment (page 16), the Navy seems to be moving at a slower pace for its analogous program. The service is undertaking an analysis of alternatives, studying its future concepts for the CCA while undertaking early refinement work. For example, the Navy's Air Test and Evaluation Sqdn. Two Four has established a small team in Australia, where the Royal Australian Air Force is developing the Boeing MQ-28 Ghost Bat.

The Boeing MQ-25 Stingray refueling UAS is the trailblazer for carrier uncrewed operations, and the service installed the first control station on the USS George H.W. Bush (CVN-77) in August. This ground station would control future Navy CCA in addition to the MQ-25.

Replacing the T-45 trainer is a ma-

ior priority for the NAE, as the Goshawk fleet has been grounded repeatedly in recent years because of a broader backlog in pilot training. The service is moving ahead on its replacement program, the UJTS, with a series of requests for information. The latest, released in June, pushes back the UJTS timeline by two years to an anticipated contract award in the second quarter of fiscal 2028.

Competitors for the program are largely in a holding pattern, awaiting more refined requirements from the Navy that would inform the design. The latest request for information states that the UJTS would not have to go to the carrier for training, a step the Navy has already taken with the T-45 to reduce training time. However, the request for information also states that the service is still considering whether the aircraft would need to conduct Field Carrier Landing Practice to touch down. If it does, the aircraft would need to take the beating of thousands of unflared landings over its lifespan—a decision

that would require more development.

Current competitors for the UJTS are Boeing with its T-7A Red Hawk, Lockheed Martin with the TF-50N and the team of Leonardo and Textron Defense with the M-346N.

Beyond the F/A-XX and UJTS timeline, the Navy also wants to move ahead with its Future Vertical Lift (Maritime Strike) platform to replace the Sikorsky MH-60s. The Navy is targeting an initial operational capability for this platform in the early 2040s. In May, the service completed an analysis of alternatives and began work on a capabilities development document and a concept of operations.

The Navy wants the Future Vertical Lift (Maritime Strike) to build on what the Army has done with its selection of the Bell V-280 for its Future Long-Range Assault Aircraft and U.S. Marine Corps' vertical-takeoff-and-landing family-of-systems efforts to buy an aircraft that can operate primarily from surface combatants. The service plans to hold an industry day for the program this year. ☛

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Tokyo Invests in More Missiles Amid Regional Security Concerns

> JAPAN MARITIME SELF-DEFENSE FORCE IS SEEING NEW CAPABILITIES TO INCREASE DEFENSIVE STRATEGIC DEPTH

> AIR DEFENSE ARCHITECTURE OVERHAUL TO ENHANCE RESILIENCE

Chen Chuanren Singapore

The cover of the annual defense white paper Japan issued in 2021 depicted an unarmed samurai warrior mounting his warhorse. Three years on, the latest cover depicts the forging of a katana, the samurai sword.

a ship-launched variant, indicating the completion of the development phase.

The improved Type 12 will join an arsenal of standoff weapons including locally developed Mitsubishi Heavy Industries hypersonic missiles, Kongs-



Japan is expanding the capability of its Mitsubishi Heavy Industries Type 12 surface-to-surface missile system.

The message is subtle but clear: Japan is preparing for the inevitable and arming itself. Defense Minister Minoru Kihara underscored the point, saying the country “finds itself in the most severe and complex security environment of the postwar era.”

The white paper itself further illustrates Tokyo's preparation for potential conflict. Japan's Defense Ministry is requesting ¥970 billion (\$6.9 billion) just for standoff capabilities, making up 11% of an ¥8.7 trillion war chest. The money is intended to support a multiprong effort to ensure a counterstrike capability during a ballistic missile attack and execution of an anti-access/area denial strategy to defeat an invasion force.

After years of accelerated development, the improved Mitsubishi Heavy Industries Type 12 surface-to-surface missile is ready to be fielded starting in the next fiscal year. On top of the ground-based version, the Japan Defense Ministry opened a new budget for

berg Joint Strike Missiles, Lockheed Martin Joint Air-to-Surface Standoff Missiles and ship-launched RTX Tomahawk cruise missiles.

The spending on missiles shows how far Japan's military has shifted after decades of a purely defensive mandate. The Type 12 will be installed on Japan Maritime Self-Defense Force (JMSDF) warships, including two new Lockheed Martin SPY-7 Aegis destroyers that will join eight ballistic missile defense (BMD)-capable destroyers. These destroyers are regarded as Japan's first line of defense in providing both timely BMD and future counterstrike capability, showing how Tokyo seeks to balance its postwar defensive focus with a newfound willingness to strike.

Japan is also studying how to replace four older Kongo-class destroyers while developing a fire control system network for all surface ships to share an integrated air picture or firing solution. That system should

provide an integrated picture linking Japanese sensors and munitions with those from the U.S.

To diversify its launch options, Japan has earmarked ¥30 billion for research into vertical launch systems for its submarines. These could mirror South Korea's KSS-III diesel-electric attack submarines, which are capable of firing tactical ballistic missiles and cruise missiles. If operationalized, these submarines could replace the destroyers and deliver Tokyo's strategic counterstrike capability closer to enemy territory.

Japan is upgrading other sensors, too, to address the evolving ballistic missile threat from North Korea and China, including their work on hypersonic glide vehicles. Tokyo plans to upgrade four J/FPS-5 and six J/FPS-7 long-range surveillance radars to improve threat detection. The Japan Aerospace Defense Ground Environment, Japan's version of the U.S.-Canadian North American Aerospace Defense Command, will be redesigned into a decentralized architecture to increase command structure resilience, especially in the event of a saturation attack. Tokyo plans to invest in a defense ministry cloud architecture to manage the decentralized functions.

New space technologies are planned to complement hypersonic missile tracking. The government seeks ¥3.1 billion, per its latest budget request, for new high-speed image-processing and gimbal technology to detect and track hypersonic glide vehicles.

Tokyo also has allocated ¥3 billion to acquire loitering munitions alongside long-endurance uncrewed aerial systems and ship-based drones.

In the air, Japan remains committed to purchasing Lockheed Martin F-35A and F-35B fighters. The short-takeoff-and-vertical-landing F-35B will operate from two newly converted JMSDF carriers, the Izumo and the Kaga. The JMSDF at the end of August completed an exchange with the Italian Navy to observe and learn from F-35B operations aboard the Italian carrier Cavour.

To streamline pilot training for modern fighters like the F-35s, the Japan Air Self-Defense Force is revamping its trainer aircraft fleet. The latest budget opens the door for the Fuji T-7 basic trainer replacement, in turn augmenting a project to replace the Kawasaki T-4 advanced jet trainers. 🌐

Competition Disappears for the UK's New Medium Rotorcraft Program

- > LEONARDO MIGHT WIN THE CONTRACT BY DEFAULT
- > A REDUCED REQUIREMENT FOR THE HELICOPTERS MAKES THE PRODUCTION ECONOMICS CHALLENGING

Robert Wall London

When the UK launched a high-profile helicopter modernization effort more than two years ago, it expected as many as five bidders to battle for the contract. The Defense Ministry has ended up with just one.

Airbus and Lockheed Martin have pulled the plug on their efforts to supply the UK with a new fleet of medium rotorcraft, leaving Leonardo as the sole bidder. Airbus says that after reviewing the invitation to negotiate issued in February to three companies, it concluded that it was “unable to formulate a responsible bid that would in parallel satisfy the customer’s requirements and provide adequate long-term returns to the business while implying a reasonable prospect of winning.”

Lockheed “elected not to submit a response to the New Medium Helicopter [invitation to negotiate] as we could not meet its minimum requirements in today’s market conditions,” the company’s UK subsidiary stated.

When asked for final bids, the UK said the program would be worth about £1.2 billion (\$1.6 billion). Airbus and Lockheed dropped out at the proposal deadline of Aug. 30. Leonardo says it submitted a proposal matching the UK’s needs in terms of platforms, timeline and budget.

This development comes as the latest twist in the UK’s effort to replace the Royal Air Force’s Airbus H215 Puma and AS365 Dauphin fleets and reduce the number of helicopter types it operates. The modernization program also once served to take the place of Bell 212 and 412 rotorcraft. The UK had phased those out and replaced them in the interim with Pumas. The country last year ordered six Airbus H145s, a type it was already using for training.

When the effort to launch the modernization program began, the UK said it was looking to buy up to 44 helicopters. Lawmakers later dis-

closed that the number had shrunk to “circa 30.” The scope of the program still remains in doubt because of the wide-reaching defense review that the new Labour government kicked off in July, results of which are not expected until next year.

Moreover, the helicopter program’s schedule has shifted. The UK had once hoped to field the new rotorcraft by January 2025. Now even the bid eval-

scale complicated the business case for UK assembly.

Leonardo said it would produce the A149, capable of carrying 16 fully equipped troops, at its existing facility in Yeovil, England. The fate of the UK’s historic helicopter production site—which belonged to Westland before that business was acquired by the Italian company that is now Leonardo—has long been a politically charged issue in the country. Leonardo promised to build helicopters for export at Yeovil; Airbus considered a similar commitment as part of its bid. The UK made considerations such as export potential a key plank of the program to underpin its defense industrial ambitions.

“We believe that the outcome of this procurement as it stands would not be able to deliver on current defense



MICHAEL PRESTON/ALAMY STOCK PHOTO

Leonardo has emphasized its historic UK ties to secure the UK Defense Ministry helicopter order.

uation and contract talks are not expected to be concluded by then.

Airbus, effectively the incumbent, was looking to offer the H175M helicopter. Leonardo has promoted the AW149 while Lockheed’s Sikorsky was in the race with the S-70M Black Hawk.

Over time, the competition became a political game about how best to promise local production in order to address UK Defense and Security Industrial Strategy demands. Airbus had proposed H175M final assembly at its site in Broughton, Wales, while Lockheed Martin had eyed Gosport, England, for the S-70M. However, the medium helicopter project’s reduced

industrial strategy objectives, particularly its ambition for long-term new jobs, opportunities for the UK supply chain and sovereign capability,” Airbus said in an Aug. 30 statement.

Leonardo played up its existing roots. “Because we have an established UK onshore helicopter design and manufacturing capability and a related domestic supply chain, we have been able to meet the [Defense Ministry’s] requirements,” Leonardo Helicopters UK Managing Director Adam Clarke stated.

Airbus and Lockheed said they were looking to work with the UK Defense Ministry on future efforts. 🌐

Poland Primes New Round of Defense Procurements

- > WARSAW'S NEXT FIGHTER BUY IS IN FOCUS AFTER LOCKHEED MARTIN F-35 ROLLOUT
- > HELICOPTER-MAKERS EYE POLISH TRAINING ROTORCRAFT PROCUREMENT

Robert Wall Kielce, Poland

Poland's defense acquisition efforts are starting to resemble a well-run, high-volume production line. Once a deal is done, another is in the works.

Whether in fighters, air defenses or other equipment, Warsaw's military modernization push keeps on humming. Underpinned by one of Europe's biggest military budget allocations, the country also is trying to build up its sovereign defense capabilities and looking to translate significant order volume into domestic maintenance and production capacities, as evidenced at this month's MSPO international defense industry exhibition.

Illustrating an unrelenting push to expand defense capacities, Warsaw is expected to decide on its next combat aircraft purchase early in the new year. That would come about five months after the Aug. 28 rollout of the first of 32 Lockheed Martin F-35 Joint Strike Fighters Poland agreed to buy in 2020. The aircraft are due to arrive in the country in 2026.

Poland's next competition also involves 32 fighters. Boeing is bidding the F-15EX, hoping to build on its success in Israel and Indonesia. The company could deliver the first F-15EX to Poland in late 2029 or early 2030, given the current backlog, says Marissa Myers, Boeing's head of fighter business development. The twin-engine fighter would integrate easily with Poland's F-35, she says, giving the country a mixed fleet to provide greater lethality.

Leonardo, which is leading the Polish campaign for the Eurofighter Typhoon consortium, argues that its aircraft's combination with the MBDA Meteor ramjet-powered beyond-visual-range air-to-air missile would better complement the F-35. The consortium would be able to deliver the first Typhoon to Poland 2-3 years after contract signing, says Costantino Panvini Rosati, Leonardo's vice president of strategic fighter campaigns. Lockheed Martin meanwhile asserts that Poland should not bother fielding a new aircraft type and instead should buy more F-35s.

The pace of deals also is unrelenting in rotorcraft. Poland agreed in August to buy 96 Boeing AH-64E Apache attack helicopters, the largest export order for the system. But industry is already gearing up for the next round of rotorcraft competitions as Poland looks to modernize its heavy-lift and training fleets.

Leonardo, which has already sold AW149s to Poland, is in the running for the training helicopter award with the AW109. Airbus is competing with the AH145, building on the type's success elsewhere in the region, including in Serbia and Hungary. The exact size of the program is still unclear, but it could involve the purchase of some 24 helicopters.

The rotorcraft situation also demonstrates that Polish defense purchases are not immune from local politics. The change in government following Donald Tusk's election as prime minister has slowed some decision-making, industry officials say, as prior decisions are under review.

Boeing formally declared at MSPO its plan to bid the CH-47 as a heavy-lift option to the Polish Armed Forces. Talks are still in an early stage, says Adam Hodges, Boeing's head of business development for vertical lift programs. The company is looking to offer the CH-47F Block II through the U.S. Foreign Military Sales process.

It is not clear if Poland will launch a formal competition. Warsaw has previously held talks with Leonardo about the potential purchase of AW101s to satisfy its needs for a heavy-lift helicopter. In neighboring Germany, where Boeing secured an order for 60 Chinooks, the company

faced competition from Lockheed Martin with the CH-53K.

Sizable orders and relatively attractive labor costs have helped Warsaw attract industrial partnerships with many of its defense acquisitions. Pratt & Whitney is hoping its history in the country will provide an opening to break into the F-15EX market if Boeing prevails in the fighter competition. GE Aerospace is the incumbent on that aircraft with the F110.

Pratt has a sizable footprint in Poland from F100 work it placed there when Warsaw acquired Lockheed Martin F-16s more than two decades ago. Josh Goodman, the senior F100 program director, says the scope of work would increase meaningfully if Poland opts for the Pratt engine in an F-15EX deal. The engine-maker would expand the work packages in the country to give the Polish Air Force sovereign sustainment capabilities, he said, adding that efforts to certify the engine for EX use would be limited. GE says its engine will be available and stresses its in-country work, which is expanding in part because its engines power the AH-64Es.



LOCKHEED MARTIN

The first Polish F-35 Joint Strike Fighter has just rolled out, but Warsaw is looking at what comes next.

Companies already are eyeing the next modernization cycle. Northrop Grumman signed industrial agreements with Polish companies around its E-2D airborne early warning (AEW) aircraft, even though Poland only recently took delivery of two Saab 340-based platforms. Warsaw has said the Swedish aircraft is an interim system but has not spelled out when it may pursue a long-term solution.

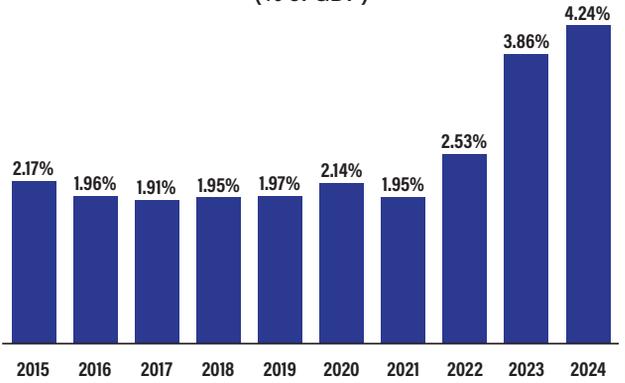
Saab is betting Poland may follow the path of the United Arab Emirates, which fielded an interim product from the company before becoming the launch customer for its GlobalEye AEW platform. Boeing, which is looking to sell its E-7 Wedgetail to NATO, has its eye on the Polish requirement as well.

Poland also has expressed interest in buying air-to-air refueling aircraft. Boeing has briefed the country on the KC-46A, while Airbus has held talks around the A330 Multi-Role Tanker Transport (MRTT), specifically the A330neo-based MRTT+, which uses Trent 7000 engines to provide greater fuel-offload potential or range.

Airbus sees Poland as a buyer at some point of A400M transport aircraft, not only for military operations but also to support missions such as evacuation of nationals. Warsaw relied on Spain to pull Polish nationals out of Sudan in 2023 as the African country plunged into civil war.

Poland's appetite goes beyond platforms. It is investing heavily in air and missile defenses and weapons. Lockheed Martin expects Warsaw to buy more Javelin anti-tank missiles, for instance, and has opened early talks with the

Polish Defense Spending Ramp-Up (% of GDP)



Source: Aviation Week Network

country about the Precision Strike Missile short-range ballistic missile system.

MBDA, which has sold several air and missile defense systems to Poland involving the Common Anti-Air Modular Missile—both in baseline and extended-range configurations—is in talks with Warsaw about launching a medium-range version of the interceptor, possibly as a cooperative effort with the UK. 🌐

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NETWORK

DOWN TO EARTH

- > MORE WORK LIES AHEAD FOR BOEING STARLINER
- > THE CALYPSO FLIGHT TEST ENDS WITHOUT CREW
- > STARLINER TEST PILOTS TRANSFER TO SPACEX CREW-9 MISSION

Irene Klotz Cape Canaveral and **Mark Carreau** Houston

Boeing's CST-100 Starliner Calypso completed a second star-crossed flight test, touching down in the New Mexico desert with the empty seats and spacesuits of the two NASA astronauts who were pulled from the return trip to Earth due to safety concerns.

Time will tell if the mission was sufficient to proceed with Starliner certification for International Space Station (ISS) crew ferry flights, possibly as early as August 2025.

Boeing has spent four years and \$1.5 billion more than planned to reach the Starliner Crew Flight Test (CFT) aboard Calypso, one of two spacecraft the company designed and built to fulfill its fixed-price, milestone-based flight service contract with NASA. The agreement, which includes up to six operational ISS crew rotation missions, is currently worth \$4.4 billion. Boeing's total investment in the program has not been disclosed.

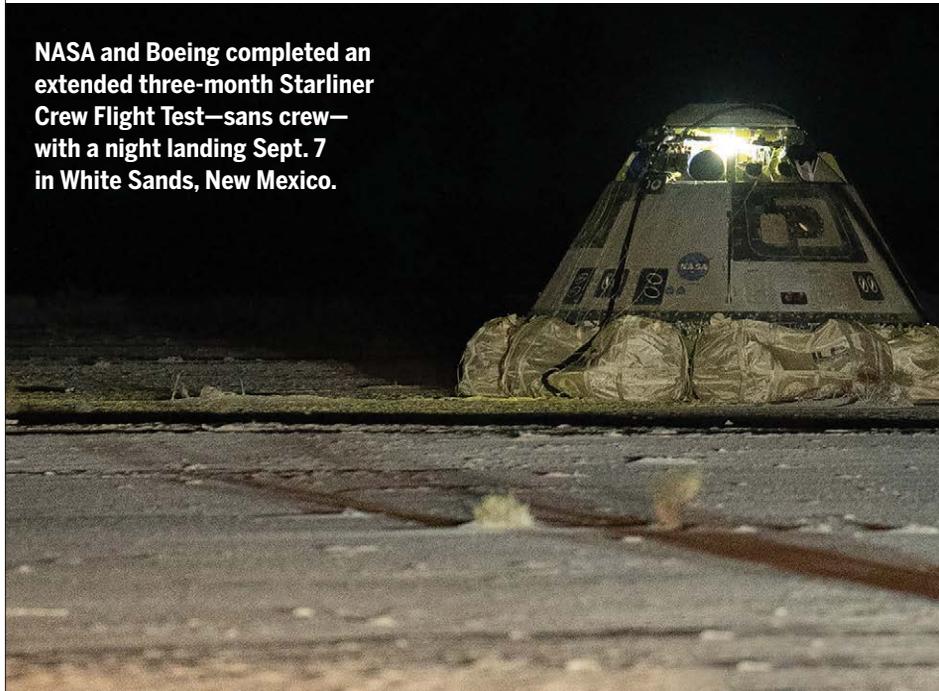
Calypso debuted in December 2019 for what was expected to be a week-long, uncrewed test run to the ISS. That mission lasted just two days due to software and communications problems that caused the spacecraft to miss its engine burn to reach the ISS. Calypso's unnamed sisterships conducted a follow-up mission in May 2022, paving the way for the CFT.

After additional delays to address parachute and tape flammability concerns, Calypso was launched again on June 5 with veteran NASA astronauts Barry "Butch" Wilmore and Sunita Williams aboard. The spacecraft docked at the station the following day for a planned 7-14-day stay.

Three months later, Calypso departed the ISS—without its crew because of NASA safety concerns about the ship's propulsion system. Problems surfaced during the spacecraft's automated approach to the ISS, when five reaction control system (RCS) thrusters were sidelined by the flight

computer due to what was later determined to be overheating. All but one of the jets were recovered, and Calypso was able to make an automated docking one orbit later.

NASA and Boeing completed an extended three-month Starliner Crew Flight Test—sans crew—with a night landing Sept. 7 in White Sands, New Mexico.



The thruster problems followed a series of small helium leaks in the system that pressurizes the Starliner's RCS jets and larger orbital maneuvering and attitude control (OMAC) system thrusters. Boeing concluded that the leaks resulted from a slight degradation of seals that had been exposed to corrosive propellants. Despite the leaks, the Starliner left the ISS with 10 times more helium than was needed for the return trip to Earth.

"One of the things we're looking at is a different material on the seal, and maybe a different, slightly enlarged seal to make that seal better so that we can solve the issue with the helium leaks," Steve Stich, NASA's Commercial Crew Program manager, told reporters during a pre-landing news conference.

As for the troubled thrusters, engineers suspect the jets overheated because of a manual flying exercise ahead of docking that caused the suspect RCS jets to fire hundreds of times in quick succession while in direct sunlight. Engineers believe the overheating caused Teflon seals in the jets' poppet valves to swell temporarily, restricting the flow of fuel. Later tests showed that the jets worked as designed, indicating that the seals had returned to normal or near-normal shape.

"We need to understand what kinds of pulses caused that swelling . . . and what temperatures the thruster gets to," Stich said. "Then, how do we tell the

vehicle not to fire the thruster in that manner to cause the extra heating?"

With the clocking ticking for the next ISS crew ferry flight—and Calypso docked in its parking spot—NASA on Aug. 24 announced that it was not fully comfortable with Boeing's work showing that the Starliner thrusters would perform as planned for the undocking and deorbit maneuvers. The agency transferred Wilmore and Williams to the ISS resident staff, giving both an unexpected third long-duration mission that will last until February 2025.

The astronauts watched as the Starliner departed the station at 6:04 p.m. EDT Sept. 6, marking the end of their roles as test pilots for the spacecraft. "She's on her way home," Williams

radioed to ground control teams as Calypso passed beyond the station's safety zone.

Wilmore and Williams will join the upcoming SpaceX Crew-9 crew, replacing two astronauts who had been assigned to the mission since January. Until the Crew-9 Dragon arrives around Sept. 25, Wilmore and Williams' emergency ride home—should an evacuation be necessary—is the SpaceX Crew-8 Dragon capsule, which has been outfitted with temporary seats on a cargo pallet in the crew cabin's middeck.

Calypso's journey back to Earth began with the opening of 12 hooks latch-



ing the spacecraft to the forward port of the Harmony module. That allowed springs on the Starliner's docking ring to push the spacecraft away from the station, a demonstration of the hardware NASA's Orion crew capsule will employ during Artemis Moon missions.

At 16 ft. from the ISS, sailing 260 mi. over central China, Calypso fired a pair of RCS jets to pick up speed, setting the stage for a dozen short burns over the next 5 min. to move the capsule up, over and behind the ISS. The maneuvers increased the separation between the Starliner and the ISS by 13.7 mi. per orbit.

The so-called breakout burn was designed to minimize the number of thruster burns and move the vehicle away from the station about twice as

fast as was previously planned with crew onboard.

Unlike Calypso's June 6 approach to the ISS, the thrusters operated flawlessly during the departure maneuvers, as Boeing predicted. The spacecraft circled the planet in free drift four times, then ignited four OMAC system thrusters at 11:17 p.m. to drop out of orbit.

The 59-sec. burn slowed Calypso by 426 ft./sec., setting up a south-west-to-northeast trajectory over the Pacific Ocean, Mexico's Baja Peninsula, the Gulf of California, northern Mexico and finally into New Mexico for a landing at NASA's White Sands Space Harbor at the U.S. Army's White Sands Missile Range.

During a final test before leaving orbit, 10 of the Starliner's 28 RCS thrusters on the soon-to-be discarded service module were fired, all successfully. Another 12 RCS thrusters on the returning crew module also were tested, with one failing to fire as commanded, an issue that is under investigation. A second up-firing thruster provided redundancy.

Calypso released its service module as planned at 11:20 p.m. for a destructive reentry in the atmosphere. As the spacecraft neared the end of its plunge through the atmosphere, its guidance, navigation and control (GNC) system failed briefly but then came back online. The spacecraft's sublimator, or cooling system, functioned satisfactorily during reentry, although it had experienced some difficulty during the capsule's June 5 launch.

At an altitude of about 24,500 ft., two small drogue parachutes unfurled to slow the Starliner's descent and stabilize the ship. At about 8,000 ft., a trio of pilot parachutes deployed to pull out the Starliner's three 104-ft.-dia. main parachutes, slowing the spacecraft's speed to about 18 mph. About 2,500 ft. above the ground, airbags inflated to mitigate the force of the touchdown, which occurred at 12:01 a.m. EDT Sept. 7 (10:01 p.m. Sept. 6 local time) to bring the three-month CFT mission to a close.

The extra time in orbit gave Boeing a head start on work that will be needed before the Starliner flies again. "I want to recognize the work the Starliner teams did to ensure a successful and safe undocking, deorbit, reentry and landing," Mark Nappi, vice president and program manager

of Boeing's Commercial Crew Program, said in a statement. "We will review the data and determine the next steps for the program."

Boeing has declined interview requests and did not attend a CFT post-landing press conference.

"A safe and successful landing was exactly what we wanted," Joel Montalbano, deputy associate administrator for NASA's Space Operations Mission Directorate, told reporters after the landing. "We did learn a lot. It's important to remember this was a test mission."

"Many parts of the flight went extremely well, and Starliner is a great spacecraft," Stich told reporters during a pre-landing press conference. "What we really need to go do is look at the things that didn't perform the way we expected."

NASA intends to press ahead with a joint evaluation of the spacecraft's performance while laying out a strategy to forge ahead with any additional development and testing. "We are going to take our time to figure out what we need to do to go fly Starliner-1," Stich said after Calypso's safe return. "I think we will see where we are at in another month or so, and then we will have a little bit better idea of what the overall schedule will be."

Stich says Boeing has formed teams to look into upgrades to the Starliner, which is to be transported from White Sands to NASA's Kennedy Space Center for a thorough post-flight evaluation that will be backed up with ground testing.

Among the priorities Stich listed are upgrades to the flanges in the RCS jets to make them more resistant to the hypergolic propellants and possibly also make the flanges larger. NASA and Boeing also are looking to upgrade the thermal control of the "doghouses," or manifolds that house the RCS and OMAC thrusters. Changes to the spacecraft's GNC system to manage the thruster firings better are being considered as well to reduce structural stress. "That is really the path to Starliner-1," Stich said.

"Obviously, there's some work we need to do on Starliner," Montalbano added. "Is it slower than we expected? Absolutely . . . but we are making progress. Every time we have a mission, we learn something that gets passed on. We are sharing things across the commercial world." 🚀

Startups Push To Introduce Metal Propellants for Spacecraft

- > THE SOLIDS ARE CHEAPER AND EASIER TO STORE THAN GASES
- > METALS COULD BE HARVESTED FROM SCRAPPED SPACECRAFT OR LUNAR REGOLITH EVENTUALLY

Garrett Reim Logan, Utah

Move aside, xenon, krypton and argon. There is a new, heavier-weight class of spacecraft propellant: metals.

This year, several startups are testing electric thrusters that run on metal propellants. The companies say the hard stuff packs a greater punch for its volume and is cheaper and easier to handle than conventional gases.

[into a thruster] in a reliable way and how to keep your power budget low enough that you can run a 400-watt Hall-effect thruster system and not spend 300 of those watts vaporizing propellant," Starlight Engines CEO Todd Bailey told Aviation Week.

How Starlight Engines' Crucible system feeds zinc into the thruster is a company secret, but the metal is

years and then turn it on when it's time to deorbit."

Benchmark Space says its Xantus propulsion unit is attracting interest. "We've delivered on the order of 15 this year and have another 15 to deliver [this year]," Chief Commercial Officer Christopher Carella said at the Small Satellite Conference here in August.

Because of metal's greater mass and thrust potential, less of it needs to go to space, freeing up room on a satellite. Benchmark Space uses that extra volume to store additional propellant for a chemical propulsion unit as part of an integrated hybrid system.

In the long term, Benchmark Space sees metal propellant systems potentially being able to harvest scrap metal in space for fuel. "We've actually demonstrated at NASA Glenn [Research Center using] copper, magnesium, stainless steel [and] aluminum elements you might find in space or off spacecraft [for fuel]," Carella said at the Small Satellite Conference.

The holy grail of metal thruster propellants is bismuth, with its high atomic mass and very weak radioactivity.

Starlight sees metals contained in the regolith on the Moon or Mars as potential fuel sources as well.

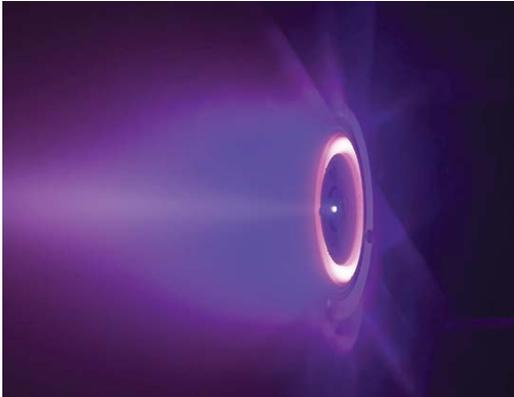
"The holy grail of all thruster propellants is bismuth," Hopkins says. "The bismuth Hall thruster has been a thing that everyone has been trying to do since 1970."

Bismuth is the heaviest element known without harmful radioactivity. "It has a very high ionization cross-section, which is to say it wants to be an ion," Hopkins explains. "Because it has such a high atomic mass, you get a really great thrust-per-unit power."

But using bismuth would require a lot more wattage, which is less practical in the near term. Starlight's long-term ambition is to see terrestrial metal propellants push spacecraft around the Solar System, Bailey says.

"Any of the hopes and dreams about asteroid mining or moving cargo back and forth between planetary bodies requires fundamentally different propulsion systems than what we have right now," he says. "There are good Hall-effect thruster propellants out there. They're in the Earth's crust. There's no reason that you can't use them." 🌌

STARLIGHT ENGINES



In March, propulsion company Benchmark Space Systems launched its Xantus plasma thruster system, which uses molybdenum as a propellant, on Orion Space Solutions' 12U cubesat. In August, Neumann Space and the University of Melbourne announced the successful completion of on-orbit tests of the Neumann Drive, an ion thruster that also uses molybdenum, on a nanosatellite. And in January, Starlight Engines plans to test its Crucible Hall-effect thruster on orbit using zinc propellant.

Metal propellants work inside electric propulsion systems in a similar way to gaseous propellants: After being vaporized, they are ionized and then accelerated out the back of the system using an electrical field. Because metal propellants have greater atomic weight, the elements require less storage volume to generate equivalent thrust.

"The real lion's share of the work is figuring out how to feed solid metal

stored as a solid chunk, Chief Technology Officer Mark Hopkins says.

"The trick was figuring out how to vaporize only the propellant that you need to vaporize and how to use the waste heat of the thruster as much as you can," Bailey says.

Advocates note that metal propellants are cheaper than their gaseous competitors, as well as less toxic and easier to store in a propulsion unit. "You can ship a system fully fueled; you can [vibration-test] a system that's fully fueled," Bailey explains.

Starlight's Crucible propulsion system nominally runs on 400 watts but can be throttled up or down depending on available power. It can generate 1,200-1,400 sec. of specific impulse. The Hall-effect thruster is best suited for satellites weighing 100-400 kg (220-880 lb.) and used for orbit-raising, station-keeping or deorbiting, the company says.

"It has a great storage life," Bailey says. "You can leave it up there for five

Boeing Entanglement-Swapping Test Is Critical for Quantum Network

- > QUANTUM TECH COULD ENABLE TASKS CONSIDERED IMPOSSIBLE
- > THE Q4S SATELLITE WILL TEST HOW THE SPACE ENVIRONMENT AFFECTS QUANTUM ENTANGLEMENT SWAPPING

Garrett Reim Seattle

Teleportation is the dream of science fiction TV shows like “Star Trek,” but Boeing soon plans to demonstrate the concept in a real, albeit smaller, way.

The aerospace company plans to launch its Q4S satellite in 2026 to demonstrate quantum entanglement swapping, a process in which two pairs of quanta—in this case, photons—become linked so that a change to one immediately affects the other, no mat-

ter their distance apart. The “spooky action at a distance” phenomenon, as Albert Einstein called it, allows for quantum transfer of information.

Earth, connected with a quantum network, could go and image one of the rovers on Mars,” says Makan Mohaegg, principal applied quantum physicist at Boeing. “It’s really wild.”

Boeing’s Q4S satellite is named after the four photons that it will attempt to entangle. To do that, its system will use a process called spontaneous parametric down-conversion, in which a laser beam is passed through a nonlinear optical crystal to

cal quantum communications network still would require classic communications tools such as a laser terminal or radio to transmit the results of what is known as the Bell state measurement to quantify the photons’ state.

Boeing has demonstrated quantum entanglement swapping on tabletop experiments at HRL Laboratories, a research facility in Malibu, California, that it operates with General Motors Co. Its satellite demonstration will test how the harsh environment of space, including radiation, affects entanglement swapping. The company also is testing a quantum entanglement-swapping protocol to enable it to scale a future communications network.

Although Boeing builds a variety of satellites, it chose to host its quantum entanglement-swapping payload on a small spacecraft developed by Astro Digital. That satellite can provide 70-80 watts of continuous power, which is critical for the project. The Q4S satellite will operate in a sun-synchronous orbit at about 550 km (340 mi.) in altitude.

Prior quantum satellite demonstrations by China, for instance, have shown the ability to perform Quantum Key Distribution in space, a system in which single-photon states or entangled photon pairs are used to generate and distribute encryption keys securely. Boeing contends that its quantum entanglement-swapping experiment is more complex and has a greater potential impact.

In addition to quantum telescopes and boosting the capabilities of quantum computers, the company sees a quantum network as useful for “exceedingly precise time synchronization,” says Jay Lowell, chief engineer for Boeing’s Disruptive Computing, Networks & Sensors organization. “Entanglement collapses at a very small time overlap. We’re talking less than a couple hundred femtoseconds.” More precise timing could be used for positioning, navigation and timing technologies, for example.

Boeing is bullish on quantum communications and is spending internal R&D funds on the Q4S experiment, Lowell adds.

“We’ve put this as one of the cornerstones of our quantum portfolio strategy,” he says. “We’re making a big bet on quantum technology.”

BOEING CONCEPT



split one photon into a pair of entangled photons. After creating two pairs of photons, a photon from one pair is then entangled with a photon from another, thus swapping entanglement between the two sets.

In a future quantum communications network, if two sets of photons (A-B and C-D) were paired at distant locations and then one of each pair (B and D) was sent via laser communications to a satellite, the entanglement of those photons at the satellite simultaneously would entangle those left on Earth (A and C). A hypotheti-

cal quantum communications network still would require classic communications tools such as a laser terminal or radio to transmit the results of what is known as the Bell state measurement to quantify the photons’ state.

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SMALL CHANGE



- > U.S. SPACE FORCE RESHAPES SMALL-LAUNCHER PROGRAM
- > LAWMAKERS ARE CONCERNED ABOUT THE IMPACT ON EMERGING LAUNCH PROVIDERS
- > RSLP IS “GOING BACK TO OUR HERITAGE”

Vivienne Machi Los Angeles

The U.S. Space Force is reverting the 1970s-era Rocket Systems Launch Program back to its customer-funded roots. But Congress is concerned that the shift will affect the small-launch market.

Lawmakers used the Senate Appropriations Committee’s fiscal 2025 defense markup, released on Aug. 1, to express concerns that although the Space Force and the National Reconnaissance Office have small-launch service contracts in place, “they are rarely used. . . . In a threat environment that requires tactical responsiveness, small-launch providers are most likely to provide this capability,” the markup states.

Senate appropriators also criticized the fact that the Space Force will launch only one payload through the fiscal 2024 Orbital Services Program (OSP) and requested no funds for the program’s fiscal 2025 budget. Lawmakers called the program “critical to having a rapidly responsive launch capability and to maintaining a competitive and innovative industrial base.”

Space Force officials say that this

funding shift is by design and that the OSP, which sits under the Rocket Systems Launch Program (RSLP), is not intended to maintain a steady funding stream.

The Defense Department established the Advanced Ballistic Missile Reentry Systems program in 1963 to manage the reutilization of deactivated ICBM assets and to perform reentry vehicle research. That effort evolved in 1972 into the RSLP program, which has provided launch options for missions with payloads weighing 400 lb. or more using retired Minuteman and Peacekeeper rocket motors, along with commercially acquired small-launch vehicles. The goal is to launch within 18-24 months, once the effort is on contract.

Historically, the RSLP procured launch services for such government partners as the U.S. Air Force, Missile

Defense Agency, National Reconnaissance Office, U.S. Army and NASA on a case-by-case, customer-funded basis. But starting in 2019, the program included regular funding in its annual budget to support one or two launches per year, primarily in support of the Space Test Program (STP).

The RSLP received about \$39 million in procurement funds in fiscal 2023 and nearly \$75 million in fiscal 2024, but the Space Force zeroed out procurement dollars for the program in its fiscal 2025 budget request.

This funding shift “is really going back to our heritage” as a flexible contract provider that can support a very specific suborbital or orbital launch need, says Lt. Col. Steve Hendershot, chief of Space Systems Command’s Small Launch and Targets Division. “We are just doing it on a cost-reimbursable order.”

The Space Force conducted nine RSLP launches for both suborbital and orbital missions from 2022 to June of this year. Two of those launches were funded by the program office—the service’s STP-S28A mission launched by Virgin Orbit in 2022,

Rocket Lab will launch the STP-30 mission on an Electron launch vehicle under the Orbital Services Program-4, part of the Space Force's Rocket Systems Launch Program.



ROCKET LAB

and the Victus Nox tactically responsive space mission in September 2023. The other seven were customer-funded, Space Force data shows. The service plans to launch four more STP missions before 2027.

It is now time for the STP program to stand on its own legs, says Col. Doug Pentecost, deputy program ex-

ecutive officer for Space Systems Command's Assured Access to Space.

"We've determined that the Space Test Program—which is the primary use of this RSLP funding line—[needs] to build a budget for their own mission and focus on their capabilities," he says.

Small-launch vendors can still bid for the RSLP opportunities via the OSP pathway. In July, the service awarded new contracts to Blue Origin and Stoke Space, allowing the two companies to compete for OSP-4 task orders alongside 10 other vendors: ABL Space Systems, Aevum, Astra Space, Firefly Space, Northrop Grumman, Relativity Space, Rocket Lab, SpaceX, United Launch Alliance (ULA) and X-Bow. The OSP-4 contract has a \$986 million ceiling, and orders are scheduled to take place through October 2028. Although OSP missions are typically focused on small-launch capabilities, there is no upper limit on the size of launch vehicles available to compete on the contract.

The service awarded one OSP launch under its fiscal 2024 budget to Rocket Lab in April for STP-S30. The dedicated Electron launch will take place by the third quarter of fiscal 2026, from the Virginia Spaceport Authority's Mid-Atlantic Regional Spaceport within the NASA Wallops Flight Facility. It will carry the experimental DiskSat spacecraft, a 1-m-dia. (3.3-ft.), plate-shape satellite bus developed by the Aerospace Corp.

The RSLP program will continue to receive R&D funding. The Space Force anticipates requiring \$20-21

million per year in research, development, test and evaluation funds for RSLP across the five-year Future Years Defense Program, fiscal 2025 budget documents state. Those funds are used to secure and store decommissioned ICBMs and facilitate their reutilization for launch services. RSLP also uses congressional funding to enhance launch capabilities at state-owned spaceports, including Virginia's Mid-Atlantic Regional Spaceport and the Pacific Spaceport Complex-Alaska on Kodiak Island.

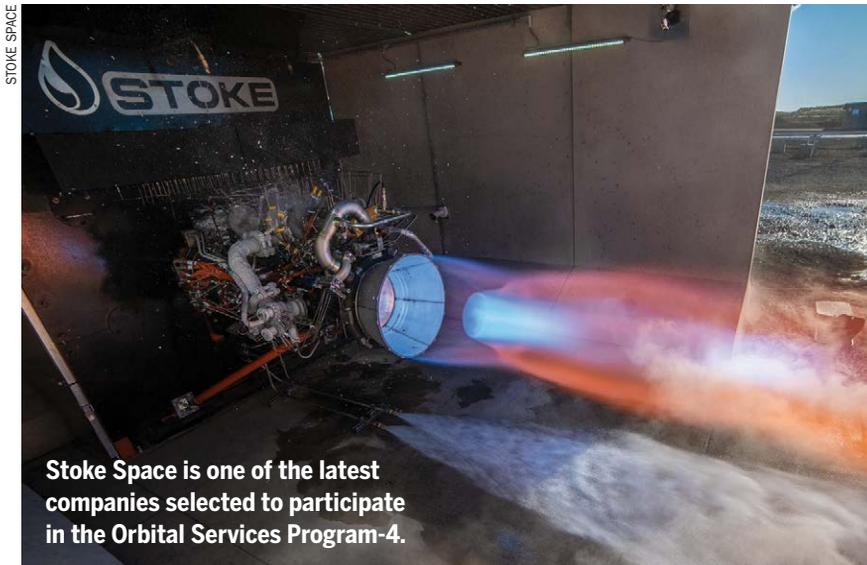
Emerging launch service companies also have a new contract vehicle to get involved with the Space Force since the service divided the National Security Space Launch (NSSL) Phase 3 into two lanes this year. Lane 1 missions are open to launch providers with just one proven flight that are willing to accept a higher risk of failure and include lighter payloads going to less-challenging orbits.

Blue Origin, SpaceX and ULA won the first three Lane 1 contracts in June as the only three competitors whose rockets have either reached orbit or—in the case of Blue Origin—presented a plan to launch an orbital-class rocket successfully by the end of 2024. The Space Force plans to open up Lane 1 to new vendors once a year, as rocket-makers mature their systems. The service is going through source selection for the first Lane 1 task orders. The three current vendors are eligible to compete for up to 30 launches until June 2029 through a firm-fixed-price (FFP), indefinite-delivery/indefinite-quantity (IDIQ) contract worth a maximum of \$5.6 billion.

Meanwhile, Lane 2 is a direct follow-on to the ongoing NSSL Phase 2 program—served by ULA and SpaceX—with the same launch vehicle certification requirements and the ability to fulfill the full range of NSSL mission profiles. The Space Force plans to award contracts for Phase 3 Lane 2 by the end of 2024, Pentecost says.

The RSLP program is complementary to the NSSL construct by providing small launch and targets for a range of missions, but the former has the explicit goal of enabling a launch within two years of contract award. RSLP launches also do not require the NSSL certification process.

On the civil space side, NASA's Launch Services Program at Kennedy Space Center runs a similar initiative



STOKE SPACE

Stoke Space is one of the latest companies selected to participate in the Orbital Services Program-4.

called the Venture-Class Acquisition of Dedicated and Rideshare Launch Services (VADR) program. The VADR setup is intended to provide a broad range of commercial launch services capable of delivering Class D, cubesats and higher risk-tolerant payloads to a variety of orbits, and it features a roster of vendors similar to the RSLP.

The VADR contracts are FFP, IDIQ procurements with an ordering period through February 2027 and a maximum total value of \$300 million across the program. It builds upon previous procurement programs, including the Venture-Class Launch Services (VCLS) and VCLS Demo 2.

Fourteen companies are now eligible to compete for the VADR task or-



The Rocket Systems Launch Program dates back to 1972 and provides access to space for the U.S. military space R&D community.

U.S. SPACE FORCE

Pentagon's Marquee LEO Constellation Prepares To Go Operational

- > SPACE DEVELOPMENT AGENCY IS BUILDING OVER 150 SATELLITES UNDER TRANCHE 1 CONTRACT
- > AGENCY STILL NEEDS FAA APPROVAL TO USE LINK 16 OVER NATIONAL AIRSPACE

Vivienne Machi Los Angeles

The U.S. Space Force is months away from sending the first operational satellites for its signature proliferated constellation into low Earth orbit.

If all goes to plan, it will be a watershed moment for U.S. military acquisition and provide a trove of space-based capabilities to warfighters. First, it needs to be approved by the FAA.

The Space Development Agency's (SDA) Proliferated Warfighter Space Architecture (PWSA) was conceived in 2019 as a vast, low-Earth-orbit-based constellation of sensors that perform seamless data communications, track hypersonic and cruise missiles, and provide enhanced battle management and alternative navigation services via layers of satellites that are replenished every half decade.

The agency is fielding the PWSA through a spiral acquisition model, recompeting two layers of transport and tracking assets over two-year tranches as new technology and capability needs come online.

In 2023 and early 2024, less than three years after contract awards were issued, the SDA launched 27 Tranche 0 satellites. Nineteen spacecraft make up the nascent Transport Layer, with 10 built by Lockheed Martin and nine by York Space Systems. The Tranche 0 Tracking Layer includes eight spacecraft, split between SpaceX and L3Harris Technologies. Those systems are being used to demonstrate

Link 16 from space to ground and air systems and intersatellite laser communications (page 36).

The next tranche involves a sizable jump in satellite units, as the agency targets an operational constellation. Tranche 1 includes 156 space vehicles: 126 satellites for the transport layer, split among York Space Systems, Lockheed Martin and Northrop Grumman; and 30 satellites for the Tracking Layer, with Northrop Grumman building 14 and L3Harris contracted for 16 systems.

The SDA originally planned to launch the initial Tranche 1 spacecraft starting this fall, but production hiccups from Tier 3 suppliers pushed the timeline to year-end, SDA Director Derek Tournear says. He expects to procure 10 launches for Tranche 1 satellites under the National Security Space Launch contract—at a cadence of about one launch per month—and anticipates that the satellites will reach operational acceptance by the end of 2025.

For that to occur, the SDA must first receive approval from the FAA to deploy Link 16 from orbit over national airspace. The civil agency has yet to grant that approval, which has forced the SDA to conduct recent Link 16 tests over international waters and allied airspace in Australia.

The SDA is undergoing electromagnetic compatibility features certification via the Naval Information Warfare Systems Command (Navwar), Tournear says. Link 16 shares the same spectrum as certain GPS signals, and features are built into Link 16 radios that will automatically shut them down if they are suspected of interfering with navigation signals.

The FAA said in a statement that it is “collaborating with several federal agencies to understand the unique compatibility issues as we continue to work to ensure the safety of the national airspace system.”

The aviation regulator has indicated that it will grant a temporary frequency authorization that would allow the SDA to broadcast over national airspace, but only after Navwar has completed the certification tests, Tournear says. If the FAA does not issue a waiver by early 2025, Tranche 1 demonstrations will be affected, leading to delays in operational acceptance.

The SDA's hardware deliveries have been hampered by

ders; the most recent three—Arrow Science and Technology, Impulse Space and Momentus Space—joined the program in August. Other current VADR vendors include ABL Space Systems, Astra, Blue Origin, Firefly, L2 Solutions, Northrop Grumman, Phantom Space, Relativity Space, Rocket Lab, SpaceX and ULA.

While the government continues to be the primary investor in space—and thus launch—technologies, rocket startups have remained buoyed by venture capital investments. Stoke Space, a vendor for the OSP-4 program and an unsuccessful bidder for NSSL Phase 3 Lane 1, raised \$100 million in Series B investments in 2023. Meanwhile, Impulse Space—one of three new vendors for the NASA

VADR program—raised \$45 million in Series B funding last year.

Despite the healthy flow of venture capital investment into the launch market, it is still vastly overshadowed by government contracts. Outside the U.S., the European Space Agency's Flight Ticket Initiative is also working to stimulate the small-launch market, supporting such companies as Isar Aerospace and Rocket Factory Augsburg.

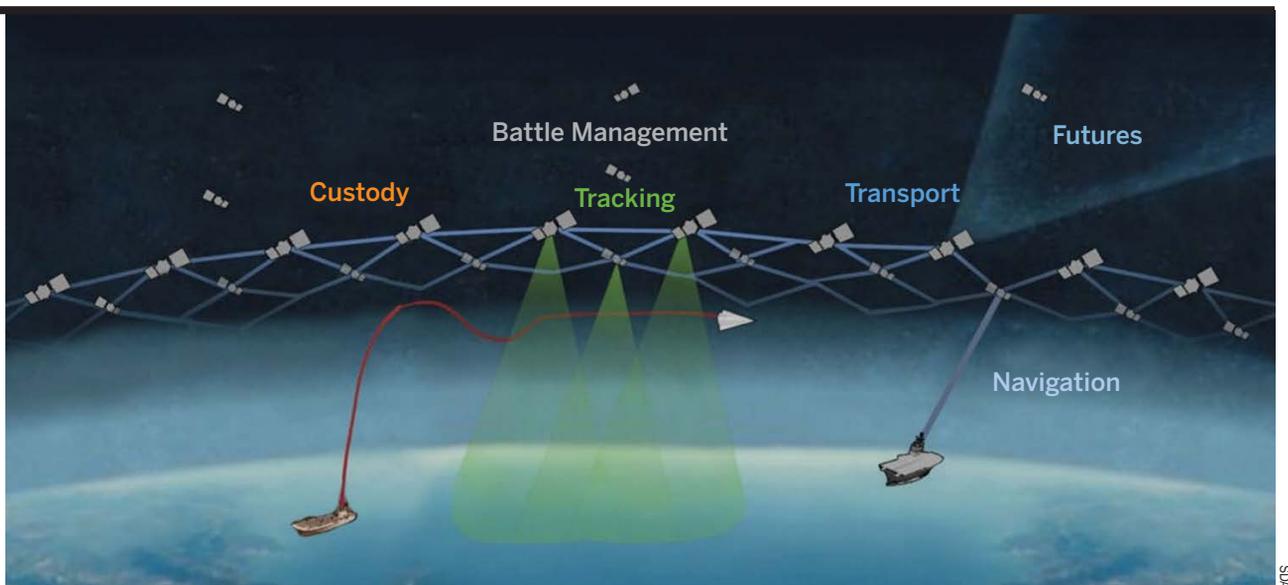
The Space Force might consider itself less as a supporter of the emerging commercial launch market writ large, even if that is the ultimate outcome of its programs, says Dallas Kasaboski, principal analyst with NSR, an Analysys Mason company.

“What they might be supporting is

additional types of service, security and reliability, which happens to be something that a lot of the new and emerging players are pursuing as a way of differentiating themselves compared to the very competitive established players,” he says.

While one of the goals of the RSLP is to boost small-launch suppliers, “at the same time, we also don’t want to be the market driver and pick winners and losers,” Pentecost says.

The one or two STP missions per year cannot be the primary driver by which a small-launch company survives or not, he adds. “We want to take advantage of the diversity of the launch market and support it,” Pentecost says. “We also want to put capability in space and focus our funding there.”



The PWSA is planned to include hundreds of on-orbit sensors performing data communications seamlessly, tracking hypersonic and cruise missiles and providing enhanced battle management, navigation, ground support and deterrence from space.

supply chain hiccups for subcomponents like the optical communication terminals (OCT), which are key to connecting the PWSA's Transport Layer. German OCT provider Mynaric, which supplies a number of SDA vendors, recently dismissed its CEO, Mustafa Veziroglu, as the company struggled to scale up production and to rein in development costs for its Condor Mk. 3 laser terminals.

The SDA is working to minimize these supply chain growing pains for future tranches, Tournear said Sept. 5 at the Defense News Conference in Washington. The agency was approved to begin Tranche 3 solicitations six months ahead of the original schedule, in part to give the supply chain more breathing room before launches for that tranche begin around 2028.

Meanwhile, work is moving ahead for the SDA's Tranche 2 satellites. That represents yet another leap in unit numbers—264 space vehicles in total, of which 210 are dedicated to the Transport Layer—with added capabilities and upgrades, fielded on the same two-year turnaround with launches to begin in 2026.

The vendors for the Tranche 2 Transport Layer are Lockheed Martin, with 36 satellites, Northrop Grumman (74), Rocket Lab (18), York Space Systems (72) and Tyvak (10). The tracking layer vendors are Lockheed Martin, L3Harris and Sierra Space, building 18 satellites each. Most companies are in the process of reaching design review milestones.

Under Tranche 2, the SDA separated the hardware contracts into multiple variants for the first time and welcomed new vendors Tyvak, Rocket Lab and Sierra Space. Tyvak's parent company, Terran Orbital, provides the bus for Lockheed Martin's transport and tracking layer spacecraft.

The SDA also will launch eight satellites built by Millennium Space Systems under the Fire-control On Orbit-support-to-the-war Fighter (FOO Fighter) program, taking

flight alongside the Tranche 2 spacecraft. These systems will provide an operational demonstration of fire control capabilities—separate from but complementary to the Tracking Layer spacecraft—with launch expected by early fiscal 2027.

With Tranche 1 satellites approaching delivery and Tranche 2 system designs underway, the SDA soon will release solicitations for Tranche 3, including about 140 satellites for the transport layer and 54 Tracking Layer satellites, to begin launching in 2028. The SDA wants to release the first Tranche 3-related solicitation for ground systems by the end of 2024, with spacecraft requests for proposals coming out early next year.

By 2028, the initial Tranche 1 satellites are to start decommissioning, and the new spacecraft will replenish the PWSA, primarily on the Transport Layer. “That means you have to maintain that Link 16 constellation and then add additional capabilities,” Tournear says.

Tranche 3 systems will include advanced phased-arrays that allow the PWSA to service more users at once, primarily those using S-band signals, he says. On the Tracking Layer, Tranche 3 systems also will replenish decommissioning satellites while beginning to layer in a global missile defense capability.

The PWSA has stayed fairly true to the design envisioned in 2019 by the SDA’s first director, Fred Kennedy, who previously led DARPA’s Tactical Technology Office, Tournear says. The agency identified the data communications backbone enabled by the transport layer and beyond-line-of-sight targeting and tracking as the quickest and most efficient capabilities for the warfighter, he adds. Other capabilities—notably navigation, battle management and custody—are being incorporated into the next tranches.

For navigation, the SDA is adding situational awareness sensors to all transport satellites to detect jamming or spoofing on the ground, Tournear says. The agency also is embed-

U.S. Space Development Agency Faces Critical Tech Demonstrations

- > LINK 16 WAS DEMONSTRATED FROM SPACE TO AIR AND GROUND
- > MORE TESTS ARE PLANNED BEFORE YEAR-END TO STUDY ON-ORBIT OPTICAL AND LASER COMMUNICATIONS TO AIRBORNE SYSTEMS

Vivienne Machi Los Angeles

The Space Development Agency is on the cusp of proving out a massive experiment in Pentagon acquisition and military space operations. First, it must relay data among its on-orbit systems, from space to an airborne system and to ground receivers.

The five-year-old agency’s signature Proliferated Warfighter Space Architecture (PWSA) will include hundreds of satellites stationed in low Earth orbit (LEO), and a new tranche of satellites is planned to come online every two years. The constellation includes an evolving set of low-latency communication transport satellites for 24/7 data transmission and a Tracking Layer of satellites to detect and monitor ballistic missile threats in real time. Once fully fielded, the PWSA also is intended to enable enhanced battle management, navigation, ground support and deterrence from space.

This massive, rotating constellation hinges on the ability of the Space Development Agency (SDA) to demonstrate intersatellite connectivity using onboard optical communication terminals (OCT) as well as laser connectivity among space systems

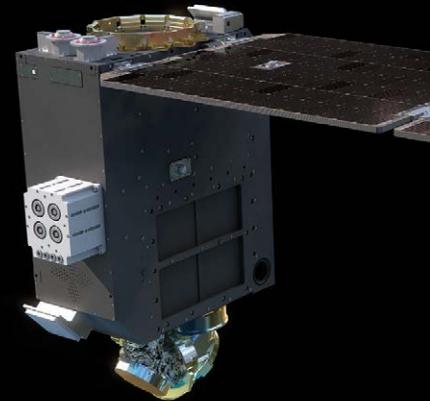
and airborne and ground assets.

The agency first tested space-to-space data relay between two prototype satellites in 2021 under a partnership with DARPA. But since launching its initial batch of 27 Tranche 0 satellites between late 2023 and early 2024, the SDA has prioritized ramping up on-orbit demonstrations for both the Transport and Tracking Layer satellites.

York Space Systems and Lockheed Martin each built 10 satellites for the Tranche 0 Transport Layer, with one of the York-built spacecraft in use as a ground-based software testbed and the other 19 currently on orbit. SpaceX and L3Harris each developed four satellites equipped with wide-field-of-view sensors for the Tracking Layer. The SDA plans to launch the next 154 Tracking and Transport Layer satellites under Tranche 1 by year-end, representing the first operational batch of spacecraft for the PWSA.

The agency is using the Tranche 0 satellites to demonstrate the most critical technologies that the PWSA needs to prove out in order to be viable: Link 16 data transmission from space to ground, airborne and space systems;

GENERAL ATOMICS CONCEPT



space-to-space optical communications; and laser communications among space and airborne systems.

The SDA prioritized Link 16 from space early on because it would provide the most immediate capability—and lowest adoption burden—to the warfighter, says the agency’s director, Derek Tournear. The Link 16 tactical data link communication system is used by the U.S. along with its NATO and coalition partner forces to transmit and exchange real-time situational awareness data among network participants.

The first attempt to demonstrate Link 16 from space occurred in November 2023, when the SDA transmitted data from three Tranche 0 satellites built by York Space Systems to ground-based radios located at an Australian test site. The test was conducted first over Australian sovereign territory, then over international waters.

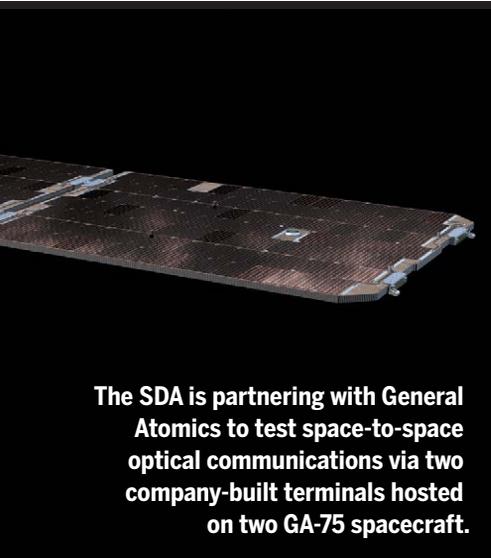
ding a position, navigation and timing (PNT) signal over its Link 16, K_a-band and optical communication channels to offer alternate PNT to users in a GPS-denied environment. That capability is being incorporated on a small scale on Tranche 1 satellites and will be part of Tranche 2's baseline satellites.

The battle management element is enabled by stand-alone processors on the transport satellites that will then operate "as a federated cloud computing system in space," Tournear says. SAIC is building the Battle Management Command, Control and Communications application factory, and the company reached the minimum viable product milestone in June, says Andy Sullivan, company vice president of strategic space.

The SDA wants to have several applications processed by and approved to move through the application factory before the Tranche 1 satellites are launched and ready to begin on-orbit testing, Sullivan adds.

The original SDA vision included an independent constellation of remote-sensing spacecraft performing the custody mission, but that was soon deferred in favor of partnerships with other agencies and commercial partners already building such systems. Recently, the SDA has identified several niche missions for the Defense Department that would use an agency-derived custody layer, and the FOO Fighter satellites will help demonstrate those capabilities before new birds are added into future tranches, he says.

The agency recently chose to rename what was originally called the "support cell" of the PWSA to the ground and launch cell, to better reflect its mission of supporting satellite operations. The original plan also included a deterrence element in the constellation, but that mission will now be performed by other Space Force and Defense Department offices, Tournear says. ☉



The SDA is partnering with General Atomics to test space-to-space optical communications via two company-built terminals hosted on two GA-75 spacecraft.

The connection made during that initial test was not very reliable, says Melanie Preisser, York Space Systems executive vice president and general manager.

"We were able to enter the Link 16 network, but we weren't able to maintain that linkage throughout the entire satellite pass," Preisser tells Aviation Week. The company worked with the SDA in the spring to perform about 50 additional test events during which the York-built satellites successfully connected multiple times to Link 16 ground receivers, she says.

Those tests culminated in a Link 16 data transmission in July among the Tranche 0 satellites in LEO and a U.S. Navy aircraft carrier in international waters as well as an aircraft stationed aboard the ship. Over a two-day period, the SDA demonstrated "consistent" linking from LEO to ground, mobile

and maritime Link 16 radios and antennas, Damon Feltman, the agency's transport cell chief, said on Aug. 8 at the Space and Missile Defense Symposium in Huntsville, Alabama.

Demonstrating that the transport satellites could connect reliably to the Link 16 network was "the biggest concern" so far, Tournear says.

"We are now focused fully on getting the transport satellites to do the optical communication," he says, noting that the goal is to link two satellites from separate vendors by the end of September. "Getting York to talk to York [or] getting SpaceX to talk to SpaceX is one thing. But we want to demonstrate that we can have those two talk to each other," he says.

October's test campaigns will focus on demonstrating space-to-air laser communications with several pathways using separate air vendors, Tournear says. The agency has agreements with TESAT Government, Calspan and General Atomics to conduct a series of OCT-related tests in the coming months.

One of those tests, dubbed Stallion, will involve a space-to-airborne demonstration for which General Atomics is building an airborne OCT to be flown on a De Havilland Canada DHC-6 Twin Otter aircraft leased by the SDA. The OCT will need to connect with a space-based terminal already in orbit, says Gregg Burgess, General Atomics vice president for space systems. That test could occur by year-end, pending the success of earlier optical communications demos.

"They need to get the space-to-space crosslinks demonstrated before moving to the space-to-air" mission,

Burgess says. General Atomics is the payload provider for Lockheed Martin's satellites in development for the SDA's Tranche 2 Tracking Layer.

General Atomics also is participating in an experiment called Manhattan, which involves two OCT that General Atomics built to the SDA's standard and that will be hosted on two company-developed spacecraft.

Manhattan is planned to demonstrate space-to-space crosslink data relay in degraded environments, meeting the agency's specifications for data rate and range. It also is intended to be capable of performing space-to-ground and space-to-air communications, Burgess says. The company is funding the design and hardware build while the SDA is paying for some of the spacecraft operations as well as the launch of the two satellites. General Atomics plans to integrate the complete systems in its Centennial, Colorado, facilities late this year and be "ready to launch" by the second quarter of 2025, although a ride has not yet been purchased, Burgess says.

On Sept. 3, the SDA hit a new milestone when it connected two SpaceX Tranche 0 Tracking-Layer birds using TESAT-built optical communications terminals, Tournear said on Sept. 4 during the Defense News Conference in Washington. Acquiring the link between the two spacecraft took about 10-100 sec.; the link was maintained for several hours.

"From my perspective, we have demonstrated all of the big rocks and burned down all of the risk for Tranche 1 in Tranche 0, based on that success last night," he said. ☉

Pursuing Change, Southwest Shareholders Spur Board Refresh

- > EXECUTIVE CHAIRMAN GARY KELLY IS AMONG THOSE TO DEPART
- > A FUTURE-FOCUSED TRANSFORMATION IS UNDERWAY

Christine Boynton Boston

Gary Kelly initially encountered Southwest Airlines as a teen, taking his first-ever flight when the carrier was in its infancy and the Boeing 737-200 carrying him was also transporting only two other passengers.

“That memory is still very vivid to me,” the airline’s executive chairman said while accepting the L. Welch Pogue Award for Lifetime Achievement in Aviation on Sept. 10—roughly 50 years since that memorable first journey and just hours after announcing his intent to retire in 2025. “A lifetime contribution in this air transport industry for me translates, of course, only to Southwest Airlines,” he added. “That’s my one and only for 38 years.”

Six directors also will step down from the board in November. The changes follow feedback from a variety of shareholders and pressure from activist investor Elliott Investment Management, which has pushed for new leadership since revealing its stake in June.

Blaming poor execution for a share price decline of more than 50% over the past three years, the fund has called Southwest “the most compelling airline turnaround opportunity in the last two decades.” The carrier’s unprecedented 47-year profit streak ended with the COVID-19 outbreak in 2020, and although it has since regained profitability, soaring costs and capacity have contributed to a disappointing performance.

Kelly outlined Southwest’s governance departures in a Sept. 10 letter to shareholders the day after he and two independent directors met with Elliott at their New York office. His letter acknowledged a need to transform for the future, stating that the carrier began thoroughly evaluating its strategy in 2023, ahead of announc-

ing considerable changes in late July (*AW&ST* Aug. 12-Sept. 1, p. 22). Those changes include an end to its hallmark open seating, with more details to come at an upcoming investor day in late September.

“We’ve faced challenges many times and have overcome them,” Kelly wrote, noting wars, recessions, oil price spikes, 9/11 and the Great Recession. “We are taking swift and bold action, and we will overcome these challenges, too.”



Southwest Airlines Executive Chairman Gary Kelly will retire in 2025 after nearly 40 years at the carrier. Six directors will step down this fall.

Kelly also cited continuing and unanimous support for CEO Bob Jordan from the airline’s board and leadership, although Elliott previously pushed for an immediate CEO change, a sticking point in earlier discussions.

“The next generation is more than ready to take the mantle of leadership and is already executing the plan that continues to build on our legacy of success,” Kelly added. “I had intended to consider [this retirement] next year . . . but I’ve since decided it is more important to expedite the plan in an effort to put this governance debate behind us and allow Bob and his team to focus exclusively on running the airline and restoring

our industry-leading performance.”

Reacting to Southwest’s announcement, Elliott appeared pleased with the degree of change while anticipating more to come. “We hope to engage with the remaining directors to align on the further necessary changes,” the fund said. “The need for thoughtful, deliberate change at Southwest remains urgent.”

A new chairperson will be appointed when Kelly retires at the annual shareholders meeting in the spring. Six of 15 directors will step down at a regularly scheduled board meeting this fall: David Biegler, compensation committee chairman; Veronica Biggins, nominating and corporate governance committee chair; former U.S. Sen. Roy Blunt (R-Mo.); William Cunningham, lead director; Thomas Gilligan, audit committee chairman; and former JCPenney CEO Jill Soltau.

Southwest says it expects to appoint four new independent directors in the near future, giving due consideration to up to three of the 10 candidates that Elliott publicly proposed for the open slots. Elliott’s roster includes former executives from Virgin America, Air Canada, WestJet, Ryanair and JetBlue.

The changes ahead will bring the board to 12 members and reduce average tenure to approximately 2.5 years from 7.3. Southwest already has added eight new independent directors since late 2021, while five have retired. Outside experts and consultants also have supplemented board oversight, providing independent scrutiny on the company’s go-forward plan, Kelly noted, including former Spirit Airlines and AirTran Airways CEO Robert Fornaro.

Kelly has served as Southwest’s board chairman since co-founder Herb Kelleher’s retirement in 2008 and as CEO since 2004, relinquishing the latter role to Jordan in early 2022. When stepping down from the CEO position, he voiced intent to serve as executive chairman at least through 2026.

“Now is the time for change,” Kelly stated in his letter. “It’s time to shake things up, not just stir them a bit. . . . We know that changes are required to some of our historic business practices. We know we will need to continually bring in new talent—in leadership and on the board. We know we will need to continue to invest and transform. All that is underway.”

U.S. Flight Attendant Contract Negotiations Push for Improvements

> EXPECTATIONS ARE HIGH FOR THOSE SEEKING BETTER CONTRACTS

> POTENTIAL STRIKE ACTION AUTHORIZED AS TALKS DRAG ON

Christine Boynton Boston

The release of Spirit Airlines pilots to strike in 2010 followed more than three years of negotiations, including over six months in mediation. Major sticking points centered on pay as well as scheduling, and the ensuing work stoppage lasted five days.

In the most recent round of U.S. pilot contract negotiations, several votes to authorize the potential action preceded landmark agreements, including at American Airlines, Delta Air Lines and Southwest Airlines.

United Airlines pilots did not take that vote, but the carrier's flight attendants did on Aug. 28—the first time since 2005 bankruptcy negotiations—approving the possible measure with 99.99% in favor. Calling that tally historic, Ken Diaz, president of the United chapter of the Association of Flight Attendants-CWA (AFA), told Aviation Week it sends a clear message to all parties: “When it comes down to it, we do whatever it takes.”

During this contract round, all four of the five largest U.S. airlines with union-represented flight attendants have authorized the pursuit of a strike if necessary—action that could only follow release from the National Mediation Board (NMB) and a mandatory 30-day “cooling-off” period. Negotiations are taking place in the wake of the COVID-19 disruption and two decades complicated by bankruptcies and merger negotiations.

“We took concessions after 9/11, then we saw the consolidation of the industry. . . . It has been a long time since we have been able to get what we are due,” AFA International President Sara Nelson said at an August event announcing the United vote. “Across the industry, flight attendants are living on wages that are not livable wages—we have some people living in cars. It's time to fix that.”

Among the largest U.S. airlines, Transport Workers Union (TWU)-represented flight attendants at Southwest were first to achieve a deal, rati-

fying a contract in April valued at \$6.3 billion over its four-year term.

Flight attendants at American ratified a contract on Sept. 12, gaining immediate wage increases of up to 20.5% plus other improvements. During negotiations, their union, the Association of Professional Flight Attendants, twice requested release from the NMB before it announced that progress had been made with “cabinet-level involvement” from Transportation Secretary Pete Butti-

At United, flight attendant contracts became amendable in August 2021, and agreements were reached on eight of 34 contract sections by the end of 2023. Today that number has not changed, the AFA confirms, stating that concessionary asks have hampered mediated talks in almost every section—concessions it considers nonstarters.

“I have never ever seen a management negotiating team, especially in a time of prosperity, deal like they're in bankruptcy negotiations,” Diaz said. “Some of these proposals are worse than when we were in bankruptcy.”

United's flight attendants are seeking double-digit base salary increases, pay for time on the ground and quality of work-rule improvements. Federal mediation began in March, with sessions scheduled twice a month through November.



United Airlines negotiating teams reached agreement on eight of 34 flight attendant contract sections by the end of 2023, but no further progress has been made.

DECEE CARTER/MEDIA PUNCH/ALAMY LIVE NEWS

gieg and Labor Secretary Julie Su.

Meanwhile, AFA members at Alaska Airlines in August voted down a tentative agreement that included an average 32% increase in pay scales and boarding pay over three years, with 68% rejecting the terms.

Lengthy negotiations, some delayed by the COVID-19 pandemic, have drawn lawmakers' attention. A June letter signed by 32 U.S. senators urged NMB action, including releasing parties from mediation as necessary. “Unfortunately, it seems airline carriers do not feel pressured to reach agreements quickly, likely because the flight attendants' ability to strike has rarely been allowed to be exercised,” the letter states.

United “continue[s] to work toward an industry-leading agreement,” an airline spokesperson said. “Both sides have been actively engaged in these negotiations, facilitated by the federal mediator requested by the union.”

Included among the 90% of United AFA members who cast ballots over strike authorization was a veteran flight attendant who described the vote as her first with the union, Diaz noted. “She said, ‘I voted in this one because I don't recognize the airline that I work for, and I've been here 47 years,’” he said. “She wasn't a pro-union person; she was honest with me. But she said, ‘I've come to realize, you're the only one speaking for us.’”

Europe's Airlines Fear New Border System Will Cause Delays

> EUROPEAN COMMISSION IS WORKING TO LAUNCH A NEW ENTRY/EXIT SYSTEM IN NOVEMBER

> AIRLINES WARN THAT THE CHANGEOVER COULD CAUSE DELAYS

Helen Massy-Beresford Paris

European airlines are looking ahead to the new Entry/Exit System with trepidation, fearing that the effort to make the border-crossing process safer and more efficient could bring logistical challenges and delays at airports during the changeover.

The European Commission (EC) says it is working toward Nov. 10 as the target date for the Entry/Exit System (EES) to go live, following repeated

tion FNAM—whose members include Air Caraïbes, Air France, Corsair and French Bee—sounded the alarm over implementation.

The centralized EES, already delayed for more than two years, will replace the current system of manually stamping passports at the external borders of the EU Schengen Area as well as Iceland, Liechtenstein, Norway and Switzerland.

conscious that it is not going to take place in a completely seamless way.”

FNAM said on Aug. 21: “The air transport, travel and tourism sectors are indeed seriously concerned about the likely waiting times at border-crossing points of French airports, which could lead to major disruptions for airlines, airports and air passengers (including connecting passengers) from the implementation of the EES.”

FNAM teamed up with other industry representatives, including the International Air Transport Association, French airports association UAF as well as tourism and transport bodies in France, to write to the interior ministry on July 31 demanding urgent action before the EES comes into force.

FNAM wrote: “To the extent that the European regulation provides for the possibility of progressive implementation of passenger-control measures provided for within the framework of the EES, the Ministry of the Interior was asked to quickly implement a steering committee aimed at organizing this implementation in a proactive and concerted manner. The objective is in particular to guarantee waiting times at borders that are reasonable and compatible with the operating constraints of airlines and airports.”

The concerns are not limited to France. Some countries are behind on their preparations, which the EC has acknowledged. Malta, for example, is reportedly ready to implement a temporary alternative to the EES if necessary.

But the problem goes beyond individual countries. Airlines and others in the industry across the region are worried that the arrival of the new system will cause delays and disruption.

“We remain deeply concerned that issues remain unaddressed that will hamper the seamless introduction of the EES,” Airlines for Europe (A4E) says. “Many of these issues were flagged months ago, and progress to address them has been slow.”

For now, with the start date looming, EC action is not coming fast enough, A4E says. “The European Commission needs to accelerate its preparations if it is to have any hope of ensuring a smooth introduction of the EES,” the association states. “This will require close coordination with member states, airlines and airports to ensure sufficient support is provided to these stakeholders and passengers alike.”



Industry representatives are concerned the system could cause airport delays.

delays. The European Travel Information and Authorization System for visa-exempt nationals is to enter operation in the spring of 2025.

“The commission remains in close contact with member states, supporting them to be ready to operate,” an EC spokesperson said.

But industry is skeptical about whether enough preparation has been undertaken for a smooth rollout.

The good news—particularly for French airlines, following a summer fraught with the logistical challenge of the Paris Olympic and Paralympic Games—is that the new date allows for more breathing space than the previously planned October start.

In May, the French airline associa-

The EES will automatically register non-EU nationals using biometric data to monitor refusals of entry, overstays and fraudulent documentation. The system is intended to help prevent irregular migration, terrorism and serious crime, and to simplify travel for bona fide non-EU nationals.

At FNAM’s annual congress in May, association President and Corsair CEO Pascal de Izaguirre shared his concerns about the new system’s “heavy operational consequences.”

French Transport Minister Patrice Vergriete said at the congress that his team was working on EES readiness. “I fear there will be problems,” he said. “All I can guarantee is that we will do our best to be on time, and we are all



The second XB-1 flight reached 10,400 ft. and 232 kt.

Boom Supersonic Demonstrates XB-1 Flight Control Fixes

- > THE LANDING GEAR IS CYCLED FOR THE FIRST TIME
- > THE ROLL AXIS CONTROL HAS BEEN IMPROVED

Guy Norris Colorado Springs

Boom Supersonic's XB-1 technology demonstrator has been cleared for further envelope expansion toward Mach 1 following a review of data from its Aug. 26 second flight, which validated flight control system improvements.

For the latest flight, the 71-ft.-long delta-wing aircraft was reconfigured with a roll damper to reduce unexpectedly high lateral response rates that were encountered on the XB-1's first flight in March.

Engineers also fitted the right wing with tufts—short lengths of yarn that provide a visual indication of aerodynamic characteristics—to check if a potential wingtip stall or other unforeseen destabilizing condition caused the surprise handling issues.

On the first flight, “we learned that the aircraft’s lateral response was going back and forth more than we expected,” says Boom Chief Flight Test Engineer Nick Sheryka. “We didn’t know initially if that was just the aircraft’s natural dynamic response to the conditions it was flying through or if some kind of aerodynamic phenomenon was going on, something like a wingtip stall.

“There was nothing wrong really with the way that the aircraft flew, but it led to a poor rating from a human-in-the-loop perspective on how it was

responding,” Sheryka adds. “After we landed on Flight 1, we did a pretty thorough survey. Some additional computational fluid dynamics studies were performed to take a closer look at that wing. It was really just us asking, ‘Hey, did we miss something here?’”

During the short first flight, which occurred during gusty conditions, Boom’s chief test pilot, Bill “Doc” Shoemaker, experienced an uncommanded wing drop of about 20 deg. “So that got our attention,” Sheryka says. “The aircraft is more challenging to fly in the roll axis than we wanted it to be. So we spent some time, and we put a roll damper into that lateral axis to help improve the handling qualities.” Shoemaker, who joined Boom six years ago, has since left the company.

To verify if the roll characteristic was a natural response of the undamped control system rather than the result of shedding from an unknown forebody vortex or a stalling wingtip, Boom opted to attach the tufts. Results from the flight showed that “the dynamics of the airplane were exactly as we predicted them to be,” Sheryka says. “But what we failed to anticipate was what that would do to the pilot [response] sitting in the cockpit.”

The second flight, by Boom Test Pilot Tristan “Geppetto” Brandenburg, took

off from Mojave, California, at 7:11 a.m. Pacific. Accompanied by a Northrop T-38 chase aircraft, Brandenburg flew the XB-1 north of Mojave in an extended circuit to cycle the landing gear for the first time as well as evaluate the modified roll control characteristics. Declaring the handling qualities much improved, Brandenburg returned to land at 7:26 a.m. The maximum altitude achieved was 10,400 ft., and the speed reached 232 kt.

Brandenburg is also slated to fly the first supersonic test mission; at least three are planned for the XB-1 test effort. In addition to proving out the ability to develop and demonstrate a supersonic flight test program, the XB-1 is designed to pave the way toward the planned Mach 1.7 Overture airliner by developing Boom’s expertise in the aircraft and system design process as well as in engineering software, digital modeling, safety management and production methods.

“We’re trying to build a company from scratch that’s capable of executing a supersonic program,” Sheryka says. “There really isn’t any other company with that experience. A recent white paper that looked at the duration of aerospace programs—both in the commercial and the military sectors over the past few decades—noted the length of time is getting longer between new products.”

Further emphasizing the slowdown in development cycles, he adds: “Boeing’s last clean-sheet aircraft started almost 20 years ago. The [Lockheed Martin] F-35 has been in development for greater than two decades. On the commercial side, there’s absolutely no supersonic aircraft, and on the military side, there are some. But we’re getting to the point now where the process of going from a clean, blank sheet of paper to an aircraft in the sky is taking decades, and some people spend their entire careers on those programs.”

Sheryka says the long-term result is a shortage of qualified and experienced veterans. “So when you look in the industry and ask, ‘Is there a population of people who have relevant design experience and test experience in this space?’ the answer is, quite frankly, ‘no.’ So we had to start from scratch and create a stepping stone from which we can then launch into a commercially viable product. That’s what XB-1 was.”

WEATHER WOES

- > LONG-TERM AIRLINE PLANNING CONSIDERS MORE DISRUPTION
- > SEVERE WEATHER EVENTS ARE AN ONGOING CHALLENGE
- > CARRIERS ARE ENHANCING THEIR OPERATIONAL RESPONSES



Weather caused 74.26% of system-impacting delays greater than 15 min. in 2017-23, according to the FAA.

ALLEN J. SCHABEN/LOS ANGELES TIMES/GETTY IMAGES

Christine Boynton Boston

It is nearly 80F in Dallas when Southwest Airlines executives sit down for a post-summer interview—and thoughts are already moving to ice, with their sights set on November and beyond.

“It’s Thanksgiving right now in crew planning,” quips Mark Sutcliffe, vice president of crew planning and analytics. “We’re focusing on those holiday schedules, certainly, and really thinking about deicing.”

Southwest Airlines has been focused on improving operational resilience to disruptive weather events over the past 18 months. Its summer performance points to “further evidence of the progress we’re making,” CEO Bob Jordan said in a statement following the Labor Day travel period.

Welcoming a record 54 million customers across more than 414,000 flights over May 24-Sept. 2, the carrier improved its on-time performance by 2 percentage points compared to 2023, with a 99.3% completion factor. Southwest closed the season having achieved a 99.9% completion factor on more than 14,500 scheduled flights over the Aug. 30-Sept. 2 holiday weekend.

The airline has made considerable

investments in its technology and team since the December 2022 disruption that began with Winter Storm Elliott and cascaded into a multiday event as the carrier worked to realign crews, schedules and aircraft. The resulting action plan has upgraded airport infrastructure, equipment and preparedness; enhanced cross-team collaboration; and accelerated investments in tools for irregular operations.

One of those tools is CAIRO (Crew and Aircraft Integrated Recovery Optimizer), which can be called into play as a last resort if plans fall short or conditions change.

“The example I always use is, if this building was on fire and you needed to activate the sprinkler system, CAIRO is kind of that sprinkler system,” Sutcliffe says. “Whatever plan we built, if something went wrong with that plan—maybe the weather changed, there was a technology issue—whatever it is, we have the ability, then, as kind of a Plan B, to activate CAIRO.”

Southwest believes the concept is industry-leading, allowing the airline to determine quickly which parts of the crew network are out of position, focus on the areas it can repair, cancel where it must and ultimately reset the network.

“The most sensitive network that an airline has is its crew network, and that’s simply because it’s people,” Sutcliffe explains. “If you ever really fall behind, that’s where that mountain becomes so difficult to overcome.”

CAIRO was activated on Christmas Eve 2023, when a large amount of fog disrupted operations at Chicago Midway International Airport. That helped Southwest come out of an unplanned event in stable condition. “Though Southwest cancellations ticked up slightly, operations got back on track quickly thereafter,” Morgan Stanley analysis noted at the time.

CAIRO was not activated this summer. “We’ve invested in that tool to use in an emergency,” Sutcliffe notes. “You’re always doing everything you can to avoid the use of that tool.”

Boeing aircraft delivery delays have allowed Southwest to buffer its summer schedule more than in previous years, with extra pilots available to

make that work, aiding its improved completion factor. But a unique element is also in play, involving new collaboration among the teams responsible for planning and execution.

Adam Decaire is senior vice president of network planning and operations control, overseeing two groups that lived in separate functions until about a year and a half ago.

"This is the first time, I think, that any major carrier has put network planning with network ops control," he explains, also pointing to internal alignment with crew scheduling. "We're able to get on the same page, and then we go out and we execute."

Lessons from this summer are helping to build momentum going into winter, he says. Teams already are conducting tabletop exercises and coordinating with different groups to plan for potential disruptions.

"We're getting out in front of it a little more effectively," Decaire says. "We are on it a lot quicker. We've had tech outages, and you haven't seen them, you haven't heard about them. . . . We've just set ourselves up a little more effectively, and we're just maniacally on that to make sure that we're constantly improving as we're getting ready for winter operations."

FACING A STORMY FUTURE

Weather is the leading cause of U.S. air traffic delays, accounting for 60% in 2023, according to FAA data. Climate

change projections are factoring into airlines' long-term planning, including the potential for increased coastal flooding, extreme heat and more severe storms, among other risks (*AW&ST* Sept. 18-Oct. 1, 2023, p. 32).

In recent years, substantial weather-related disruptions over busy holiday travel periods have not only affected Southwest, but have also spurred change at American Airlines and United Airlines.

For American, two days of high winds at Dallas-Fort Worth International Airport over the 2021 Halloween holiday weekend triggered cascading delays and cancellations that left pilots and flight attendants timed out or out of position. At the time, representation for its pilot union cited an antiquated IT system as a major problem, describing it as slow to react and without modern staffing algorithms. For United, a July holiday weekend in 2023 became what its CEO would call "one of the most operationally challenging . . . in my entire career" as an overwhelmed scheduling system compounded the effects of severe weather.

The airlines prioritized investments in crew technology after each event, and the enhanced preparedness appears to be paying off.

"Despite significant flight disruptions in July brought on by the global CrowdStrike outage, summer storms and record-breaking air travel volumes, the year-to-date cancellation

rate remains below 2022 and pre-pandemic levels," noted the U.S. Transportation Department in late August.

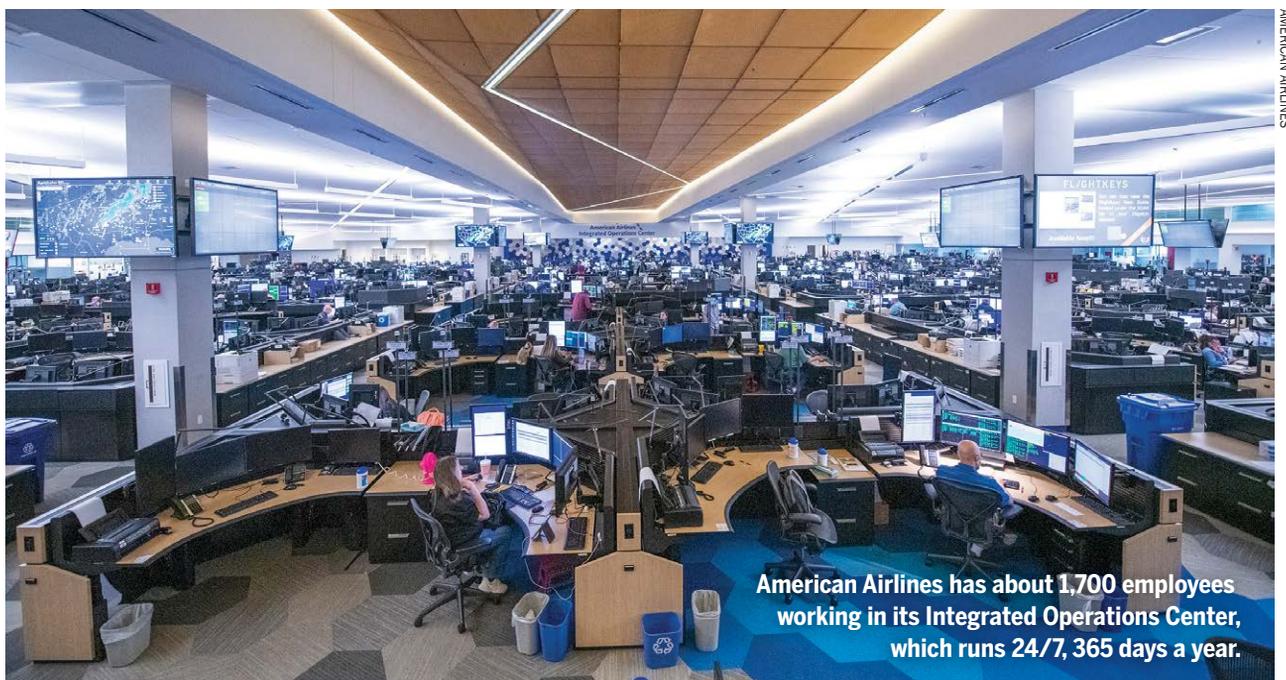
When the global IT outage occurred on July 19, American had operations restored by evening, running a near-99% completion factor the following day (*AW&ST* Aug. 12-Sept. 1, p. 21). Explaining his airline's quick response, American CEO Robert Isom pointed to lessons learned and technology built.

"What we have to go through just in terms of weather across our network, it gives us great experience in terms of disruptions," he said after the outage. "One of the things that we've learned is that in terms of any disruption, you better keep track of your aircraft, certainly, but also your crews, wherever they are. . . . We've built technology, and we've done the right things to ensure that we take early precautions, early steps."

Overall, the carrier says it has set a new standard in recovery after severe weather disruptions, which was not the case several years ago.

"Pre-pandemic we would have major storms at Dallas-Fort Worth or in Charlotte, and two days after the storm we're still struggling a bit, and our customers were asking, 'What's going on?' and we said, 'We're not going to do that anymore,'" Chief Operating Officer David Seymour says.

The key, Seymour stresses, is keeping continuity with crews. "When I



American Airlines has about 1,700 employees working in its Integrated Operations Center, which runs 24/7, 365 days a year.

AMERICAN AIRLINES

talk about our resilience, our recovery from major events, that is where we have really made a difference compared to everybody else,” he says. Comparing performance of American’s upgraded crew recovery tool with its pre-pandemic version, Seymour notes that the airline’s ability to solve disrupted crew schedules has improved roughly 60-70%.

“We’re now pushing 80-90% of our crew solutions solved in minutes,” he says. “And that’s the difference because your crews are your most precious, most constrained resource that you have during the operating day.”

Additionally, the internally developed HEAT (Hub Efficiency Analytics Tool) dynamically moves the airline’s flight schedules around when severe weather impacts its large hubs, utilizing an advanced algorithm. American says the tool reduces cancellations considerably and can even help prevent ground delay programs—a traffic management procedure Seymour refers to as a “blunt knife” compared with American’s more surgical approach.

“In a lot of cases now, when we have major events in our big hub operations, the FAA and the system command center just outside of D.C. will ask our air traffic control desk in our ops center, ‘American, are you going to run HEAT?’” Seymour says. “They prefer when we do because when we run it in our big operations, in a lot of cases, the FAA is not putting in ground stops and ground delay programs because we’ve solved the problem for them.”

Operating teams at United over the past year also have invested in technology and improved processes to enhance recovery from irregular operations. An improved ability to recover more quickly has led to not only a more reliable operation but also a more cost-effective one, Chief Financial Officer Michael Leskinen says.

“Notably, crew-related disruption expenses such as premium pay and deadheading costs are much lower than we have seen during similar events in prior years,” Leskinen said during a second-quarter earnings call.

“The full impact of these improvements drove approximately one point of [cost per available seat mile excluding fuel and net special items] improvement in [the second quarter] compared to our own expectations.”

CULTIVATING RESILIENCY

The worst planning teams are focused only on their own plan, says Sutcliffe, who describes Southwest’s enhanced internal collaboration as providing a more holistic view across the operation. As it gears up for the winter, the airline will continue to focus on resilience—the skill to bounce back from disruption, stronger and readier for the next.

“No matter how bad today gets, we want tomorrow to start fresh, and there’s proof in our ability to do that—even during the Elliott winter storm, we were able to go from 1,500 flights to 4,200 the next day,” Decaire says. “What you’ll see in our numbers is that we start tomorrow a lot faster, and we’re much more resilient because we have that in our mindset.”

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Malaysia Airlines Tackles Operational Headaches and Trims Frequencies

- > CAPACITY PULLED BACK 20% AS GOVERNMENT TIGHTENS OVERSIGHT
- > AFTER MANY DELAYS, MORE AIRCRAFT ARE FINALLY SET TO ARRIVE THIS YEAR

Adrian Schofield Kuala Lumpur

While Malaysia Airlines has cut capacity to recover from a spate of flight disruptions, the carrier hopes new aircraft deliveries will support its efforts to inject more stability into its operation.

The airline is confident the cuts will be temporary and that it can reboot its full network relatively quickly. This optimism has been underlined by an important route announcement, and the carrier also is preparing to finalize an aircraft order decision.

Surging flight delays and cancellations have affected Malaysia Airlines in recent months, in addition to a series of technical issues that caused flight turnbacks or diversions. Public and political criticism spurred the Malaysian government to increase scrutiny of the airline.

Regulators took the drastic step of requiring the carrier to reapply for its air operator certificate each year instead of every three years. Malaysia's passenger rights code also was upgraded with new rules for disrupted flights.

Malaysia Airlines has taken its own steps, announcing on Aug. 29 that it is reducing capacity up to 20% through December by trimming frequencies. This will allow it to address issues that were affecting its schedule reliability.

Malaysia Airlines has cited a range of disruptive factors, including aircraft delivery delays, parts supply shortages, increased engineering workforce attrition and engine maintenance backlogs. However, the carrier is making progress in addressing these issues, says Izham Ismail, Malaysia Aviation Group managing director and CEO.

The airline has improved its on-time performance to around 85%, versus about 70% before the capacity cuts, Izham says. The carrier plans to start restoring capacity in October, gradually increasing it through December. Izham says he has set a mandate

for staff to "start 2025 strongly with everything in order."

During the capacity drawdown period, the airline has taken the opportunity to cycle its aircraft through increased maintenance checks, placing about 15 out of service at once compared to seven before the capacity cuts.



Malaysia Airlines has received four 737 MAXs, and more are due this year.

Izham notes that many issues were due to external factors, attributing some of the turn backs and diversions to problems with rotatable parts that had recently arrived from a supplier. On the workforce front, Malaysia Airlines says it has lost engineers to maintenance, repair and overhaul companies that have entered the local market.

Despite the disruptions, Izham stresses that the airline has not compromised safety, having achieved accreditation in the International Air Transport Association's Operational Safety Audit program in July for the 10th successive year.

Extensive narrowbody delivery delays have exacerbated the challenges of dealing with an aging fleet, Izham says, but forthcoming deliveries and planned orders should help with fleet upgrade efforts.

Malaysia Airlines has received four of the 25 Boeing 737 MAX aircraft it has on order—far fewer than expected. The latest revised schedule calls for another seven to be delivered this year, but Izham says four is a more realistic estimate.

The airline also is due to receive the first of its Airbus A330neo orders on Oct. 28, pushed back from September after a delay related to seat certification issues.

Malaysia Airlines was expecting five A330neo deliveries this year, but now predicts it will receive that many by the end of the first quarter of 2025. All 20 of these orders are due to be delivered by 2028.

The carrier is in the midst of decid-

ing a follow-up order for at least 25 narrowbody aircraft. The request for proposals process has closed, and the carrier is in the final stages of negotiations, Izham says. A decision could be announced by late October.

Malaysia Airlines also had planned to make a decision this year on whether to exercise more A330neo options, but Izham says that may be pushed to next year.

The arrival of the first tranche of A330neos will allow Malaysia Airlines to redeploy some Airbus A350 capacity for the launch of a route to Paris in March. The carrier last flew to Paris nearly a decade ago, and now London is its only European destination.

Adding Paris will enhance the airline's connecting opportunities, particularly from the Australasian market, which is a primary focus for Malaysia Airlines. 🌐

Aura Aero's Hybrid-Electric Aircraft Design Effort Is in Full Swing

- > EASA CERTIFICATION OF CONVENTIONAL TWO-SEATER IS IMMINENT
- > ENGINEERS SWITCH TO ELECTRIC, HYBRID-ELECTRIC SYSTEMS

Thierry Dubois Toulouse

Aura Aero, founded in 2018, is developing the Integral E electric two-seater, which it intends to use as the basis for its upcoming 19-seat hybrid-electric ERA. As it makes technical progress while facing the daunting task of gathering enough funds, the French startup exemplifies the nascent industry of decarbonized aviation.

Toulouse-based Aura Aero's design efforts have mostly shifted to the ERA (Electric Regional Aircraft) from its Integral light-aircraft family. As certification nears for its first design—the piston-powered Integral R—the company appears to be one step ahead of the competition.

CEO Jeremy Caussade says that since its creation, the startup has raised approximately €120 million (\$133 million). With expected investments, he sees that approaching one-third of the required €450 million in the coming months. Caussade believes Aura Aero will find it easier to raise the rest, as the team has demonstrated its technological prowess.

The €450 million encompasses what Aura Aero needs to reach certification of the ERA regional aircraft, Caussade estimates. "It will cover the end of certification and the deployment of a support organization," he says. Nondilutive funding—such as subsidies, refundable advance payments and loans—will come as well.

The major fundraising success that Caussade had expected in 2023 did not materialize, but the company did raise €30 million last year, he points out. This year, the European Innovation Council (EIC) awarded Aura Aero €17.5 million through its EIC Accelerator. By year-end, Caussade anticipates closing another €60-150 million. "This is a combat sport," he emphasizes.

Investors might see lower risk, thanks to Aura Aero's growing credibility. The European Union Aviation Safety Agency (EASA) granted the company design organization and production organization approvals this year. "We are an airframer now," Caussade says.

Aura Aero's next recruits will bolster the ERA's development and support organization. As the 250-employee company awaits necessary funding, it has postponed a 100-employee hiring plan to early 2025.

Meanwhile, the Integral R light aerobatic twin-seater is in the final stages of certification. An EASA test pilot will undertake a second session of certification flights in October, Aura

The ERA's propulsion system will rely on a series hybrid-electric architecture that will include eight Safran electric motors, two 600-kW-class turbogenerators—possibly derived from helicopter turboshafts—and batteries. In addition, the wing will consist of carbon fiber for improved lightness and aerodynamic performance.

"By November, we will receive a 4-m-long [13-ft.] wing section at full scale," Padulo says. "We are thus assessing manufacturability. We will then use it to calibrate some methods and tools."

Aura Aero's engineers are also working on an expanded iron bird that will have a flight control system, including pilot controls and primary and secondary control surface actuators, as well as electric motors and batteries powered by a simulated turbogenerator.



AURA AERO

Aero Chief Operating Officer Fabien Raison says. Company officials expect certification in October or November, followed by first deliveries in December. The Integral S, a derivative aimed at air clubs and flight schools, is scheduled to follow; certification and first deliveries of it are expected in 2025.

The electric Integral E two-seater started taxi tests in February. Safran is scheduled to deliver a flightworthy engine early this month, Raison says. The first flight is expected in the coming weeks.

Under an ambitious program schedule, the ERA's first flight is planned for 2026, and its first deliveries for 2029. As part of the aircraft's development, Aura Aero is using a cabin mockup and template to study layouts. Engineers can work on two Thales FlytX-equipped avionics test benches, Chief Technology Officer Mattia Padulo says.

Aura Aero design engineers are working on the 19-seat ERA's propulsion, avionics and airframe.

Approximately 50 engineers—in addition to procurement and digital platform specialists—are working on the ERA design.

"The Integral E will be the first electric aircraft certified under CS-23, including upset prevention and recovery training," Caussade says. "Schematically, I can describe the ERA as eight times the Integral E with turbogenerators. Developing the Integral E is preventing us from making some mistakes when designing the ERA. And every airframer began with a light aircraft. We are structuring the company for the 19-seater. We are starting out with the two-seater family, with the Integral E as the bridge between the two." 🗨️

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Amid Leadership Transition, Volocopter Forges Closer Ties With China

> CEO DIRK HOKE TO LEAVE EARLY NEXT YEAR

> GEELY TECHNOLOGY CEO JOINS VOLOCOPTER ADVISORY BOARD



Volocopter recently flew the 2X prototype in Versailles, outside Paris.

Jens Flottau Frankfurt

When advanced air mobility startup Volocopter had to announce the departure of its current CEO Dirk Hoke in early September, the company tried to frame the bad news with some positivity. First, it disclosed that it has won former Daimler CEO Dieter Zetsche as the new chairman of its advisory board. Second, it announced that Geely Technology CEO Zhihao Xu will join the board as well.

The common message of the two appointments is clear: Volocopter is here to stay. Senior executives of their stature would not be prepared to expose themselves at a failing company that investors and suppliers are avoiding and that is struggling to bring its product through certification and to market. The storyline about a company that has so far also failed to attract the public attention and support in its home country could apply equally to Volocopter's advanced air mobility colleagues at Lilium.

The turnover at the top of Volocopter is taking place as the company enters a crucial phase in its history: It is trying to move certification of the VoloCity two-seat multicopter across the finish line, seeking fresh funding and moving the aircraft from testing into the production phase. Of course,

a larger model is to be developed at the same time that is more likely to become a commercial success than the initial two-seater.

Hoke stresses that his departure "has nothing to do with the team or the technical progress." He still believes that Volocopter is "in a leading position globally" when it comes to certifying and bringing to market its first model—a milestone now expected in early 2025. He says that he had been offered several jobs and selected one outside aerospace. "I had to decide whether to stay until the initial public offering or leave now," Hoke says. Given the offers, he opted for the latter.

When he leaves at the end of February, the two-seat VoloCity "will either be certified or close to it," Hoke says.

Volocopter has postponed VoloCity certification several times and is now targeting the beginning of 2025. Hoke says the uncertainty about Volocopter's financial stability has led some suppliers to delay release of certain long-lead items, which in turn has caused a delay in the certification campaign amounting to several months. The company is still working with some of these suppliers to accelerate delivery of crucial items, although flight tests with earlier prototypes have been continuing.

Its public flight display at the Summer Olympics in Paris had to be scaled down. Among other things, Volocopter flew only the 2X technology demonstrator rather than the production version of the aircraft, contrary to its initial plans, with deliveries of the latest standard engines delayed. It also could not carry paying passengers because it had not reached certification yet.

Hoke's time at Volocopter has been overshadowed by massive questions about the company's financial viability. Hoke warned publicly in April that Volocopter might have to file for bankruptcy if it were not able to secure government loan guarantees because private investors had become much more cautious about putting money into risky startups. Ultimately, Volocopter's existing shareholders agreed to a fresh funding round in June that would be split into several installments and finish in the fourth quarter. Volocopter said at the time that the funding would carry it through certification, which was then planned before the end of 2024. The capital injections are occurring according to plan, Hoke says.

As the new chairman, Zetsche has a complicated task: finding a new CEO and securing fresh funding. Then, production will have to be ramped up, and

development spending for a larger four-seat version will have to increase. In that context, the appointment of Xu may actually be the more important decision. Since China has made advanced air mobility one of the strategic priorities of its economic policy, the speed at which the sector is emerging has picked up massively. “In many places, massive infrastructure is being built for companies that don’t even exist,” Hoke observes.

Given that Volocopter is more advanced in its certification campaign and aiming for European Union Aviation Safety Agency approval, Hoke hopes the company can gain a head start vis-a-vis Chinese manufacturers. That is where Geely, the large industrial conglomerate, comes into play. The exact way in which Geely, a current minority shareholder, will help has yet to be seen, but Volocopter’s road to market may well be via China.

Selling to China has been an option for Lilium for some time, as the company struggled to find sufficient financial backing at home. But that

has become a more distant possibility, now that the Bavarian state government has finally cleared the way for a €50 million (\$55 million) loan guarantee. The amount is expected to rise

benefitted from a large Saudia order for 50 aircraft, which includes pre-delivery payments, but Roewe said the company needs to raise more money soon nonetheless.

“The road to market for both Volocopter and Lilium may well run through China.”

to €100 million, as the German federal government has pledged to contribute a matching amount to the aid package.

The company argued that it needs government support to fund its ongoing development work and later flight testing and to improve investor confidence in the startup. Lilium CEO Klaus Roewe said in July that many potential investors had indicated they are willing to put in money if Bavaria and the federal government move ahead.

Current investors participated in a relatively small capital increase (\$114 million) at the end of May. Lilium also

Lilium is also seeking a much larger French government support package that is linked to building a production facility in the country. A decision on that deal is not expected until the spring of 2025. The company has started building the initial flight-test aircraft. The first Lilium Jet is planned to fly at the beginning of 2025.

Volocopter continues to seek government loan guarantees, too, but its attempts have been rejected in its home state of Baden-Wuerttemberg. Talks continue with Bavaria, among other states. 🌐

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REPORT

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Carriers Delve Into Contrail-Avoidance Practicalities

> AMERICAN AIRLINES AND AMELIA TEST ALTERED FLIGHT PLANS FOR REDUCED CLIMATE IMPACT

> CHIEF TECHNOLOGY OFFICERS CALL FOR A CAUTIOUS APPROACH

Thierry Dubois Lyon



TWO DISTINCT VIEWS have emerged in the industry about contrails and how to prevent their formation.

Some, such as flight plan optimization specialist Satavia, assert that enough knowledge has been gathered to combat the climate-warming phenomenon. While admitting that more research will be useful, they say it is best to take action now instead of waiting for science to pinpoint the climate impact of contrails.

Chief technology officers (CTO) who gathered at the Farnborough International Airshow in July exemplify the second perspective regarding contrails. To substantiate their wait-and-see approach, the CTOs of Airbus, Boeing, Dassault Aviation, GE Aerospace, Rolls-Royce, RTX and Safran stressed how uncertain a contrail's climate effect is. They called for better understanding of the ins and outs of contrails.

Some carriers lean toward the “let’s do something” mindset. At the aircraft operator level, avoiding the formation of contrails involves operational considerations. An operator may have to change a flight plan in the pursuit of a reduced net climate impact, so some carriers have started their own contrail prevention trials to understand what is in store for them.

“Partnerships among the aviation, academic and technology communities have developed strategies aimed at predicting when a flightpath is likely to cause a contrail and deploying an alternate path at a slightly lower altitude to avoid doing so,” American Airlines’ 2023 Sustainability Report states. The carrier sees a potential for relatively low-cost and high-impact climate intervention. “Rerouting a small percentage of flights could avoid the majority of contrail warming,” the report adds.

American participated in a study last year led by Google Research and Breakthrough Energy. A small group

of American pilots flew 70 flights over six months using artificial intelligence (AI)-based predictions. They made small modifications to routes that were projected, due to atmospheric conditions, to create contrails. The flights that used the AI predictions reduced



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Avoiding contrail formation improves a flight’s climate impact 30-40%, Amelia estimates.

contrail formation 54%, as measured by distance, compared with flights on which pilots did not use the predictions, the report says.

In June and July, Amelia, a regional carrier operating as part of the Regourd Aviation group in Paris, analyzed a dozen flight plans and modified some of them to prevent the formation of contrails.

“With Thales, we have been measuring our flights’ climate impact since 2023,” says Adrien Chabot, Amelia chief sustainability officer. “For non-CO₂ effects, especially contrails, we have spotted a regular flight between France and Spain. It is suitable for action because the cruise altitude is high enough to potentially create long contrails. As we fly it on a weekly basis, it gives us time to prepare.”

Just 6 hr. before the flight, Amelia provides Thales with an initial flight plan. Thales engineers use their Flights Footprint tool—fed by the contrail cirrus prediction (COCIP) model—that suggests alternatives. “We consider both CO₂ and non-CO₂ impacts,” Chabot says. “If we see a potentially large and favorable impact of the alternative route, we prepare the vertical deviation that will avoid the area where contrails could form.” Amelia then shares the flight plan with air traffic management organization Eurocontrol.

“Thanks to the updated COCIP model, which integrates weather observation, we can estimate the effect of our flight deviation after the flight,” Chabot explains. “The outcome is that a flight deviation can cut contrail formation 80%.” Amelia calculates that this results in a 30-40% improvement in a flight’s overall climate impact.

“We did such post-flight analysis on four flights for which we decided to deviate and eight for which we decided to keep the initial flight plan,” Chabot says. “We saw satisfactory results on the 12 flights.”

However, regularly planning a lower cruise altitude may affect the business case. The aircraft’s fuel consumption increases 3-4%, Amelia engineers say. In the absence of a financial incentive for contrail avoidance, the extra fuel burn only adds to costs.

The European Commission or other authorities might one day encourage and fund contrail avoidance. For the time being, Amelia is preparing to comply with the obligation for European operators to monitor, report and verify its non-CO₂ emissions, including contrails. The rule will come into force in 2026, for 2025 emissions.

“We will carry on with our contrail formation prevention approach on another 50 flights on the same route by year-end,” Chabot adds. “We will study how to implement it on other routes.”

Amelia’s effort is part of the broader Thales-led DECOR project aimed at improving air traffic and cutting aviation’s climate effect. DECOR (an acronym that stands for demonstrating eco-responsible operations) involves Airbus, Air France, Eurocontrol and aerospace research center ONERA, among others. French air navigation service provider DSNA is funding the project. 🌱

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Single-pilot operations would require redesigning current flight decks.

AIRBUS PHOTOS

Sean Broderick Washington

Pilot groups continue to fortify a united defensive position against a distant yet seemingly inevitable push to approve large commercial transport flight operations with fewer than two pilots on the flight deck.

The union-led campaigns started five years ago and show no signs of slowing down. The European Cockpit Association (ECA) recently placed advertisements in bathrooms at Brussels-Zaventem Airport, in the shadow of the European Union's (EU) headquarters. The Air Line Pilots Association (ALPA), fresh off updating a 2019 white paper laying out the case against reduced-crew operations (RCO), will kick off its upcoming annual safety forum on Sept. 9 with a panel on the topic featuring ALPA President Jason Ambrosi and ECA counterpart Otjan de Bruijn.

The International Federation of Air Line Pilots' Associations (Ifalpa) has also joined the ECA and ALPA in the unified effort. Their primary concern is a set of rule changes the European Union Aviation Safety Agency (EASA) is exploring in response to specific requests from at least two manufacturers—including Airbus and Dassault.

"The industry is currently developing technologies that, in combination with appropriate operational proce-

dures, crew training and cockpit design, will support new operational concepts, such as extended minimum crew operations," states an EASA summary of the extended minimum crew operations (eMCO) rulemaking task issued in December 2023. "The progress made in automation, cockpit design and monitoring systems will probably allow to safely rely on one pilot at the controls during noncritical segments of the cruise phase."

Manufacturers first approached EASA in 2017 with the RCO concept, later renamed eMCO. The regulator then received formal applications "for the airworthiness approval of eMCO capability on large airplanes," EASA said. Both Airbus and Dassault have acknowledged plans to take advantage of potential eMCO opportunities.

The rulemaking task focuses on operational changes that would permit only one pilot on the flight deck during specific scenarios, such as during the cruise phase of long flights. This could pave the way for pilots to sleep without being relieved by a reserve pilot—

seemingly a cost-savings opportunity for airlines.

In the minds of manufacturers and operators, RCO would be another tool in the fatigue management box. Some regulators allow one flight crew member to take a short rest on the flight deck while the other acts as pilot flying. RCO would enable the resting pilot to leave the flight deck under certain circumstances.

The FAA studied onboard napping 30 years ago, going as far as releasing a draft advisory circular that would have authorized it. But pushback from ALPA and other pilot unions helped stop the process. The agency's official policy: Naps are fine so long as there are two pilots on the flight deck, not counting anyone resting. In-seat naps are not permitted.

Of greater concern to the unions than nap-augmenting strategies are plans to design flight decks for just one pilot. Airbus and FedEx have already broached a single-pilot-operations (SPO) idea for future freighters.

But implementation would require new rules and changes to flight deck design—both of which will take years. The size of the regulatory hurdles is the main reason Airbus' plan to have an SPO-approved A321 freighter and an RCO-capable A350F in service

OPPOSITION

- > MANUFACTURERS AND REGULATORS ARE EXPLORING SINGLE-PILOT OPERATIONS
- > PILOTS' UNIONS ARE CLEAR IN THEIR OPPOSITION
- > BASIC IMPLEMENTATIONS STILL LIKELY YEARS AWAY

around 2026 proved too ambitious (*AW&ST* Oct. 16-29, 2023, p. 32).

EASA is studying SPO and its ramifications under the EU's Horizon Europe research initiative. The regulator also proposed a formal International Civil Aviation Organization (ICAO) work program on eMCO at the organization's 41st General Assembly in September-October 2022. While the concept was not seen as mature enough to justify ICAO resources, the idea was not rejected, either. "This means that ICAO may decide to begin work on the topic as their resources allow," the updated ALPA white paper states.

The FAA's boldest step has been to agree with a Research, Engineering and Development Advisory Committee (REDAC) recommendation that

the FAA develop a research plan to "be prepared with scientific data to support the processes for aircraft design and operational approvals for concepts such as Extended Minimum Crew Operations," the agency wrote in a formal response to REDAC this year.

"[It] is not the agency's responsibility to develop or mature the science and technology to enable use of the eMCO concept, but the FAA needs to be ready to apply rigorous guidance and oversight once they are approached by a stakeholder looking to implement eMCO in commercial operations," the FAA wrote.

The agency said it is "in the process of focusing our safety research plans to emphasize key strategic thrust areas related to eMCO," including focuses on automation and artificial intelligence.

"The resulting foundational knowledge will support many new concepts, including eMCO," it added.

The uncertainty around ICAO's direction, combined with EASA's commitment to have initial conclusions from its rulemaking task in the next year or so, is fueling the pilots' union push to head off efforts before they yield practical operational concepts.

"Despite the fact that there is an ever-present influx of challenges, commercial air travel is the safest mode of transportation," the ALPA white paper states. "The remarkable safety record of the airline industry hinges on the requirement for two pilots on the flight deck. Single-pilot operations, by definition, reduces this level of safety and security. Current and projected automated system technologies do not represent an acceptable solution or safety equivalence to the two-pilot model."

Another potential hurdle is that pilots often struggle to understand existing aircraft automation.

"Automation dependency continues to be a safety issue worldwide," said the report, developed by an ICAO working group charged with examining global automation policies and trends and released last year (*AW&ST* Nov. 27-Dec. 10, 2023, p. 34). "Contributors to automation dependency can include operator policies, regulatory policies and lack of confidence in pilot manual flight skills."

Airbus considered reduced-crew concepts for in-development aircraft, such as the A350 freighter.



If current training protocols are not effective enough to ensure that two-pilot crews grasp what an aircraft is doing, removing one of those pilots in favor of increased automation seems to invite questionable levels of risk.

EASA recognizes this. The 2022 ICAO paper formally submitted by EU states and backed by EASA notes that any economic savings realized through reduced crew operations could be offset by higher training and infrastructure costs.

“Although transitioning from multi-

crew to minimum-crew operations may reduce costs associated with the workforce and potentially introduce more flexible rostering, on the other hand, different pilot competencies may be required,” the ICAO paper states. “Therefore, economic drivers may not be considerable, taking into account the higher level of competence of the ‘remaining’ pilot. Potential additional costs related to higher-level ground support and two-way communications should also be considered.”

A competing paper from Costa Rica

and Ifalpa targets both the reduced-crew and single-pilot concepts.

“Pilot fatigue management is a much wider concept than providing pilots more opportunities to rest during the flight,” the Ifalpa paper argues. “Adequate pilot fatigue management starts with a scientific-based fatigue risk management system (FRMS) established by the operator in collaboration with the pilot group. With a fully functional and properly established FRMS, the operator will have the data to better understand how fatigue is impact-

How a Small U.S. Air Force Unit Will Shape the Service's Autonomy Goals

- > SIX F-16s ARE PLANNED TO ROLL OUT AUTONOMY SOFTWARE
- > THE SERVICE HOPES TO INCREASE AI USE IN THE LONG TERM

Brian Everstine Washington

While the U.S. Air Force wants to move rapidly toward fielding the first increment of the Collaborative Combat Aircraft—a first step to get iron on the ramp before worrying about more advanced capabilities—a small unit with specially modified jets is thinking long term.

The Air Force announced the Viper Experimentation and Next-Gen Operations Model (VENOM) program at Eglin AFB, Florida, last year as part of its push for autonomous capabilities in the early stages of the Collaborative Combat Aircraft (CCA) effort.

As the program has progressed and aircraft have arrived this year, the purpose of the unique experimental operations unit has come into sharper focus. VENOM is using six Lockheed Martin F-16s—complete with sensors, radars, pods and training weapons—to develop autonomous capabilities beyond initial CCA increments in a way that is also designed for safety.

Other early Air Force autonomy tests have focused on the Kratos XQ-58 or the Lockheed Martin X-62A Variable In-Flight Simulation Test Aircraft. The latter is a modified F-16 that helped develop the Automatic Ground Collision Avoidance System (Auto GCAS) but lacks the sensors and other systems needed for combat. By using six F-16s straight from an Air Force flight line, VENOM is setting its

sights on readying the service's autonomous capabilities for combat.

“They’re going to be focused more on the beyond-visual-range kinds of engagements, and I think the main thing is going to be human-machine interfaces and pilot-aircraft teaming,” Air Force Secretary Frank Kendall tells Aviation Week. “So we’ll get a chance to explore some of those things I think we’ve been doing in simulation. Now we’ll get to do it on an aircraft.”

The first F-16s arrived at Eglin in the spring from the U.S. Air Force Weapons School at Nellis AFB, Nevada, for initial modifications. Col. Tucker Hamilton, who was then commander of the 96th Operations Group at Eglin, told Aviation Week that these F-16s will be the stars of autonomy testing because, unlike the XQ-58, the type is a well-known aircraft that does not need initial flight sciences testing to be ready. Experienced pilots and the known airframe will be able to push autonomy systems to their limits in a safe manner.

“VENOM is officially a risk-reduction effort for the Collaborative Combat Aircraft program office,” he told Aviation Week in July before leaving the command role. “It’s not just the capability that we’re testing with VENOM; it’s how you test the capability, how you have the right data architecture, infrastructure, how you share data—all those things.”



Hamilton said he was involved in bringing on Auto GCAS, and autonomous operations are a next step. VENOM also aims to build on foundational work both within and outside the service, such as the Air Combat Command U-2 Federal Laboratory's integration of Kubernetes open software to enable inflight updates. The initiative overlaps somewhat with DARPA programs, such as Air Combat Evolution—which pitted an artificial intelligence (AI) pilot against a human pilot—and Artificial Intelligence Reinforcements, which has contracted with five companies to develop AI software.

VENOM, however, is focusing on autonomy ahead of potential AI integration. An F-16 pilot will watch over the autonomy software piloting the jet, testing, evaluating and turning it off if needed.

“I think of it as test infrastructure—when we do have an autonomy solution, we can take it here and test it before we put it into a purely auton-

ing the crews and take the necessary measures to address it.”

Requirements to train pilots differently for SPO risk unintended, big-picture consequences, the paper says.

“Lack of crew interaction and coordination would create new hazards in pilot training that need to be carefully evaluated before any kind of reduction in crew composition is seriously considered,” the paper adds.

One emerging threat about which pilot groups are not concerned is advanced air mobility (AAM). Despite

the apparent links between aspiring single-pilot and fully autonomous AAM aircraft under development and SPO concepts in air transport, the unions see a clear regulatory divide between the two.

“Investors of [AAM] companies are major airlines and aircraft manufacturers, therefore, success in [AAM] may lead some to consider migration of automation technology and practices related to SPO to traditional commercial aviation,” the ALPA white paper says. “Furthermore, legislative interests to

license [AAM] vehicles could have an impact on regulations in Part 121.

“However, AAM is a very different environment to Part 121 and there are appropriately different regulatory standards for operations under Part 121,” the ALPA paper continues. “Substantial differences between AAM and commercial aviation include varied operating environments and economic cases, and it would be premature to apply advances made in AAM to current passenger and cargo aviation operations.”



The first F-16s to be modified for autonomy testing arrived at Eglin AFB, Florida, in April.

DAVID SHELKOFF/U.S. AIR FORCE

omous platform,” says Col. Timothy Helfrich, senior materiel leader for the advanced aircraft division and director of the Agile Development Office at the Air Force Life Cycle Management Center.

The basic approach for the early stages of VENOM autonomy testing focuses on software working through if-then statements: If a mission requires A, then the aircraft will do B. At a basic level, it resembles how a General Atomics MQ-9 Reaper automatically flies to a designated orbit if it loses connection to the ground station. This type of approach is intended to develop into more robust processes using deterministic software code, whereby based on a specific input, the aircraft would choose an outcome or notify the pilot to do so, Hamilton explained.

This method compares to some broader AI evaluations that will be done with the XQ-58, wherein the software will take the inputs and decide on its own what the outcome should

be by evaluating its parameters inside the software code—albeit with an option to turn off the software to ensure human governance.

“So VENOM is meant to give us a platform in order to be able, when the time is right, to evaluate AI,” he said. “A lot of it is focused on autonomy. What does autonomy look like for an uncrewed system that we’re imagining will be flying with support from another entity?”

What that looks like is something VENOM hopes to pursue. The Air Force initially envisioned the CCA as a Next-Generation Air Dominance platform that would control a team of uncrewed systems, although that has evolved into potential operators on other platforms.

“The solution isn’t necessarily a sixth-generation fighter aircraft that has a bunch of uncrewed systems on its wing controlling them,” Hamilton said. “I think the solution is, we’re going to have some uncrewed systems

that are being controlled by a human and that have certain autonomous functions. Where that human sits I don’t think we fully know.”

The Eglin efforts are a buildup approach to increase confidence in autonomy. It is too early to identify VENOM’s exact best use case—suppression of air defenses, dogfighting, air-to-air-targeting, air-to-ground target recognition or something else altogether.

Figuring that out is “going to be a very deliberate step-by-step approach,” Hamilton said. “We are having conversations, by the way, of what is appropriate for an autonomous system and an AI-enabled autonomous system to make decisions regarding. That’s why I think . . . we are not going to unleash on the battlespace autonomous capability that has no oversight from a human. A human will be responsible for, and in the loop of, these types of autonomous capabilities.

“AI is not magic,” he continued. “It’s math. And once you understand some of the aspects of the math, you understand some of the pitfalls of the science. Then you can mitigate for those pitfalls, and you can ensure that our approach mitigates the risk of undesirable activity.”

Kendall himself took to the skies of Southern California in May in an X-62A piloted by a series of autonomous systems to demonstrate his confidence in the technology. That confidence is spreading, he argues, including among those within the service who have been more resistant to change.

“Initially, I thought that our fighter pilots might resist the idea of CCA,” he says. “Now the opposite has happened. In the words of one of the leaders in that community, ‘We understand that if we’re going to survive, we’re going to need this.’”

Robinson Adds Hydrogen-Powered Helicopters to Its Innovative Ventures

- > A MODIFIED R44 IS BEING PREPARED FOR FLIGHT TESTS
- > THE COMPANY IS HELPING CERTIFY THE FUEL-CELL-POWERED R66

Graham Warwick Washington

Robinson Helicopter’s partnership with United Therapeutics to develop a hydrogen-electric version of the R66 is a sign of new CEO David Smith’s drive to bring innovation to the storied manufacturer and its iconic line of light helicopters.

joined Robinson from Bell in March 2023 that the two companies began working toward a partnership.

UT’s founding objective—to manufacture organs and overcome the critical shortage of human organs for transplantation—is nearing takeoff as the

emission vertical-lift aircraft able to transport organs quickly and cleanly from manufacturing centers to transplant hospitals. The others are Beta Technologies’ electric vertical-take-off-and-landing (eVTOL) Alia and eHang’s autonomous EH216-S.

The eR44 “demonstrated an electric helicopter is possible, beyond a shadow of a doubt,” Rothblatt says. “But the R44 with its L/D [lift-to-drag ratio] could not achieve 250 nm on batteries. So we took the same type of battery into the Beta Alia with its L/D of 17—four times better—and with the same empty-weight fraction of batteries we achieved the 250-nm mission.”



TIER 1 ENGINEERING/UNITED THERAPEUTICS

United Therapeutics switched to hydrogen-electric propulsion after Tier 1 demonstrated a battery-electric R44 was feasible but limited.

Since Smith took over as CEO in February, Robinson has announced a collaboration with Rotor Technologies on autonomous helicopters based on the R44 and made the first acquisition in its 51-year history, buying coaxial-rotor uncrewed helicopter-maker Ascend AeroSystems. Robinson also has agreed to provide Skyrise with R66s as the first platform for its automated flight control system.

Robinson has been involved with organ transplant technology company United Therapeutics (UT) for almost a decade, providing technical advice to Tier 1 Engineering as it sought to electrify the R44 for organ delivery missions. But it was only after Smith

company lays the foundations for its plans to operate a fleet of zero-emission, optionally piloted vertical-flight aircraft to transport organs quickly and cleanly.

“We’re at rotation,” says Martine Rothblatt, founder, CEO and chairwoman of UT as well as a pilot and pioneer in electric aviation. “I can say with 80% confidence we will make our first organ electric transport in 2025.”

This progress sets the stage for efforts to field a transport fleet through the United Therapeutics Organ Delivery System program. Run by UT’s Unither Bioelectronics (UB) company in Quebec, the program set a goal of 250-nm range with a 450-lb. payload. UT began by pursuing the electric-powered eR44.

The effort with Tier 1 to convert the R44 from piston power to all-electric propulsion was one of Rothblatt’s “three shots on goal” to develop zero-

UT shifted focus to hydrogen-electric propulsion for longer range, developing an R44 proof-of-concept demonstrator internally at UB and then signing a collaboration agreement with Robinson Helicopter to certify a fuel-cell-powered R66. With initial low-temperature fuel cells, range is estimated at 200 nm with a 450-lb. payload. With later high-temperature fuel cells, the 250-nm target can be achieved, UB says.

“Robinson was a part of the Tier 1 Engineering project purely in an advisory role, pretty much focused on just technical advice in areas where they hit a stopping point,” Smith says. “Then over the past year, Martine and I engaged in a variety of ways to try to accelerate their success and make this a team effort. So it’s been a long time getting to this point.”

“We worked with Robinson back

then [with Tier 1]," Rothblatt says. "We are strengthening that relationship as we have seen a greater corporate responsiveness on the part of Robinson to electric aviation. They are the only helicopter company we work with."

UB has modified an R44 into a proof-of-concept demonstrator with two fuel cells, a booster battery, a gaseous hydrogen storage tank and an electric motor. The helicopter is undergoing ground runs while UB works with Transport Canada Civil Aviation to obtain a permit to begin piloted flights, says Mikael Cardinal, head of the United Therapeutics Organ Delivery System program.

The proof-of-concept fuel-cell aircraft is being prepared for flight testing in Bromont, Quebec, where there is easy access to green hydrogen from Hydro-Quebec, Rothblatt says. Beta is flight-testing the Alia eVTOL, with certification expected in 2026. UT also has orders for the conventional-takeoff-and-landing Alia CTOL, expected to be certified in 2025. While the agreement is still in place, UT "is not in much communication with EHang," she says, because of geopolitical tensions between the U.S. and China.

With the UT collaboration agreement in place, Robinson "will support the next milestones on the project," Smith says. "Our primary role is to help them get through the certification challenges," he explains. "We have a history certifying aircraft, and it gives you a different vantage point from those who are doing it for the first time. We can help Mikael and the team have a head start and see around corners so that there's a better chance of success and a faster timeline for success."

Another aspect of the collaboration is making sure the hydrogen-electric helicopters can be produced at a scale and price point that UT can use to meet its objectives. "We are working that as well to make sure that decisions are scalable," Smith says.

UT planned initially to base its hydrogen-electric helicopter on the piston-powered R44 but has shifted to the larger turbine-powered R66 for the production version, Rothblatt says. "Our internal studies show the R66 has a considerable advantage," Smith says. Direct-drive electric motors are closer in speed range to the R66's Rolls-Royce RR300 turboshaft, requiring fewer parts.

The R66 has "definite benefits" for

the hydrogen-electric application, Cardinal says, including greater available volume and a 200-lb. increase in maximum takeoff weight. "We think there is a strong argument for the R66," Smith says. "We will look with them at the commercial aspects of the price point of the R44 or the R66 derivative, and those will be inputs to the decision."

Also to be decided is whether the conversion will involve supplemental type certification or a type certificate extension. "We have a lot of experience making substantial modifications—for example, our police helicop-

station has been installed at Roanoke-Blacksburg Airport, and UT is building a hangar at Martin State, Rothblatt says, adding that other chargers are planned to be positioned strategically along the route to Maryland.

The preparations come as UT's organ manufacturing efforts accelerate. The company is developing four platforms: regenerating human organs, xenotransplantation, 3D organ bioprinting and bioartificial organs. The efforts are focused on producing hearts, kidneys, livers and lungs for transplantation.



New CEO David Smith is bringing innovation to Robinson through internal research and external partnerships.

ROBINSON HELICOPTER

ters—under a type certificate extension, and that has proven to be a good thing for us," Smith says. "It makes our factory run smoother and allows us to do a better job conforming the product once it's built.

"Our long-term objective is to make a type certification variant around this hydrogen architecture, but supplemental type certification is often a step along that road," he continues. As for timing, certification of the electric engine is expected to be the long pole. "So a couple of years away, minimum, and from our perspective, our involvement will accelerate that to be likely a factor of two faster than any of the other players in electric vertical lift," he notes.

UT, meanwhile, has opened its first organ manufacturing center in Christiansburg, Virginia, and is planning to fly organs from nearby Roanoke-Blacksburg Regional Airport to Martin State Airport in Maryland for delivery to its transplant hospital partners Johns Hopkins and the University of Maryland Medical Center in Baltimore.

In preparation for the beginning of organ delivery flights, a Beta charging

Rothblatt says UT is within months of the 500th lung transplant using refurbished organs, which she describes as an "insane" achievement. The Christiansburg facility can produce 100 organs a year. At the same time there have been 10 xenotransplants, and UT has received approval for its laboratory-manufactured kidney, with the first clinical trial of a bioartificial organ planned to begin this year.

As for the desired optionally piloted capability for its organ transporters, "we are trying to keep that moving along at the same time . . . [but] regulatory receptivity is lagging relative to electric propulsion," Rothblatt says. "We are continuing our funded efforts and have a lot of good programs at UB."

UB has mapped flight corridors from the manufacturing center in Virginia to the transplant hospitals in Baltimore with the goal of enabling autonomous flights. "We are pursuing regulatory authorization with a super-high-resolution route," Rothblatt says. "Hopefully, with onboard sense-and-avoid, we can provide them with confidence we can fly this Virginia-Baltimore route." 🚁

ON HOLD

- > THE PENTAGON'S NGAD UNCERTAINTY PRESSURES ADAPTIVE ENGINE-MAKERS TO "ADAPT"
- > GE SAYS IT "STANDS READY" FOR NGAD RESPONSE
- > PRATT PUTS NGAP TECH INTO F135 UPGRADE

Guy Norris Colorado Springs and **Steve Trimble** Washington

After decades of development and billions of dollars of investment, the destiny of U.S. adaptive combat engine technology hangs in the balance as the U.S. Air Force reconsiders requirements for its intended initial application, the Next-Generation Air Dominance platform.

turbofan and the competing Pratt & Whitney XA103.

Amid the NGAD turmoil, Air Force Secretary Frank Kendall has indicated that the issue is partly due to the cost and complexity of NGAP engines. He has strongly suggested that the engine-makers study potential alternatives that are simpler and smaller.

Other insiders, meanwhile, warn that the nearly unrivaled position of the U.S. in high-performance military engines could be eroded if initiatives such as NGAD and NGAP stall. "The U.S. Air Force is at a key inflection point when it comes to stewarding this technology," says Douglas Birkey, executive director of the Mitchell Institute for Aerospace Studies. "Sustaining existing designs is not the same as developing, fielding and producing new technology. The Air Force knows this, and that is why it has invested in multiple programs to pursue new engines that deliver enhanced perfor-



Adaptive engines use a variable third stream (in blue) to increase fuel efficiency or boost thrust.

Offering a step change in performance over conventional fixed-cycle designs, the adaptive engine's ability to transition automatically between fuel-efficient and high-thrust settings has been heralded as the biggest game changer in military propulsion since the invention of the turbofan. Adaptive engines achieve this by continually varying the two main propulsion parameters that affect thrust and specific fuel consumption: bypass ratio and fan pressure ratio.

Before mid-June, the Next-Generation Air Dominance (NGAD) program and the propulsion systems being groomed to power it appeared to be on

a firm path toward fielding at the end of the decade. But as Boeing or Lockheed Martin came within weeks of being awarded a full-scale airframe development contract, Air Force leaders suddenly expressed second thoughts and pressed the pause button.

After reconsidering undisclosed threats and requirements for the NGAD platform, the Air Force put plans for a contract award on indefinite hold in late July. As a result, uncertainty also hovers over the Air Force's parallel Next-Generation Adaptive Propulsion (NGAP) program, which funds development of the GE Aerospace XA102 adaptive

mance, reliability and efficiency attributes necessary to meet current and future mission requirements.

"However, R&D investment must eventually transition to production in volume for tangible results to positively shape the operational realm," Birkey continues. "Far too many propulsion programs and their related efforts, like NGAD, have been canceled and or curtailed. This is a competitive realm, and adversaries are pressing hard. It's crucial that the Air Force, [Pentagon] and Congress take this into account as they consider the future of these programs."

The engine-makers have already

GUY NORRIS/AWAST

developed and tested variable-cycle engines (VCE) for two thrust requirements—a 45,000-lb. powerplant suited for the Lockheed Martin F-35 and a lower-thrust variant for NGAD—and say they are prepared to be adaptable.

GE, the main driving force behind the service's two-decade investment in adaptive propulsion, has emphasized the inherent flexibility of the VCE three-stream engine technology as NGAD platform requirements evolve. "We're as anxious as anyone to see which way they go," GE Defense and Systems CEO Amy Gowder tells Aviation Week. "We stand ready for the government to figure out their form factor."

Despite the platform-level uncertainty, Gowder asserts that a portfolio with two adaptive turbofans of different sizes offers an advantage as the Air Force determines final requirements for the NGAD platform. Having two options redefines the term "adaptive" to apply to sizing the engine for thrust, too.

GE's XA100 "is actually a much larger engine, but it's certainly available," she says. "The XA102 kind of scales down. Whichever way they land on their requirements, we believe we have technology that's relevant."

The XA102 and Pratt's XA103 follow a \$6 billion technology investment plan the Air Force launched in 2006. That path most recently produced the 45,000-lb.-thrust GE XA100 and Pratt XA101 under the Adaptive Engine Technology Development (AETD) program. Both engines entered development in 2016 to become candidates to reengine the F-35. But the Air Force ultimately decided to upgrade the core of the incumbent Pratt F135. GE completed a fourth series of ground tests on the XA100 last year.

"We are hitting the max of the fourth-generation or even, you could argue, the fifth-gen engines," Gowder says. "You can keep doing some materials improvements, but this architecture—the ability to cruise like an airliner, and without pilot intervention other than pulling the throttle, you're able to fly like a fighter—I think that technology will ultimately make its way into the solution and ideally sooner than later to keep our asymmetric advantage."

Overall, GE remains optimistic. "The Department of Defense needs advanced engine capabilities, regardless of the platforms they power, and

we are delivering on that front," GE said in a statement. "We continue to see bipartisan support in both the House and Senate for the development and testing of adaptive-cycle engines to ensure our ability to maintain U.S. air superiority."

Pratt & Whitney completed a critical design review of the XA103 with the Air Force in the first quarter and is considering options as it awaits direction from the government. "We have 500-plus people working on NGAP today," says Jill Albertelli, president of

edge and learning and have completely accomplished our objectives for that program, which is phenomenal, to tell you the truth."

Several advances gained through NGAP—particularly in hot-section technologies, such as materials, coatings, cooling and systemwide thermal management—also are transferable to the F135 engine core upgrade (ECU) program. "Some of the technology will go right into the ECU, and the balance of it goes into NGAP for our sixth-generation propulsion system," Albertelli



Technology proved on the XA100—pictured in testing—was scaled down and applied to GE Aerospace's NGAP XA102.

Pratt & Whitney Military Engines. "We will support the timeline that our customer needs with all of that. So at this point in time, it is something that we are continuing to carry forward until we are told something different."

In terms of new engine designs that could emerge from the ongoing Air Force deliberations, Albertelli says: "As far as shape and size, we always base things on requirements. We're working to the set of requirements that we have today, and we'll wait and see if something changes, and we'll adapt—no pun intended—accordingly."

Pratt is "working closely with the U.S. Air Force on exactly what they want to do from a hardware standpoint," she says, referencing the disposition of test assets, such as the XA101. "But we have all that knowl-

says. "A lot of experts over the years have worked on the development of these. As we work the NGAP program, those experts are able to transition from the success of the current program over to these other areas."

A key element that Albertelli highlights is NGAP's focus on the advanced use of digital tools. "We're demonstrating it every single day," she says. "It might be certainly for design, but for sixth-generation, it should be able to help you prioritize what your testing will be. Some things I would even say, from a design standpoint as a former engineer, you can just do it faster. So that's very key in this entire approach. We've received very positive feedback from the Air Force on how we're engaging and really working digital modeling throughout." ❁

China Steps Up Research Into Adaptive Combat Engines

- > BEIJING UNVEILS A HYPERSONIC ADAPTIVE CONCEPT
- > THE COUNTRY'S RESEARCH FOCUSES ON TRANSITION CONTROL

Guy Norris Colorado Springs

As the U.S. dithers over introducing adaptive propulsion into its next-generation combat aircraft, there is growing evidence that China is doubling down on efforts to develop a similar capability.

Adaptive, or variable-cycle, engine technology is widely viewed as the next breakthrough in military power, particularly for operations in regions like the widely dispersed Asia-Pacific, where the concept's ability to switch between fuel-efficient cruise and high-thrust combat modes could give both a tactical and strategic advantage.

2022, indicates that indigenous high-performance turbine capability lags that of the West. However, the country's rapid development of hypersonic systems is widely viewed as a stark example of what its government, industry and research complex can achieve in short order.

Indicative of some of the adaptive propulsion innovations under study in China is a newly unveiled concept from the Beijing-based Beihang University's Research Institute of Aero-Engines. Outlined with a potential top speed of Mach 5 and operation at alti-

other adaptive designs by including an interstage turbine burner (ITB).

The ITB is designed to compensate for low mass flow at high altitudes, and as the engine transitions from turbofan to turbojet mode, the unit functions as the main combustor. By being in the main bypass duct, the ITB enables the use of a smaller-core engine and opens up more area for bypass flow while enabling the bypass flow to participate in the cycle as well. The TDCE also includes a fluid-based heat exchanger in the external bypass duct that cools bleed air in the high-pressure turbine.

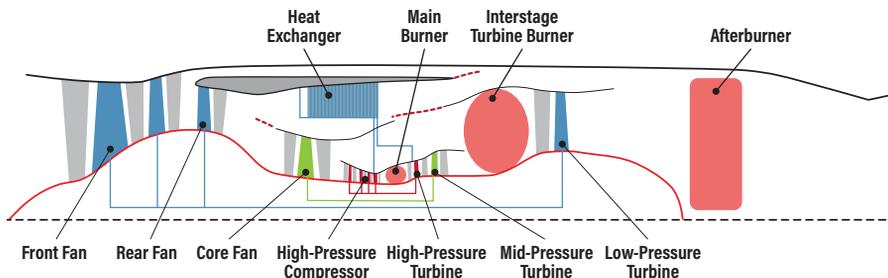
As with all adaptive engines, the TDCE includes a set of variable-geometry valves, vanes and injectors to enable mode transition. The TDCE's formidable array of variable features includes forward and aft variable-area bypass injectors, adjustable guide vanes on the fan, booster stages and compressor inlets, and adjustable guide vanes on both the low-pressure and intermediate-pressure turbines. The engine incorporates a variable-bleed high-pressure compressor and a variable-bleed exhaust nozzle, too.

Research at Beihang, the Beijing-based Aero Engine Academy of China and the AVIC Shenyang Engine Research Institute, among other groups, has also focused on managing the complexities of mode transition control laws and scheduling. Much of this work has been supported since the mid-2010s by the National Natural Science Foundation of China and the Collaborative Innovation Center of Advanced Aero-Engines of China.

Other recent studies at Beihang's Research Institute—in association with the colocated National Key Laboratory of Science and Technology on Aero-Engine Aero-Thermodynamics—have focused on modeling variable-cycle engines, flow analysis and experiments on key mechanisms such as variable-area bypass injectors.

The uptick in studies into adaptive engines over the past decade supports findings in a 2023 report by the Center for Strategic and International Studies: "There is little evidence to suggest that China has, or imminently will, reach parity with Western engine technology," the report states. "However, there is robust evidence that it is making a concerted effort to do so." 🇨🇳

Three-Rotor Dual-Variable-Cycle Engine Concept



Source: Beihang University, China

U.S. adaptive engine technology, most recently represented by the GE Aerospace XA102 and Pratt & Whitney XA103 three-stream engines, is the culmination of research efforts that in some cases extend back to the 1960s. China's indigenous military engine development heritage is relatively limited in comparison, and current progress appears to be heavily based on leveraging lessons learned from decades of U.S. and European research.

While hard evidence of adaptive engine development within China's closed military propulsion infrastructure is hard to obtain, the increasing number of academic research papers on the concept emerging from China offer new clues that activity is accelerating.

Even so, the 20-plus-year development of China's most advanced military engine, the Shenyang WS-15, which first flew in a Chengdu J-20 in

tudes over 90,000 ft., the design could offer a path to hypersonic capability far exceeding that of comparable Western engines.

Unveiled at the Turbomachinery Technical Conference and Exposition in London in June, the concept combines variable-cycle features with a three-shaft configuration—unlike the two-shaft engines in development under the U.S. Air Force's Next-Generation Adaptive Propulsion program.

"In order to meet the high maneuverability and long-range design requirements of the new generation of aeroengines, variable-cycle engines with variable geometry characteristics and multiple mode adjustments have become a mainstream research direction," the university researchers write. Aside from its triple-shaft configuration, the three-rotor, dual-variable-cycle engine (TDCE) differs from most

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By **Graham Warwick**

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Cranfield University Proposes C-130J Hydrogen Testbed

Cranfield University is proposing conversion of a Lockheed Martin C-130J Hercules into a platform for flight-testing hydrogen propulsion technologies in the UK. The military transport's four-turboprop layout would allow in-flight testing of hydrogen combustion engines with flexibility and safety, researchers say.

UK DEFENSE MINISTRY



The C-130J could make a versatile hydrogen propulsion demonstrator.

"We are looking at the possibility of a UK flying demonstrator for hydrogen-combustion turbine engines," David Zammit-Mangion, a lecturer at Cranfield's College of Aeronautics, told the American Institute of Aeronautics and Astronautics' Aviation conference in Las Vegas in July. "The C-130J is an ideal candidate because it has four engines, a large cargo bay and a rear loading ramp."

The C-130J would provide the versatility to demonstrate multiple hydrogen technologies, including different engines, heat exchangers, tanks and fuel systems. The cargo bay and rear ramp would allow quick and cost-effective conversions by enabling roll-on, roll-off installations and removals.

"If it was my money, I would buy a C-130 Hercules and convert two of the engines to run on hydrogen," Pericles Pilidis, head of the Propulsion Engineering Center at Cranfield, said in April. "Two of the engines I would retain as conventional fuel so you could move it around. The Hercules is capable of carrying a lot internally, and with hydrogen, that can occupy a lot of volume."

Cranfield has developed the concep-

tual design for a C-130J-based demonstrator. Heat exchangers and hydrogen fuel pumps would be mounted at the forward end of the cargo compartment and hydrogen tanks under the wing, where they are close to the center of gravity and easily replaced via the ramp.

The C-130J would be able to accommodate one or two 2.2-m-dia. (7.2-ft.) aluminum dewar tanks containing up to 1,670 kg (3,680 lb.) of liquid hydrogen. Fuel pipes would run overhead in the cargo bay for safety, and the existing kerosene fuel system would be retained unmodified. "We need to look at venting the fuselage and rerouting the electrics away from the hydrogen systems," Zammit-Mangion said.

The modified aircraft would not have room to accommodate a team of flight-test engineers; the engineering team would be based on the ground in Cranfield's concept, operating remotely using telemetry to relay test data from the aircraft.

Cranfield has studied configurations in which one or two of the existing four turboprops are replaced with hydrogen-combustion engines. With only one engine switched to hydrogen fuel, the aircraft could fly anywhere on three kerosene engines, with the fourth powered up as and when required.

A single-engine conversion would support initial flight testing. A two-engine conversion would allow dual-fuel operation with the possibility of shutting down the hydrogen propulsion system and flying on the remaining two kerosene engines in the event of an emergency.

Configuration 1, the single-engine conversion, would allow ferry flights and demonstration of one hydrogen engine and its fuel system while operating with a level of safety commensurate with European Union Aviation Safety Agency CS-25 transport-category airworthiness requirements, but it would not allow flight on hydrogen alone.

Configuration 2, the two-engine conversion, would allow the C-130J to fly solely on kerosene or hydrogen, but it would not meet the engine-out safety requirements of CS-25—assuming they would apply to an essentially experimental aircraft, Cranfield noted.

Preliminary performance analyses indicate that the conversion of one engine to hydrogen can be easily accommodated, while the conversion of two or more engines may be feasible but requires further study to confirm feasibility and operational safety. "Config-

uration 2 has greater versatility, but needs further consideration," Zammit-Mangion said.

—With Guy Norris in Colorado Springs

Ductile Composites Enable Lightweight LH₂ Tanks

Liquid hydrogen tanks are large and heavy, making them challenging to install in aircraft, but a U.S. company has developed and tested a lightweight, leakproof composite cryogenic tank technology that could unlock the potential for hydrogen to outperform kerosene as a fuel for aviation.

Based in Tullahoma, Tennessee, Gloyer-Taylor Laboratories (GTL) is taking composite tank technology developed to store liquid oxygen and liquid methane in space launch vehicles and adapting it to liquid hydrogen and aircraft propulsion, beginning with drones and helicopters.

Hydrogen's energy density per unit mass is three times that of kerosene, but its volumetric energy density is four times lower. As a result, a key figure of merit for tanks is gravimetric efficiency, or hydrogen fraction—the ratio of hydrogen stored to total fuel system weight.



GLOYER-TAYLOR LABORATORIES

Gloyer-Taylor is building a flightworthy prototype LH₂ dewar tank.

For typical thin-gauge metal tanks, gravimetric efficiency ranges from 6 to 15%, depending on size. The target for aviation is at least 35%, the level at which liquid hydrogen reaches parity with kerosene in terms of the total fuel system weight for the same amount of energy stored.

GTL founder and CEO Paul Gloyer says the company's ultrathin composite tank technology can achieve volumetric efficiencies exceeding 70% for larger tanks. Such a high hydrogen fraction could be transformative for aviation.

A conceptual study by GTL for NASA

showed that using its tanks to retrofit the Boeing 787 MAX 8 for LH₂ instead of kerosene reduced maximum takeoff weight by 13-17% while maintaining the same payload mass and volume, passenger capacity, range and speed.

“Everyone knows carbon fiber is so much stronger than metal,” Gloyer says. “The issue with fuel tanks is they can’t leak, especially with cryogenics. Everything shrinks and gets brittle, then when you pressurize and stretch it and you end up with cracking.”

GTL was formed in 2005 by the merger of PacAstro—a failed venture to develop a low-cost small satellite launcher—with composites manufacturer Aspect Engineering. The new company targeted pain points in the development of rockets, including predicting combustion instability and reducing tank weight.

“We came up with a materials and manufacturing process breakthrough that allows our laminate to be ductile at cryogenic temperatures. It’s able to stretch, and the matrix stretches as much as the fibers do, so it doesn’t crack,” he says. “Our tanks are on the order of the thickness of a business card. We figured out how to keep cryogenic tanks from leaking by using very thin composite structures.”

GTL has been developing tanks for 10 years with support from DARPA. The focus was space, and the shift to aircraft brought the challenge of minimizing liquid hydrogen boil-off. Spray-foam insulation was too heavy, so GTL has developed an all-carbon, double-wall, vacuum-insulated dewar tank.

“We knew that our composite technology worked for warmer cryogenics—liquid oxygen, liquid methane, liquid nitrogen—but the shift to liquid hydrogen was a much bigger challenge,” Gloyer says. To prove its claims, GTL built and tested a subscale LH₂ tank, demonstrating successful operation.

The tests verified the composite tank is leak-tight with LH₂. The vacuum jacket held 2.8-6 torr for about 50 min. “You could not hold that with any type of a leak,” Gloyer says. “This was a really big validation point.”

The subscale tests also verified the tank’s ability to hold LH₂ for long durations, about 1% boil-off per day for a full-scale tank, and to be filled quickly, chilling from ambient temperature to a cryogenic 20K (-423F) in less than 20 sec.

GTL is building a flightworthy small tank for flight testing on a crewed helicopter by year-end. This prototype has

a diameter of 28 in., contains 42 lb. of LH₂ and weighs 33 lb. for a hydrogen fraction of almost 55.6%, increasing to 62.5% for a stretched version housing 110 lb. of LH₂.

European Hydrogen Power Project Picks H3 Fuel Cells

H3 Dynamics has been selected to supply fuel cells to a European research project developing a modular, distributed hybrid hydrogen-electric propulsion system for future regional aircraft carrying up to 19 passengers.

Part of the Clean Aviation research program, HyPoTraDe (for Hydrogen Fuel Cell Electric Power Train Demonstration) is a three-year, €4.5 million (\$5 million) project led by Slovenia-based Pipistrel.

Launched in January 2023, HyPoTraDe is a follow-on to several projects under Europe’s previous Clean Sky 2 research, including the Unifier 19 project to develop concepts for a community-friendly Miniliner.

Completed in August 2022 and led by Pipistrel, the Unifier 19 project developed a concept design, C7A-HARW, for a liquid-hydrogen-fueled 19-seater with a high-aspect-ratio wing, distributed electric propulsion and a tail-mounted pusher propeller. This is the reference design for HyPoTraDe.

Pipistrel also led the Mahepa project (Modular Approach to Hybrid Electric Propulsion Architecture) to demonstrate a modular hybrid-electric propulsion architecture for future small, short- and medium-range regional aircraft.

The Mahepa project concluded in October 2021, having flown a hybrid-electric powertrain combining a lightweight internal-combustion engine with batteries in a four-seat Pipistrel Panthera and a hybrid-electric propulsion system using hydrogen fuel cells in the twin-fuselage Hy4 testbed.

Following on from these projects, HyPoTraDe is focused on developing and testing a modular 500-kW fuel-cell/battery hybrid powertrain that is scalable to megawatt class to power CS-23/Part 23 aircraft. The project will ground-test the system at simulated altitudes up to 25,000 ft. and generate data to validate a digital twin that can be used to predict the performance of future scaled powertrains.

Targeted at regional and short-range aircraft entering service in 2035, HyPoTraDe also is exploring using the waste heat produced by the fuel cells to heat the cryogenic liquid hydrogen from -432F to the above-zero temperatures required for their operation, increasing the system’s efficiency.

The HyPoTraDe project includes development of a kilovolt-class battery and electric distribution system that can handle power peaks and store excess energy produced by the fuel cells, as well as a multipropeller distributed electric propulsion array that would be mounted on the wing leading edge.



The concept for the 19-passenger hydrogen-electric Miniliner was developed under Europe’s Unifier 19 project.

Planned for the third quarter of 2025, the ground demonstration at Royal NLR in the Netherlands will comprise a liquid hydrogen tank and distribution system, hydrogen fuel cell stack and battery system, kilovolt-class electrical distribution system, propulsive loads, including motors and propellers, nonpropulsive aircraft loads, and a complex thermal management system. The project will conclude at the end of 2025 with validation of the digital twin.

Pipistrel’s partners in the HyPoTraDe project include Honeywell, Delft University of Technology, the Fraunhofer Society, Royal NLR and the University of Stuttgart.

Pipistrel is also teamed with Honeywell on the Newborn project under Clean Aviation. Newborn is developing a ground demonstrator of a fuel-cell propulsion system for 19-passenger CS-23 aircraft with a total takeoff power of 2 megawatts.

The overall goal is to achieve a propulsion system efficiency—hydrogen tank energy to propeller shaft power—of 50% by 2026. The system integrates an innovative liquid hydrogen tank concept with the goal of demonstrating a gravimetric index—the ratio of fuel mass to the mass of the full fuel system—of 35% for a CS-23 aircraft and 50% for a larger CS-25 regional aircraft. ☪

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Community of Brands..... 51
Defense Market Analyzer..... 47
Fleet & MRO Forecasts 27
Global Defense 44

Market Briefings 4
2024 Photo Contest 23
Embraer Defense & Security 2nd Cover
Lockheed Martin..... 4th Cover
Ontic Engineering and Manufacturing..... 4
AVIATION WEEK MARKETPLACE 64
Asset Remarketing International 64
Safe Association 64

Russia and the Future of Western Defense

By **Byron Callan**

Russia's full-scale war with Ukraine will reach the 1,000-day mark in late November. The war is bound to end in a settlement eventually, as neither Ukraine nor Russia appears to have the capability to defeat the other unconditionally. What happens before that settlement, when the war ends and what follows are unknown, but the bottom line is that the war and what comes next in Russia will remain major factors shaping defense markets in this decade and beyond.

Three major variables must be considered for the rest of this year and in 2025. First is the outcome of the U.S. election. Republican candidate former President Donald Trump has promised to bring the war to a quick conclusion by suspending aid to Ukraine. That may not happen abruptly, but the direction of change will be set. Whether Europe and other states can backfill the loss of U.S. aid is an open question. If Ukraine is forced to settle, Russia would still be left with a military that has been seasoned, a defense industrial base that has been retooled and the need to recapitalize equipment it lost in the war.

The second variable is the wild cards that could yet be played during the war. Russia has threatened to use tactical nuclear weapons in the past and could elevate those threats or actually use them. The war could spread to involve Poland or another NATO member. Some Polish and Ukrainian officials have called recently for Poland to shoot down Russian missiles in Ukraine. That sort of escalatory involvement could provoke a Russian response.

A third variable is a Russian or Ukrainian breakthrough that would end the military stalemate. Kyiv's offensive into the Kursk oblast of Russia has underscored that Moscow does not have the forces to defend all of its border with Ukraine and that Ukraine can craft a combined arms operation enabling its forces to maneuver. Whether this proves strategically significant remains to be seen. If Russia gains more territory in Ukraine, the Kursk offensive may have achieved little. Western aid is not providing Ukraine with the armor, infantry fighting vehicles, engineering, logistics and artillery to conduct a major offensive. That is not likely to change in 2024-25.

In 2025-27, other factors could emerge to shape defense sentiment. China so far has been willing to support Russia's broad war effort by exporting machine tools and other dual-use items as well as purchasing Russian com-

modities. That level of support could change if China opts to provide Russia more direct military aid at a scale that could decisively tip the war in Moscow's favor. The motive for that could be to make Russia a military threat strong enough to anchor part of U.S. military power and European militaries in Europe rather than in the Indo-Pacific.

Another factor could be whether Ukraine decides to develop its own nuclear weapons later this decade. Ukraine has 15 nuclear reactors that generate about 50% of its electricity. It would need to develop enrichment facilities, but if South Africa, Israel, North Korea and Pakistan could develop nuclear weapons, it may not be too much of a stretch for Ukraine to do the same—if Western security assurances erode and Russia remains an existential threat. In this scenario, something like the Israel-Iran dynamic over Iran's nuclear program could play out on Europe's eastern borders. Russia under President Vladimir Putin might see a Ukrainian program the same way Israel views Iran's capability.

And then there is a longer-term issue: What is to become of Russia? Putin is 71 years old. Russia has no clear, logical succession path for a new leader, let alone an opposition party. Putin could be in power for another decade or more, but if he is somehow deposed or dies, a post-Putin regime could embrace his views of Russia's place in the world and sustain its anti-Western stance.

There may be an analogy between the end of the Russia-Ukraine war and that of the Iran-Iraq War in 1988. Iraq had to contend with unemployment and lower prices for the oil on which its economy was highly dependent, which led it to invade Kuwait in 1990.

Russia in the 2020s and '30s will have a more seasoned military that may have learned from the fighting in Ukraine. It will remain a nuclear power that rivals the U.S., but it will have major challenges in recapitalizing airpower and replacing equipment lost or worn out in the war with Ukraine. Russia will continue to be a key factor shaping defense demand in this decade and beyond. Europe and the U.S. were unable to integrate Russia into the West in the 1990s. That would be a far taller task in the 2030s. ☛

Contributing columnist Byron Callan is a managing director at Capital Alpha Partners.



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“RUSSIA WILL HAVE MAJOR CHALLENGES IN RECAPITALIZING AIRPOWER AND REPLACING EQUIPMENT LOST IN THE WAR WITH UKRAINE.”

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SAE International's Workshop on Simulation & Modeling for Certification will focus on identifying today's top challenges in utilizing digital tools, models, and simulations to improve design, production, and ultimately certification of aerospace vehicles.

The workshop will be held prior to Aviation Week's Welcome Reception at the Digital Transformation Summit on Monday October 7.



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