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& SPACE TECHNOLOGY

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Shadowy Success

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20 Twenties
Class of 2025



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**Airbus Kicks
Hydrogen
Down the Road**

**Why India's
Air Force Chief
Is Not Happy**

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Sikorsky's X2-based offering is a contender for NATO's Next-Generation Rotorcraft, which is slated to replace about 900 helicopters across member countries starting in 2035.



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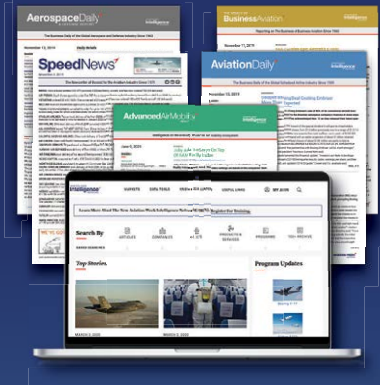
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DATA SECURITY

Two cheers for Jennifer Tisdale's viewpoint on cybersecurity ("*Securing the Skies From the Ground Up*," Jan. 27-Feb. 9, p. 66). Yes, cybersecurity is extremely important, but the clearest option was not mentioned. No dataset, without significant reason, should have any possible direct physical connectivity to the internet. The firewall must be total and clear.

Many, if not most, data systems do not need to be connected. Other irrelevant desires often push that connection, and they must be restricted. Data can be updated as required in a controlled process by IT staff using a strict quarantine process with physical signoff, in and out. A sanitized subset may be in a "live" separate zone if necessary, but most critical internet protocols, designs, data and the like should have zero possible direct connectivity so they cannot be externally reached, and they should be based on shielded servers in the corporation's own building, under their own physical guardianship and not in the cloud with its vulnerabilities.

Roger Cooper, Denver

HELP FINDING A HERO

Fifty years ago, Fred D. Williams saved my life in a Hughes TH-55 at Fort Rucker (now Fort Novosel), Alabama. I was in the TH-55 Warrant Officer Rotary-Wing Aviator Course, and he was my instructor pilot. Civilian contractor Doss Aviation had the contract back then to provide introductory flight instruction to Army flight candidates.

Williams, who had flown Bell UH-1 Iroquois Hueys in Vietnam, had an exceptionally calm, unflappable demeanor. I believe he was full-blooded Cherokee. I am one-eighth Cherokee; my paternal great-grandmother was full-blooded Cherokee, and my paternal great-grandfather was Scotch-Irish.

He was like a big brother to me. The first time we flew the TH-55 together, he told me I could control the antitorque pedals while he controlled the cyclic and collective levers as we taxied to the runway for take-off. I quickly got myself into a pilot-induced oscillation by getting out of sync with the pedals, resulting in us doing a complete 360 before Williams took the controls back and saved us.



Fred D. Williams (right) and Sherman Morgan in July 1976.

After I had flown about 8 hr., I was taking off from Hatch Stage Field with a very gusty crosswind, and a strong gust hit us just as we were transitioning through effective translational lift that caused me to lose control of the helicopter. If my instructor pilot hadn't been there to take the controls and save me, I would have crashed.

My class eventually graduated from the TH-55 syllabus and moved on to the UH-1 advanced training syllabus. After I was awarded my Army wings, we were assigned to the 155th Assault Helicopter Company at Fort Ord, California, and over time, Williams and I lost touch.

If you happen to have any information about Fred Williams, please contact me or let him know that I'm looking for him. You can readily find me on Facebook or send me an email at the address below.

Sherman Morgan, Rock Hill,
South Carolina
sherman.morgan@gmail.com

CAPACITY CATASTROPHE

Congress is systemically at fault for the Jan. 29 midair collision of American

Airlines Flight 5342 and a U.S. Army Sikorsky UH-60L Black Hawk near Ronald Reagan Washington National Airport (DCA) ("*Institutional Failure*," Feb. 10-23, p. 16).

The airport is over capacity by 40%. Nonstop services to the airport are limited to a perimeter of 1,250 mi., but congressional representatives want nonstop flights to their constituencies beyond that perimeter. Legislation passed by Congress empowers the Transportation Department to issue "beyond-perimeter" exemptions.

Last year, the FAA Reauthorization Act allowed the addition of 10 more daily flights to DCA's schedule, all of which are outside the perimeter. This decision was made "over the strong opposition of the Airports Authority," DCA's website says. Congress also added slots in 2000, 2003 and 2012, totaling 54.

In addition, helicopters should be nowhere near commercial aircraft landing flightpaths. Commercial airline pilots on final approach are flying low and slow, and laser-focused on the electronic approach path, as they should be. If they see other commercial aircraft, they can perform a go-around. But helicopters are flying too quickly for commercial aircraft to look on final approach. It is time for big changes at DCA.

Kenneth E. Gazzola, McLean, Virginia
Gazzola was publisher of *Aviation Week* from 1987 to 2006.

ON AVIATIONWEEK.COM, on Feb. 7, in response to the article "Pilot Reports Foreshadowed Washington Midair Collision" (Feb. 10-23, p. 16), LUNDC wrote:

This is a pretty comprehensive report as of what is known today, thanks.

While I am not a pilot, I have done several test flights in both helicopters and fixed-wing commercial and business aircraft. I would have liked to have seen more discussion on what frequencies the tower was using and why both aircraft were not at least monitoring the tower in that proximity to the airport.

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.



Tom Doxey has been appointed chief financial officer at *Southwest Airlines*, effective March 10. He was president of Breeze Airways and before that was senior vice

president of technical operations at United Airlines.

Gulfstream Aerospace has named **Tim Waterman** chief financial officer. He was director of financial planning and analysis at parent company General Dynamics and held positions across the business for 27 years.

Jonathan Wakenshaw has joined satellite navigation company *Xona Space Systems* as chief operating officer. He held the same title at Elroy Air, with past positions at Toray Advanced Composites, Ascent Aerospace and GKN Aerospace.

Safran Helicopter Engines has promoted **Jean-Francois Sauer** to executive vice president of programs from vice president for military aircraft engine support, succeeding Valentin Safir. Sauer has worked with Safran since 2002, including at Safran Aircraft Engines and the Europrop International consortium.

Otto Gergye has joined Colombian airline *Avianca* as chief commercial officer. He was director of revenue at Thai Airways and before that worked at Sabre, Qantas and Fiji Airways.

Special Aerospace Services has promoted **Warren Kohm** to CEO from chief financial officer, succeeding Heather Bulk as she transitions to vice chairman. Before joining the company, Kohm was chief financial officer at Red River and prior to that worked at Alion and Booz Allen Hamilton.

Bill Read has been named chief financial officer. He held the same title at



Redwire and held executive positions at Abaco Systems.

Michael Young has joined *Terran Orbital* as senior vice president of business development. He

was vice president of business development at Hanwha Phasor and before that worked at Ultra Intelligence & Communications, Envistacom and General Dynamics Satcom.

Drone technology company *PDW*

has hired **Dan DeFay** as vice president of information security. He was chief security officer at NorthStar Technology and was founder and CEO of SmartFirm before its acquisition by NorthStar. **David Spirk** has also joined the board of directors, adding to his position as senior counselor at Palantir. He was previously the first



chief data officer at the U.S. Defense Department.

Julia Laurenzano MacDonough has been named vice president and general manager for U.S.

Air Force and missile defense strategic systems at *Draper*. She was vice president and general manager of space systems and before that worked for eight years at BAE Systems Inc.

Huntington Ingalls Industries has promoted **Derek Murphy** to vice president of new-construction aircraft carriers at its shipbuilding division in Newport News, Virginia, where he will oversee production of the John F. Kennedy (CVN 79), Enterprise (CVN 80) and Doris Miller (CVN 81) carriers. He was program director for CVN 79 and



has worked in the shipbuilding division since 2007.

Cameron Gowans has been appointed vice president of operations at *Partners in Aviation*. He

has more than 30 years of experience in business aviation and sales, most recently as president, chief operating officer and chief commercial officer at Four Corners Aviation. Before that, he worked with Jet Linx, Embraer and Flight Options.

The *Metropolitan Nashville Airport Authority* has hired **Lisa Levya** as vice president of concessions and **Steven Woods** as vice president of information technology. Levya joins from Raleigh-Durham International Airport, where she was senior director of commercial management. Before that,

she was aviation development manager for the city of Albuquerque, New Mexico. Woods was global director of data, technology and security at Worldwide Broker Network and chief information officer at Brentwood Services Administrators.

Drone technology company *Red Cat Holdings* named **Geoffrey Hitchcock** chief revenue officer. He was general manager at subsidiary Teal Drones and before that was senior vice president of global defense solutions at Red Cat. In addition, **Chris Rill** has been promoted to president of Teal Drones from director of partner integration at Red Cat. He has served as chief technology officer at various companies, including Canary, which he co-founded.

Matthew Friendly

has been hired as general counsel at *AE Industrial Partners*, a private equity firm focused on aerospace, industrial services and national security. He was a partner at McDermott Will & Emery, providing counsel on private equity transactions.

Reliable Robotics has tapped U.S. Army Gen. (ret.) **Richard D. Clarke** and U.S. Air Force Gen. (ret.) **Mike Minihan** as advisors. Clarke was commander of U.S. Special Operations Command before retiring and has since been a special advisor at General Dynamics, IVP and Shift5. Minihan was commander of Air Mobility Command and before that served at U.S. Indo-Pacific



Command and United Nations Command.

Kimberly Montgomery has joined the corporate advisory board at fixed-wing vertical-takeoff-and-landing

aircraft business developer *XTI Aerospace*. She is president of health systems at medical transport company Global Medical Response, and she has held senior positions at Seven Bar Aviation, Med-Trans and EagleMed. ☪

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

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FIRST TAKE

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U.S. ARMY



DEFENSE

The first of two U.S. Army Athena-R surveillance aircraft, produced by L3Harris and MAG Aerospace and based on Bombardier Global 6500 business jets, deployed to South Korea on Feb. 12.

U.S. President Donald Trump revived a long-dormant proposal to sell Lockheed Martin F-35s to India during a visit to Washington by Indian Prime Minister Narendra Modi.

The Trump administration on Feb. 7

cleared Israel to buy thousands of bombs and missiles worth nearly \$7.4 billion, lifting a Biden administration hold on 2,000-lb. Mk. 84 bombs.

Canada has selected domestic simulation and training leader CAE to co-develop and manage the acquisition plan for the Royal Canadian Air Force's next lead-in fighter training system.

India's Hindustan Aeronautics Ltd. (HAL) has rebranded its troubled HJT-36 intermediate jet trainer as the Yashas after addressing a series of aerodynamic issues through a redesign (page 40).

Japan conducted a fourth live firing test of a new hypervelocity glide munition on Jan. 25, paving the way for the stand-off missile to enter service in 2026.

Automotive software startup Applied Intuition has acquired autonomy specialist EpiSci, forming a new midtier player in defense for autonomy programs.

European defense startup Helsing plans to supply 6,000 of its new HX-2 loitering munitions to Ukraine, having opened a factory in southern Germany to produce more than 1,000 per month initially.

India has canceled three orders placed in 2023 for a total of 400 military uncrewed aircraft systems (UAS) due to security concerns about Chinese-made components.

The Australian Defense Department has awarded a \$171 million contract to CEA Technologies to build 14 phased-array radars to support Australian Army long-range fire capabilities.

TECHNOLOGY



TEXTOR AVIATION

Pipistrel has conducted the first hover flight of its prototype Nuuva V300 hybrid-electric vertical-takeoff-and-landing (eVTOL) uncrewed cargo aircraft. Initial flights are all-electric.

Archer Aviation has raised another \$300 million in equity to help finance development of its planned hybrid eVTOL aircraft for military applications.

Washington-based startup Eviation has paused operations and laid off most staff after failing to raise additional funding to develop the Alice nine-seat electric aircraft.

German eVTOL startup Lilium has suspended operations and may be forced to file for insolvency again because of delays in receiving funding promised by new investors.

Leonardo has paused flight testing of its AW09 single-engine light helicopter after discovering issues with transmission parts from a supplier.

India's HAL has debuted the Dhruv NG, an upgraded commercial version of its Dhruv Mk. 3 Advanced Light Helicopter for offshore support missions.

SPACE

Russia's first space launch in 2025, on

VIEW FROM WASHINGTON

FAA: No 'Safety-Critical' Staff Cut

The Trump administration's government layoffs have not affected any safety-critical employees at the FAA, Acting Administrator Chris Rocheleau said Feb. 19 in an agencywide email.

The agency "regrettably had to let go of some probationary employees last week," Rocheleau wrote. "Despite what you may be hearing, I want to assure you the agency has retained employees who perform safety-critical functions." Rocheleau, a former FAA senior executive who returned in January, said the agency is adding air traffic controllers "and other safety professionals, including our maintenance technicians and others who directly support them."

His message framed the Trump administration's efficiency push, led by the so-called Department of Government Efficiency (DOGE) and a team of "special government employees," as complementary to the agency's "continuous improvement" efforts. DOGE representatives have visited several FAA facilities, including the Air Traffic Control System Command Center and Potomac Tracon, co-located in Warrenton, Virginia, west of Washington.

Rocheleau's message came as Sen. Richard Blumenthal (D-Conn.) sent a letter to Transportation Secretary Sean Duffy requesting details of every FAA employee terminated since Feb. 14. "Now is not the time to frantically discard FAA employees that work tirelessly to ensure the safety of every aircraft that takes to the skies," Blumenthal wrote, citing a series of high-profile accidents.

Feb. 5 from Plesetsk, also marked the 13th and final mission of its Soyuz-2.1v light launcher, after the country ran out of 1970s-era NK-33A core-stage engines.

Airbus has won the \$158 million Oberon contract to provide the UK military with a pair of synthetic aperture radar satellites as part of an effort to build indigenous Earth-observation capacity.

Boeing, primary contractor for NASA's Space Launch System, notified employees on Feb. 7 of possible layoffs due to potential changes to the agency's Artemis Moon exploration program.

Vast has delayed launch of its Haven-1 private space station almost a year, to May 2026, after manufacturing problems with stainless steel caused it to pivot to aluminum.

COMMERCIAL

Airbus has postponed development of a hydrogen-powered aircraft by 5-10 years under its ZEROe initiative and canceled plans to fly a fuel-cell powerplant on an A380 testbed (page 14).

ATR has delayed the launch of the EVO, a hybrid-electric version of its ATR 72

A Delta Connection Bombardier CRJ900 flipped over on touchdown at Toronto Pearson International Airport on Feb. 17 in an apparent hard landing in gusting winds and blowing snow. All 76 passengers and four crew were evacuated safely; 19 were injured, two critically.

For the latest developments, go to [AviationWeek.com](https://www.aviationweek.com)



KATHERINE KY CHENG/GETTY IMAGES

turboprop, saying battery performance will remain insufficient for several more years (page 27).

Southwest Airlines has instituted the first round of layoffs in its 53-year history, with plans to cut 1,750 employees, almost entirely in corporate and leadership positions (page 24).

Boom's XB-1 supersonic demonstrator flew for the 13th and final time on Feb. 10, completing an 11-month test

program that culminated in a top speed of Mach 1.18.

CFM International delivered 1,407 Leap turbofans in 2024 and is planning on a 15-20% increase this year while expanding its dual-source supplier strategy to a country level.

Russia has legalized the installation of parts manufacturer approval spares on the country's commercial fleet in a bid to develop domestic production of alternatives to embargoed components.

100 YEARS AGO IN AVIATION WEEK

"One of the greatest forward steps ever taken in this country to make commercial air transport available to the public is announced," proclaimed an article in our Feb. 23, 1925, edition. The momentous announcement was the launch of an air taxi service connecting San Francisco with "any point on the West Coast." The venture, known as Checker Air Service, was capitalized with \$500,000 (about \$9 million in current dollars) and operated a fleet of three New Swallows, two Hispano-Standards and two Hispano-Jennies, with three additional New Swallows on order. With two passengers traveling to the same destination, it charged 20 cents per mile, half the prevailing rate of other U.S. air transport companies. While travel from San Francisco to Los Angeles took a day on the train, the taxiplane could cover the 340 mi. in just 4 hr. "A businessman will thus be enabled to leave the city early in the morning, transact business in Los Angeles and be home again by night," the article explained. At 20 cents per mile, that would add up to \$136 for a round



trip, or \$2,453 in current dollars. Checker Air Service also planned to offer package freight and parcel delivery, "which offer untold possibilities for business development."

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Thales and French regional airline Amelia are scaling up their collaboration on avoiding contrail formation, applying prevention measures to every eligible flight in 2025.

Spirit Airlines has rejected a third acquisition offer from Frontier Airlines, concluding it would deliver less value than its stand-alone restructuring plan (page 24).

A \$1.67 billion loan guarantee to build a sustainable aviation fuel plant in Montana, agreed to by the Biden administration but frozen when Trump took office, has been approved.

AWARDED

The Smithsonian's National Air and Space Museum will award its 2025 Michael Collins Trophy to pioneering software engineer Margaret Hamilton for lifetime achievement. Hamilton led the development of flight software for the Apollo guidance computer. NASA's Osiris-Rex asteroid sample-return team will receive the trophy for current achievement. 🏆

UP FRONT

RICHARD ABOULAFIA

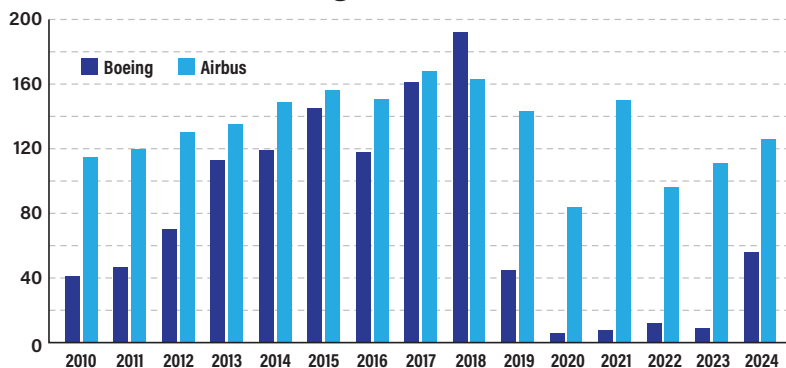


AFTER A FIVE-YEAR HIATUS, China's jetliner market is surging again. Yet politics and industry dynamics complicate this resurgence and raise big questions about the coming years.

China's demand for large commercial jets increased dramatically in the last decade, both in absolute numbers and as a percentage of the world market. In line with strong economic and passenger traffic growth, China reached a peak of 355 deliveries in 2018, representing 22% of the entire world market for jetliners with more than 120 seats. At the start of the 2000s, China accounted for a mere 2% of global demand.

The COVID-19 pandemic and consequent air travel collapse coupled with a broader economic slowdown in the country and strained ties with the West resulted in a serious downturn; Chinese carriers received just 108 airliners in 2022, representing 9% of all worldwide deliveries. The following year was about the same.

Airbus and Boeing Airliner Deliveries to China



Source: AeroDynamic Advisory

The downturn was particularly tough for Boeing, due largely to the 737 MAX grounding—China was the first to ground the type and the last to reapprove it—but also to U.S.-China political tensions. Between 2018 and 2024, China ordered a grand total of three Boeing passenger jetliners. Between 2019 and 2023, the country took only token numbers of Boeing jets.

Chinese air traffic has returned to roughly 2019 levels; it is somewhat higher domestically and somewhat lower internationally. Deliveries are coming back, too. In 2024, 182 airliners were delivered to Chinese carriers, representing 16% of world demand, and 56 of them were Boeing jets, the most since 2018.

The first question about this recovery concerns demand levels. Since Chinese economic growth has slowed markedly since the 2010s, it is likely that air travel demand growth will stay muted, and therefore orders will, too. China's 22% of world demand might represent the country's peak.

This question is complicated by China's longstanding habit of underordering, at least on paper. At the start of 2025, Chinese airlines had 135 outstanding

orders for Boeing jets and 323 for Airbus jets. But Chinese orders tend to be dual-switched: Airlines order behind the scenes, and the government then approves them, with public fanfare. Thus, it is likely that many "undisclosed" orders are for China—Boeing alone has 690 orders for "undisclosed" customers.

Market Mover

Airliner demand in China has recovered, and it raises big questions

The second question concerns market share. While Airbus has dominated the China market for the past five years, in part because of its final assembly line in Tianjin, Boeing briefly pulled ahead in 2018 for the first time in many years. Given that U.S.-China tensions seem to be worse than European-China tensions and quickly worsening further, will orders continue to trend in Airbus' favor? And will this trend affect Trump administration trade measures?

Third, and perhaps most important: The arrival of Comac's C919 is a wild card. China's emerging national jetliner champion delivered 10-13 (accounts differ) C919s to Chinese customers (deliveries began in 2022, but just three were delivered in 2022-23). While that is a relatively insignificant number for the industry, it is the first time since the start of the jet age that a new large commercial jet manufacturer has joined this exclusive club.

With Comac aiming to deliver up to 50 C919s this year—and a goal of ramping up to more than 100 annually—China could fill over half of its jetliner requirements with a home-grown product. But given the C919's dependence on Western engines and other components—and no hope of achieving self-sufficiency anytime this decade—the U.S. might not permit this ramp-up to take place, particularly if China heavily favors Airbus for its imported jet demand. The Trump administration's promised hard line on China and the broader question of technology rivalry and decoupling of China and the West further complicate a potential ramp-up.

In short, China's role in the jetliner market mirrors the broader concern about the country: To what extent will China's rise as a world power be accompanied by a determination to go it alone? Will the country continue to create alternatives to Western producers of everything from electric vehicles to artificial intelligence to jets? Is it even possible for any one country to succeed with such a strategy? 🇨🇳

Contributing columnist Richard Aboulafia is managing director at AeroDynamic Advisory.



GOING CONCERNS MICHAEL BRUNO

BOEING IS REBUILDING AND

pruning, Honeywell Aerospace is next in line, and Triumph Group will be sold off to private equity investors. Is the long national nightmare that was the shareholder-first era in aerospace and defense finally ending? Do not bet on it—it could be on the verge of starting again.

The back-to-back announcements in early February that Honeywell officially will spin off its aerospace and defense division, along with Triumph's sale to private equity firms Warburg Pincus and Berkshire Partners, seem only to punctuate the headshaking around industry about how financial prioritization has blown so many marquee brands off course.

"We really believe that our industry has gone through kind of a dark period called Shareholders-First, where in a long-cycle aerospace business, OEMs are more focused on quarterly earnings than the long term," AeroDynamic Advisory Managing Director Kevin Michaels told the audience at the Pacific Northwest Aerospace Alliance's annual February supplier conference in Seattle.

Michaels noted a litany of complaints over Honeywell that resonated with the audience. "I bet if you were to ask, off the record, some of the OEMs in the room that deal with them, if there were airlines in the room, you would certainly get a strong dose of reality of what's happening," he said. "They've gone down this cul-de-sac of shareholders. They're near the bottom of every customer satisfaction ranking. They're not a good place to work, according to many employees. They piss off their customers. They're not investing in the future, generally, and it's what happens with Shareholders-First."

Michaels has a lot of company in his criticism of excessive shareholder prioritization by publicly traded aerospace and defense companies. Aviation Week has heard the complaints for decades (*AW&ST* May 31-June 13, 2021, p. 12). Executives who failed to invest enough in their own companies and strove too hard to reward shareholders have been fingered at numerous players beyond Boeing, Honeywell and Triumph, including Aerojet Rocketdyne (sold to L3Harris Technologies with government and industry blessings) and Raytheon, now part of super-Tier 1 RTX. Indeed, activist investors in 2019 even lobbied to stop the United Technologies Corp. takeover of Raytheon after the latter's then-CEO Thomas Kennedy admitted to investors that a stand-alone Raytheon would be "out of business" in a decade if it mirrored the capital allocation policies of its peers.

Ironically, however, more and more aerospace and defense companies are looking to go public. Private equity-owned Karman Space and Defense announced plans on Feb. 5 for an initial public offering (IPO) on the New York Stock Exchange. Private equity-backed Voyager Space rebranded as Voyager Technologies and filed with regulators for its own IPO in January.

According to an October report by analysts at Jefferies, only five aerospace and defense IPOs were priced in the past decade, including Loar (2024), Telos (2020), EHang (2019) and Parsons (2019). U.S. industry IPOs averaged \$450 million, with Parsons' \$575 million offering representing the largest until StandardAero blew past that with its \$1.2 billion IPO around the time of the report.

While StandardAero's share price is down 11% since then, the other four aerospace and defense IPOs were up 84% since their debuts—Parsons and Loar were up 270% and 170%, respectively, as of the report.

End of an Era?

The shareholder-first mantra might not be a thing of the past in aerospace and defense



STANDARDAERO

Those growth levels, accompanied by other data points such as Boeing's record-breaking \$24.3 billion secondary offering of stock last year, underpin why more companies such as Karman and Voyager are looking at IPOs.

Animal spirits are returning to aerospace and defense stock debuts, and elsewhere, shareholder returns remain an ingrained expectation. Note that despite turning over CEOs, Boeing still has not abandoned its goal of achieving \$10 billion in free cash flow before 2027. And Northrop Grumman announced a new \$3 billion share repurchase authorization by its board of directors in December.

Public shareholders may not be head and shoulders above other constituencies like they were in recent decades, but you can bet that they will remain first among equals. ☺



LEADING EDGE

GRAHAM WARWICK

GIVEN THE DOOM AND GLOOM

surrounding the prospects for the decarbonization of aviation—with challenges and reversals in sustainable fuel and

hybrid-electric and hydrogen propulsion—it is easy to forget there has been progress.

The first electric aircraft certified in the West, Pipistrel's Velis Electro, has been approved for pilot training in the U.S. The first electric engine, Safran's ENGINEUS 100, has been certified in Europe. And the first four-seat electric aircraft, the Rhyxeon RX4E, has been certified in China.

These are small but significant steps. The electrification of aviation is still in the proselytizing phase. The number of people with direct experience of electric aircraft is limited. Like any new technology, putting it in the hands of the customer is the key to success.

With that end in mind, Swiss electric-propulsion startup H55 plans a sales tour in the U.S., and the Bristol Energic electric training aircraft (pictured) should kick-start demand ahead of type certification, now expected by mid-2026.

While the Velis Electro is a light sport aircraft, optimized for airfield pattern training, the Energic will be a European Union Aviation Safety Agency CS-23-certified aircraft capable of performing almost all the flight training required for a private pilot's license.

H55's Across America initiative is planned to begin at the Sun 'n Fun Aerospace Expo in Lakeland, Florida, in April and conclude at the Experimental Aircraft Association AirVenture show in Oshkosh in July. Supported by charging system provider Aerovolt UK, the tour will make stops at flight schools and military bases in several states across the U.S., H55 co-founder Gregory Blatt says.

The U.S. tour is part of an effort launched by H55 with Czech aircraft manufacturer BRM Aero to commercialize the Energic, a version of the two-seat Bristol B23 equipped with the first electric propulsion system developed by the Swiss startup. "We're acting like an agent for BRM in selling airplanes," Blatt says. The sales drive was launched in Europe in November and has so far resulted in orders and options for 35 aircraft from flight schools and leasing companies. "There's a good momentum going in Europe," he adds.

H55 has taken the path of certifying the motor, controller and battery as a stand-alone electric propulsion system (EPS). This differs from others that are certifying

the electric powertrain as part of the aircraft type certificate, certifying the motor and controller as an electric engine or qualifying the battery system under a technical standard order that is then wrapped into the aircraft type certificate.

The Swiss startup is developing the energy storage system and motor controller internally while UK company Equipmake develops the motor. In addition to providing the complete EPS for the Energic, H55 has contracts to develop battery systems for CAE, Harbour Air and Pratt & Whitney Canada.

"We continue to work on those projects as we build out our energy modules," Blatt says. "Those could be modules that are for power or endurance. And that is putting us on projects going to larger airplanes in the higher CS-23 categories, eventually taking us over time toward fixed-wing CS-25 applications.

"We are very bullish about fully electric propulsion up to maybe 20 seats, and above 20 seats hybrid electric. That's where we see an interesting response from the market, where the economics make sense," he says. "Feeder and commuter routes are interesting, and we have to be realistic about battery energy density."

There are two views on battery technologies, ambitious and realistic, he says. "There are a lot of interesting projects on test benches in labs, but getting to gigafactory industrialization is a long road," Blatt adds. "And we need to have gigafactories. We need to have batteries that are mature and derisked [for certification]."

H55 has taken the realistic view, Blatt says. "When we started five years ago, we said, 'What can the technology do?'" he adds. "OK, we can fly for an hour with 15-20 min. of reserves. Who flies like that? Flight schools. We looked at flight schools, and the airplanes are 37 years old. They need replacing. There's a good market.

"Can we guarantee 1 hr. of flight time plus reserves, which is what we need for five or six circuits?" Blatt continues. "Can we guarantee the reserves? Can we recharge in an hour or so? Is there at least 1,000 charging cycles? That was what we needed to say go or not go. And the answer to all those questions is 'yes.'"

That sounds like a small step, but being competitive with a combustion-powered aircraft will be a big achievement and will enable customers to experience the advantages of electrification: low energy and maintenance costs and low noise with zero emissions. It is a grassroots, bottom-up approach to the decarbonization of aviation, but it is a route the industry needs to take. ☛

Progress Amid Setbacks

Decarbonizing from the bottom up



ANNA PIZZOLANTE/H55



THE LAUNCHPAD

IRENE KLOTZ

ON ITS WAY OUT, THE NASA administration under former President Joe Biden left its successors revised plans to return curated samples from the surface of Mars, an effort that could reveal whether life ever arose beyond Earth.

Omitted, however, was the option to recast the over-budget Mars Sample Return (MSR) baseline mission using a completely new architecture developed and sold by Rocket Lab. Instead, before leaving office in January—along with the rest of the Biden administration—former NASA Administrator Bill Nelson and managers unveiled two versions of a similar plan to bring back samples collected by the Mars Perseverance Rover.

Overseen by NASA's Jet Propulsion Laboratory, the rover in 2021 began collecting rock and regolith samples from Jezero Crater, the site of an ancient lakebed and river channels. Scientists believe sediment from Jezero could have preserved samples of ancient bacterial life, if it existed there.

NASA's revised plan for the MSR mission maintains its partnership with the European Space Agency, the primary contribution of which is a spacecraft to retrieve the samples from Mars orbit and fly them back to Earth.

The original mission was on track to cost as much as \$11 billion—twice initial estimates—and take years longer to complete. NASA turned to private industry and its field centers in January 2024 for ideas to simplify the MSR mission, cut costs and return the samples sooner.

Ultimately, the agency decided to scale down the Mars Ascent Vehicle (MAV), switch to a nuclear-powered landing platform and then use either its proven sky crane landing system or buy commercial Mars lander services from a U.S. industry partner. Both SpaceX and Blue Origin are developing heavy-weight landers as part of NASA's Artemis lunar exploration initiative.

The revisions could cut MSR mission costs to \$5.8-7.7 billion, depending on which option is chosen, Nelson

told reporters Jan. 7. Neither plan would return the samples before 2035.

Hours after the announcement, Rocket Lab, which provided one of a dozen MSR rapid architecture studies to NASA, posted details about its proposal, which purports to cut mission costs to less than \$4 billion and to return the samples as early as 2031. The plan builds

on technologies created and matured for Rocket Lab's existing Electron and upcoming Neutron launch vehicles as well as the company's experience building spacecraft and components, developing partnerships and operating in Earth orbit and beyond.

Rocket Lab proposes a three-launch MSR mission, beginning with a telecommunications satellite that would remain in Mars orbit and be available for use by NASA and other customers beyond the MSR campaign. Similar to the agency's plan, the company would develop and fly a sample-return lander, a MAV and an Earth-return orbiter.

"We bring to the table a commercial approach, which is more affordable and which leverages our extensive launch vehicle and propulsion expertise and a lot of other innovating and capabilities," Richard French, Rocket Lab vice president of business development and strategy, tells Aviation Week. "We think we're uniquely positioned to do this."

Rocket Lab proposes a single-stage-to-orbit, liquid-

propulsion MAV, a solar-powered lander and simplified robotic systems, including a seven-degree-of-freedom arm to transfer the samples from Perseverance onto the lander. It would use a heritage aeroshell design for Mars atmospheric entry and landing.

Rocket Lab said it could be prepared to launch the first leg of the mission—the telecommunications orbiter—in 2028, the next time Mars and Earth are favorably aligned for interplanetary flight.

"We love the opportunity to do science, and commercial capabilities are one of the key things that will help increase the opportunity to do more science at NASA," French says. "We're hopeful we'll get a chance to do this." 🚀

Mars Sample Return, Take 3

An alternate proposal tests NASA's use of commercial services



COLD REALITY

- > AIRBUS POSTPONES PLAN FOR A ZERO-EMISSION AIRLINER
- > THE OEM DELAYS ITS HYDROGEN-POWERED AIRLINER 5-10 YEARS
- > SAF-FUELED ENGINE DEMONSTRATIONS WILL PROCEED



Graham Warwick Washington, **Guy Norris** Colorado Springs and **Thierry Dubois** Lyon



AIRBUS' POSTPONEMENT OF A ZERO-EMISSION hydrogen-powered commercial aircraft will send a chill through decarbonization efforts of an aviation industry already struggling to keep its net-zero 2050 target within reach.

The 5-10-year delay comes hard on the heels of an updated road map, developed by an industry alliance, that estimates reaching net-zero emissions by midcentury will cost European commercial aviation €2.4 trillion (\$2.5 trillion), €510 billion more than projected in 2023.

Net-zero emissions in aviation by 2050 remain within reach, says the Destination 2050 report released on Feb. 4, but will rely heavily on sustainable aviation fuel (SAF)—at higher cost than previously estimated—with hydrogen playing a much reduced role than forecast.

Unveiled in 2020 with substantial European government support, Airbus' ambitious ZEROe initiative to bring a zero-emission commercial aircraft to market by 2035 has been

responsible for much of the rekindled interest in hydrogen for aviation.

Aiming for a product launch decision around 2028, the manufacturer embarked on multiple projects to explore hydrogen-electric and hydrogen-combustion propulsion using liquid hydrogen (LH₂). The OEM studied aircraft concepts ranging from 100 passengers and 1,000-nm range to 200 seats and 2,000-nm range, and it launched collaborations with airports and airlines to identify the infrastructure required—from production to refueling—to secure the supply of green hydrogen at airports in advance of service entry.

French press agency AFP reported on Feb. 7 that Airbus workers' union Force Ouvriere had revealed that the company had informed employees

hydrogen technology was 5-10 years behind where it needed to be for a 2035 entry into service. The ZEROe budget was being cut by 25% and flight demonstration of a hydrogen-electric fuel cell propulsion system on an A380 testbed canceled.

"We are committed to our goal of bringing a commercially viable, fully electric hydrogen-powered aircraft to market," Airbus said in a statement. "Hydrogen has the potential to be a transformative energy source for aviation. However, we recognize that developing a hydrogen ecosystem—including infrastructure, production, distribution and regulatory frameworks—is a huge challenge requiring global collaboration and investment."

Airbus had already warned that its ZEROe initiative could be delayed by the lack of infrastructure for green hydrogen production, transport and storage as well as fueling of aircraft at airports. "Recent developments indicate that progress on key enablers, particularly the availability of hydrogen produced from renewable energy



A hydrogen-electric 100-seater (far left) had emerged as the favored candidate over larger, longer-range hydrogen-combustion concepts studied under ZEROe.

AIRBUS IMAGES

sources at scale, is slower than anticipated,” the company stated.

This is not the first time Airbus has changed tack. The company shelved plans in 2017 to flight-test Safran’s counterrotating open-rotor engine, citing integration drawbacks. Now it plans to fly CFM International’s RISE open-fan demonstrator on an A380 testbed in 2026.

The company canceled the E-Fan X hybrid-electric demonstrator program in 2020, having abandoned plans to develop an E-Fan family of electric light aircraft. Now it is planning a microhybridization demonstration. And in January, Airbus announced it would pause development of its CityAirbus NextGen electric vertical-takeoff-and-landing (eVTOL) air taxi at year-end due to battery challenges.

Airbus has already completed substantial work under ZEROe, including ground tests of a megawatt-scale hydrogen fuel-cell engine developed internally with a partner from the automotive industry. Tests have included deliberately failing the system to test control logic, Glenn Llewellyn, Airbus vice president of zero-

emission aircraft, said at a Wings Club event in New York in November.

Working with ArianeGroup, in which Airbus has a 50% share, ZEROe has been developing an LH₂ storage and distribution system, including aluminum vacuum-insulated cryogenic tanks. “We’ve done a huge number of experiments to understand the specific characteristics of hydrogen in interesting failure cases,” Llewellyn said. “We’ve been setting tanks on fire and looking at what happens.”

Compared to other industry sectors, aviation is particularly difficult to decarbonize. The combination of excellent power-to-weight ratio and compactness of turbine engines with the high energy content of jet fuel has proven virtually unbeatable. Alternative propulsion solutions not only are more complex and expensive but also make the aircraft heavier or reduce volume for passengers.

Airbus looked at ammonia, butane, methane and propane as well as hybrid and SAF before settling on liquid hydrogen, Llewellyn said. “SAF is the only fuel compatible with the existing fleet of aircraft, and hydrogen is not going to solve that problem,” he explained. “But there are already people questioning if it makes sense to use energy or agricultural processes to take CO₂ out of the air and then for aviation to be allowed to put that CO₂ back

demand for SAF. Adapting engines to biomass-based SAF is relatively straightforward, but the net CO₂ emission reduction is 80%, not 100%. Synthetic power-to-liquid SAF could have a smaller carbon footprint, but its large-scale production is even more challenging.

Despite the current challenges with SAF availability and affordability, Airbus is pushing ahead with plans to demonstrate engine options for a mid-2030s A320 replacement that would use the low-carbon fuel. Under Europe’s Clean Aviation public-private research program, Airbus plans to test CFM’s RISE open-fan engine and a to-be-selected advanced ducted turbofan on an A380 testbed.

“We have decided that the flight-test demo is going to be SAF-based, not hydrogen,” Clean Aviation Executive Director Axel Krein said in January at the American Institute of Aeronautics and Astronautics SciTech Forum in Orlando. “We are going to fly first with an open fan on an inner engine on an A380. Second, we will be looking at the ducted engine on the same pylon.”

The ducted fan engine for this flight demonstration could be a smaller derivative of the Rolls-Royce UltraFan geared turbofan, which is in development partially backed by Clean Aviation’s Heaven project, or a version of Pratt & Whitney’s PW1100G geared

Airbus planned to flight-test a 2-megawatt hydrogen fuel cell engine on an A380 testbed.



in the air again. Hydrogen provides us resilience to that potential critique.”

As for SAF, consumers and producers cannot agree on which is lagging, supply or demand. Airlines complain about slow growth in SAF production; fuel industry specialists retort that the main problem is the nonexistent

turbofan, which is in development under the Clean Aviation Switch project.

Airbus’ decision will have an effect on wider European hydrogen research. Clean Aviation has funded several projects under its hydrogen-powered aircraft theme in Phase 1 of the 10-year effort. Hydrogen was

not included in the first call for projects under Phase 2, Call 3 released in December, but it is planned for later calls. That could change.

“Clean Aviation is pursuing the execution of its strategic research and innovation agenda, including the elements related to H₂-powered aircraft,” Krein tells Aviation Week. “The definition of the detailed content of our future Calls 4 (March 2026) and 5 (March 2027) will continue in the coming months in close cooperation with our members.”

Airbus’ postponement inevitably will affect hydrogen propulsion development efforts underway at suppliers targeting their research at meeting

ing Fuel Cell (FFC) technology development. “We are sticking to our schedule: Tests of a product-related FFC full system demonstrator are scheduled for 2026,” the company says. Supported by the German government, the FFC program is targeting regional aircraft.

Does Airbus’ decision spell the end of hydrogen propulsion advancement, at least for the rest of this decade? That could now depend on startups, such as H2Fly and ZeroAvia, that are vertically integrated and not reliant on the existing aerospace supply base.

Airbus’ ZEROe initiative was aiming to develop a clean-sheet hydrogen-powered aircraft to be operated

be sufficient to support initial flights. Larger aircraft for larger airlines come later in the plan.

“Airbus has been a genuine leader in developing hydrogen aviation through ZEROe,” ZeroAvia says. “We’re still very confident because hydrogen-electric aviation will tackle climate impacts where SAF clearly won’t—providing the much-needed license to operate to the wider industry—and it will also offer superior economics to kerosene or SAF combustion. It’s a matter of when, not if, with hydrogen in aviation, and it will be of immense commercial advantage for those that are early.”

Europe’s enthusiasm for hydrogen in aviation has not been matched in the U.S., by Boeing or NASA, and Airbus had expressed frustration that its established propulsion suppliers were not stepping up to the challenge.

Delaying any ZEROe aircraft by 5-10 years therefore pushes back the potential for a disconnect between Europe and the U.S. on hydrogen-powered aircraft and a schism in what is largely a globally harmonized aviation industry.

But speaking in New York, Llewellyn expressed concern about China taking the lead. “In October 2023, five Chinese ministries signed a green aviation paper,” he said. “In that paper, there are 49 mentions of hydrogen. I think we know what happens when, at least in China, all the government’s ministries line up on certain trajectories.”

China is already flying a fuel-cell-powered light aircraft, and commercial aircraft OEM Comac displayed a model of a potential C909-based hydrogen-powered airliner at the Zhuhai Air Show in November. “I believe that we need to be clear in Europe and in the U.S. that we’re not going to be overtaken by the technologies that hydrogen enables,” Llewellyn said.

The aviation industry says sustainability is its chief concern, and it is studying new architectures, but it may in fact be falling into complacency. The backlogs at Airbus and Boeing are so strong there is little incentive for a far-reaching change in aircraft design. Because the envisaged decarbonization solutions pose major technical challenges and industry is not pushing hard enough, aviation may find itself trapped. ☹️

Check 6 Aviation Week editors discuss Airbus’ decision to put hydrogen on the back burner: [AviationWeek.com/Check6](https://www.aviationweek.com/Check6)

AIRBUS

The 100-seat, 1,000-nm-range ZEROe concept would be powered by a pair of hydrogen-electric powertrains.



the expected needs of the major commercial OEMs. The decision to delay could result at least in a slowdown of hydrogen-related projects.

“We are in close collaboration with Airbus to ensure our technology development plans are aligned and create mutual value,” says GKN Aerospace, a Tier 1 that has taken an aggressive stance on developing hydrogen-electric propulsion technology for regional aircraft, with support from the UK government.

Under programs totaling £135 million (\$167 million), GKN and its partners have been working to ground-test a 1-megawatt hydrogen-electric powertrain demonstrator by 2026, demonstrate an LH₂ fuel system by 2027 and prepare a 2-megawatt integrated propulsion system for flight testing by 2030. GKN’s response suggests those plans could change.

MTU Aero Engines, a Tier 1 supplier to Airbus engine providers, tells Aviation Week it is continuing its Fly-

by established airlines in major air transport markets in Europe and the U.S. The startups are initially targeting smaller aircraft and retrofits.

ZeroAvia, in which Airbus is a major investor, is developing its own electric propulsion unit and fuel-cell power generation system and hopes to secure supplemental type certification of its first retrofit application, the nine-passenger Cessna Caravan, by 2027. Plans call for 19-, 40- and 80-seaters to follow by decade-end.

H2Fly, which is owned by Joby Aviation, is targeting eVTOL air taxis followed by 40-seat regional turboprops. Not only are smaller aircraft technically less challenging, they operate over shorter ranges from smaller airports, potentially reducing the infrastructure hurdles.

ZeroAvia is looking to niche customers operating in rural, remote and environmentally sensitive regions where on-site green hydrogen production at small regional airports would

THE SPACE REPORT

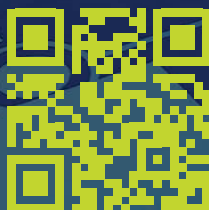
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Airbus' Nagging Issues: Spirit, Satellites and A400M Sales

> A350F FREIGHTER SERVICE ENTRY SLIPS TO 2027

> CEO SEES MBDA AS MODEL FOR EUROPE'S SATELLITE OPERATIONS

Jens Flottau Toulouse and **Robert Wall** London

Airbus faces challenges on several fronts in making 2025 the year in which it can leave nagging problems in its wake, with the looming acquisition of parts of Spirit AeroSystems proving complex and a push to restructure its satellite business remaining a work in progress.

The purchase of the Spirit businesses that produce parts for the Airbus A220 and A350 should close mid-year, but the European airframer expects it will take a lot of time and money to bring up the units to its own levels of cost controls and output.

"We are struggling with the ramp-up on the A350 and A220 against the backdrop of Spirit," Airbus CEO Guillaume Faury said as the company reported full-year results for fiscal 2024 Feb. 20. Faury warned that Airbus will be "significantly impacted" in 2025

because of Spirit and declined to say whether the company will be able to boost output on the two programs this year. "We just can't build the plane if Spirit does not deliver section 15," Faury said, referring to the A350's center fuselage barrel.

Within weeks, Airbus is slated to sign the agreement to take over those parts of Spirit it is absorbing, and the closing is expected around July 1, Chief Financial Officer Thomas Toepfer said. Airbus may have to put up to \$500 million annually into Spirit in 2026 and 2027, he added, noting the company has staff on the ground to determine what will be required.

Spirit's work packages for Airbus are losing money now. "Efficiency has to be improved, and they are not able to ramp up," Toepfer said.

Airbus is taking over Spirit sites in

Kinston, North Carolina, and Belfast, Northern Ireland. Spirit also has a put option to sell a facility in Prestwick, Scotland, to Airbus, where most of the work is for Airbus.

Development of the A350F freighter program also has been hobbled by the Spirit situation, the company said. Airbus disclosed another delay to the program as part of the earnings release on Feb. 20. Service entry has been pushed into the second half of 2027 so employees can focus on building existing models, but production of the first A350F is planned to start this year.

Airbus targets some 820 commercial aircraft deliveries in 2025—up from 766 last year but still shy of the 2019 figure of 863 aircraft.

Deliveries in the first quarter will lag due to CFM International's preference for supporting airline customers with Leap 1A engines in lieu of servicing Airbus' production line. CFM's operations were affected by the 2024 Florida hurricane season late last year, Faury said. That caused "a lot of arm-twisting for the allocation of engines," he added. "We knew there would be some missing hardware at the beginning of this year." Airbus is

Spirit's problems building the so-called section 15, the center fuselage section, have hobbled Airbus A350 production.



SPIRIT AEROSYSTEMS



Airbus is eyeing satellite cooperation with Thales and Leonardo to lower costs.

producing “gliders” that will be parked at its Hamburg Finkenwerder plant while they await engines.

Rival engine-maker Pratt & Whitney also is struggling with the PW1100G, Faury said, referring to a long-standing powder metal issue. However, Faury added: “They are on trajectory; we knew that this would come with less engines for new aircraft.”

Airbus has continued with production ramp-up plans it moderated last year, affirming an ambition to make 75 A320-family aircraft per month in 2027 and raise A350 output to 12 aircraft per month in 2028. The A220 is to reach 14 aircraft per month in 2026, up from an average of six in 2024. Airbus is not adjusting production plans for the A330neo, where order intake has been muted.

To meet strong narrowbody demand, Airbus plans to open a second final assembly line at its site in Tianjin, China, toward the end of the year.

Adding to uncertainties for the company are potential tariffs the U.S. may impose on aerospace products. “We have all our sensors on, we try to understand what is happening, [but that is] very difficult,” Faury said. He voiced confidence the company could adapt to whatever happens.

He also defended Airbus’ recent decision to take a step back on plans to introduce a hydrogen-powered aircraft (page 14). “We are not moving away from hydrogen; we are adapting the plan,” Faury said, adding hydrogen fuel-cell system propulsion “is the most promising pathway for a commercially viable aircraft.”

The company’s defense and space business, which accounts for about 17% of turnover, also has issues that Airbus is struggling to fix. Faury said talks with Leonardo and Thales to address an overcapacity problem in European satellite development and production could lead to creation of a combined entity modeled on missile-maker MBDA to help turn things around.

The companies have been in talks for months about how to deal with the collapse in the market for big geostationary-Earth-orbit satellites amid competition for low-Earth-orbit constellations, triggering earnings hits and workforce reductions at several companies. MBDA was created by putting the missile assets from Airbus, BAE Systems and Leonardo into one company with each as a shareholder, and it has become a global player.

Faury said he thinks a similar setup for satellites could be the best way forward by creating scale to reduce recurring cost and pooling investment to move more nimbly in the rapidly evolving space market. Airbus, Thales Alenia Space and Telespazio have the technology to compete, Faury said, but they need a better structure.

The new European space business would center on satellites and satellite services and not launchers, Faury said. Talks with Leonardo and Thales remain preliminary and nonbinding, he told reporters, and there is no timeline for selection of a setup.

A combination could involve a complicated antitrust process, Toepfer said. While such a business could look monopolistic within Europe, Faury

expressed hope that regulators would see how it could compete globally.

Airbus, in the results, announced an additional charge on its space programs that it had signaled would be coming as it wraps up reviews of troubled programs. The latest charge of €300 million (\$313 million) for the fourth quarter brought the full-year total to €1.3 billion and almost €2 billion over the past two years.

“This exercise is now behind us,” Toepfer noted, adding that “we can now focus on taking orders with a good risk profile.”

The company does not expect a cash burden this year from its space operations. Toepfer also said the A400M military transport aircraft, a drag on Airbus earnings for years, could be cash-neutral this year and turn slightly positive in 2026. But the more positive outlook comes only after Airbus took another €121 million charge on the program, in part reflecting risks in production plans.

Airbus also signaled it is growing anxious about the dwindling backlog for the A400M, with 131 of 178 aircraft ordered already delivered. “In light of uncertainties regarding the level of aircraft orders, the company continues to assess the potential impact on the program’s manufacturing activities,” the OEM said in a statement.

“We have a clear path for the next three years,” Faury said, but the company needs more clarity on the longer-term horizon. “There are export prospects,” he added, as well as opportunities for top-up deals with existing customers.

The company is chasing deals for its aircraft in the United Arab Emirates (UAE), Saudi Arabia and Poland to keep production running into the next decade. Airbus is trying to lure customers with workshare incentives and indicated on Feb. 20 that it is hopeful it can land an order of 8-10 aircraft from the UAE, with deliveries starting around 2028.

Faury also said there is scope for Europe’s two future fighter programs to come closer together. Airbus is involved in the Franco-German-Spanish Future Combat Air System project, while BAE is working on the Global Combat Air Program on which Japan, Italy and the UK are partners. However, combining the projects into a single effort is not on the near-term agenda, he added. ☛

Safran Scores a Certification First for Electric Propulsion

- > UNIT IS THE FIRST APPROVED UNDER SC E-19 STANDARD FOR eVTOLs
- > THE ENGINEUS 100B1 WILL POWER ELECTRIC TWO-SEATERS

Thierry Dubois Paris and **Graham Warwick** Washington

In a milestone for industry and regulators alike, the European Union Aviation Safety Agency has awarded the first type certificate for an electric engine under new airworthiness requirements intended to enable innovation in aircraft propulsion.

levels higher in certification requirements, says Regis Rossotto, EASA's product certification manager. "With Safran, we did in-depth failure analysis," he explains. "Endurance trials and environmental testing, which include extreme temperature, altitude,

Safran's air-cooled ENGINEUS 100B1 integrates the electric motor with the control electronics.



Safran's ENGINEUS 100B1 electric propulsion unit, approved on Feb. 3, is the first to be certified by the European Union Aviation Safety Agency (EASA) under the Special Condition for Electric/Hybrid Propulsion Systems, or SC E-19.

Published in April 2021, SC E-19 was first implemented as the propulsion certification standard for electric vertical-takeoff-and-landing (eVTOL) aircraft. Safran was the first to apply for a propulsion type certificate under the new regulation.

Approval of the 100-kW ENGINEUS 100B1 for CS-23-category two-seat trainers paves the way for motors up to 180 kW that could equip hybrid-electric regional aircraft.

The European regulator type-certified the first electric aircraft in 2020, Pipistrel's Velis Electro two-seater, but the aircraft and its motor were approved together under the CS-LSA light sport aircraft category.

The ENGINEUS approval is three

electromagnetic interference and icing conditions, were comparable to what we require from a helicopter turbine engine."

SC E-19 covers all the new aspects that electric motors bring. "The high-level regulation is adaptable, and the technical content is relatively light," says Herdrice Hereson, EASA section manager for general aviation and VTOL propulsion and powerplant systems. "We put the emphasis on the means of compliance."

Testing included fire prevention, involving electric arcing to show the motor remains safe in extreme short-circuit conditions, EASA Certification Director Rachel Daeschler says. The motor's certification campaign involved 1,500 hr. on testbeds and more than 100 flight hours on an aircraft, Safran says.

EASA has gained experience in technical conditions and compliance methods. "We will be able to reuse our learnings with other motors," Daeschler

says. Other applicants for certification of an electric motor include eVTOL developers Lilium and Volocopter as well as an unspecified European engine specialist, Hereson says.

In regional aviation, the CS-23 standard limits use of the new motor to 9-19-seat aircraft. Higher seat capacities would need motors certified under the more demanding CS-25.

EASA and the FAA are cooperating to achieve harmonization eventually. Safran has applied for certification with the FAA, but the process is less advanced, Safran Electrical & Power CEO Bruno Bellanger says.

The ENGINEUS integrates power and control electronics, enabling more straightforward wiring, Bellanger says. Air cooling was chosen for simplicity. The power-to-weight ratio is 5 kW/kg. The motor is flying on the Diamond Aircraft eDA40 and Aura Aero Integral E. Other announced customers include Bye Aerospace, CAE, Electra. aero, TCab Technology and VoltAero.

Safran plans to build two semiautomated factories—one for rotors and stators in Pitstone, England, and one for power electronics and final assembly in Niort, France—with a capacity of 1,000 motors per year. Multimotor aircraft configurations may enable that output by the end of the decade, Bellanger says.

The engine-maker is betting its in-service experience with small motors will feed into the development of larger electric propulsion systems. With the ENGINEUS XL, Safran is aiming at the range between 500 kW and 1 megawatt, having already demonstrated 730 kW, Bellanger says.

Safran Electrical & Power, meanwhile, is looking for a specialist company to create its own GENeUSPack battery systems on electric and hybrid aircraft. "Safran does not have a suitable battery solution today," Bellanger says. "We have a battery solution for the future. . . . We are targeting a technology breakthrough—we want to position ourselves not on lithium-ion but on lithium-metal batteries.

"Our job is not to do battery cells," he continues. "The issue is to partner with a chemical company that would be mature enough to understand aeronautics and would supply latest-generation cells." Safran would handle packaging, thermal management, thermal runaway and certification requirements. ☛

New EU Road Map Shows \$526 Billion Decarbonization Cost Hike

> UPDATED PLAN INDICATES THAT SAF SHOULD ACCOUNT FOR 35% OF EMISSIONS REDUCTIONS THROUGH 2050

> NON-CO₂ EFFECTS ARE INCLUDED FOR THE FIRST TIME

Helen Massy-Beresford Brussels

Reaching net-zero emissions by 2050 will cost €510 billion (\$526 billion) more than previously estimated and will rely heavily on sustainable aviation fuel, as hydrogen technology is taking a less important role than expected, according to an updated road map presented by European airline, aerospace and air traffic management industry organizations.

rope (A4E) Managing Director Ourania Georgoutsakou said as European industry organizations presented the new road map here on Feb. 4.

Armando Brunini, president of airports group ACI Europe and CEO of SEA Milan Airports, noted that the projected costs of decarbonizing aviation have skyrocketed in the four years since the last road map. "It's €500 bil-

lion more in costs to achieve net zero compared to what we had estimated in the first version of the road map," he said.

The new plan estimates total expenditures of €2.4 trillion. Excluding conventional fuel costs, that is an increase of €510 billion (27%) from the €1.89 trillion in Destination 2050's 2023 report *The Price Of Net Zero*.

"The majority of this increase stems from rising premium expenditures, which have grown from €820 billion to €1.3 trillion (+57%), driven largely by higher [SAF] market price estimates," the Destination 2050 report states.

With SAF production underway and European mandates in place, the authors of the report were able to base their projections on the real, fluctuating costs of SAF.

Measures that should be taken to surmount the cost obstacle include incentivized investments, SAF allowances to close the cost gap and a book-and-claim system to ensure uptake across the region, Georgoutsakou said. "We need to close that cost gap," he added.

The industry groups—A4E, ACI Europe, the European Regions Airline Association, the Aerospace and Defense Industries Association of Europe and the Civil Air Navigation Services Organization—are calling on the European Commission to focus on aviation decarbonization as part of the Clean Industrial Deal, the bloc's broad industrial decarbonization strategy and its Sustainable Transport Investment Plan.

The Royal Netherlands Aerospace Center (NLR) and economic consultancy SEO Amsterdam Economics were tasked with updating the report, which bases its outlook on a 2019 baseline and forecasts using a hypothetical "no-action scenario" to pinpoint the contributions different measures will have on reducing aviation's impact on emissions as the industry aims to be net zero by 2050.

One major change from the 2021 version of the report, according to co-author Elisabeth van der Sman, team leader for sustainability at NLR, is that the projected role of hydrogen-fuel aircraft technology has decreased. It is now estimated to account for 2% of the emissions reduction, while in 2021 it had been earmarked as accounting for 20%.

The new report highlights current and future technological improvements to conventionally fueled aircraft as contributing 24% of the 2050 emissions reduction.

The 2021 road map earmarked technology improvements to kerosene aircraft as accounting for 17% of the emissions reduction; SAF accounted for 34%.

There should be enough SAF to meet the 6% ReFuelEU target, European Commission Director-General for Mobility and Transport Magda Kopczynska said at the event. She noted that she is not concerned about the next target of 20% in 2035, given the consistent efforts to boost investment and to create the right environment and incentives.

Destination 2050 addresses non-CO₂ effects, reflecting industry's growing focus on them as a factor.

ASHLEY COOPER/GETTY IMAGES

The Destination 2050 road map, which sets out steps toward industry's long-term net-zero goal, highlights the key role of sustainable aviation fuel (SAF).

According to the report published Feb. 4, 35% of the emissions reductions between now and 2050 will come from SAF, both biomass-sourced and synthetic (also known as e-fuel). That figure is based on the assumption that 80% of aviation fuel will be SAF by 2050—a proportion exceeding the 70% mandated by ReFuelEU legislation by taking into account airline SAF commitments, which in many cases go beyond mandated levels.

"The biggest obstacle, the biggest risk is cost of SAF," Airlines for Eu-

lion more in costs to achieve net zero compared to what we had estimated in the first version of the road map," he said.

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Looking further ahead, Kopczyńska said more effort must be made to boost the SAF industry. “One thing that I’m missing at a national level is the realization that SAF do not fall from the sky,” she said. “The ecosystem to have the production on the ground, to have the availability at the right place, has to be created.”

The drive to reduce emissions comes against a backdrop of intense focus on improving the region’s competitiveness, as highlighted in the recent report for the European Commis-

sion by former European Central Bank President Mario Draghi, which urges using decarbonization efforts as a tool to improve European competitiveness.

“We are facing the harsh reality of climate change, no doubt about that, and at the same time we need to translate the Draghi report into action to make Europe more competitive,” Brunini said. “The target is still achievable. At same time, it’s clear that we are not going to be able to make it alone, because the challenges are much higher than what we had

estimated at the beginning. There’s a window of opportunity, and if we miss that, we won’t make it.”

The aviation industry has for many years been calling for a far-reaching revamp of airspace in the region to boost efficiency and cut down on wasted fuel caused by indirect routings, with recent Single European Sky reforms criticized as not going far enough.

Operational improvements are expected to account for 6% of the reduction under the updated road map.

The report also shows decarboniza-

BUSINESS

Expectations of M&A Wave Grow in Aerospace

- > NUMBER OF ANNOUNCED DEALS COULD RISE TO ABOUT 425 IN 2025
- > PRIVATE EQUITY INVESTORS SIGNAL GROWING ACTIVITY

Michael Bruno Seattle

The commercial aerospace supply chain is improving. There is cautious optimism over Boeing’s rebaselined narrowbody production rate plan. And every end market—from business aviation to defense and outer space—is expected to keep growing. Now comes the wave of mergers and acquisitions.

Those were the sentiments out of this year’s Pacific Northwest Aerospace Alliance’s (PNAA) annual Advance conference here Feb. 4-5. While far from exuberant—Trump administration tariff threats had the audience of suppliers on alert—one of the event’s key takeaways was to expect far more mergers and acquisitions (M&A) across aerospace and defense as forecasts and financial conditions alike improve.

“If you work in M&A, get ready to be busy over the next couple of years,” said Michael Black, managing director at middle-market investment bank First Hill Partners.

Dealmakers in aerospace and defense have been waiting for a big pickup in M&A activity. Once expected in the wake of the COVID-19 pandemic, which had been anticipated to create several distressed assets, there was only a brief spike in 2021 when interest rates plummeted. But as supply chain challenges hobbled OEMs, business owners and investors struggled to divine believable valuations. Rising interest rates also sapped enthusiasm.

Now interest rates are falling from a recent high, having peaked at 5.25% in recent years above early pandemic levels of essentially 0%. OEMs and Tier 1s are widely reporting improved supply chains, bolstering confidence in steady aircraft manufacturing volumes. Other factors are also expected to boost underlying M&A activity, including pent-up sales demand from retiring small business owners and delayed exits by private investors, many of whom had to wait until now to get more reliable pricing on their assets.



A \$3 billion take-private buyout of Tier 2 provider Triumph Group is just the latest signal that mergers and acquisitions across industry are expected to pick up this year.

Stephen Perry, managing director at Janes Capital Partners, another middle-market investment firm and a longtime dealmaker in aerospace and defense, told the PNAA audience that while interest rates have risen and fallen dramatically in recent years, business valuations have largely stuck to their pre-pandemic levels, partly based on the continuation of record backlogs of expected manufacturing work. “In M&A, interest rates are really the jet fuel of deals,” he said. “If interest rates are high, it’s harder to get deals done. If they’re low, it’s a lot easier to get deals done. So relatively speaking, with high sustained valuation expectations on the part of sellers, it’s been tougher to get deals done.”

That is all changing. Christopher Pannacciulli, senior director of aerospace, defense and government contracting at Western Alliance Bank, noted that so-called Federal Reserve forecast curves point to a 0.5% interest rate reduction this year from the current 4.3%.

Perry expects industry to announce some 425 M&A transactions this year. That would be up from 391 in 2024 and 399 in 2023 but down from 438 in 2022. The modern peak was set at 525 deals in 2021, when interest rates were practically abolished and companies and individuals were flooded with free government loans such as through the Paycheck Protection Program.

tion measures that make flying more expensive have a greater impact than before. Economic measures, SAF costs and hydrogen technology costs that will increase prices—and therefore reduce air travel demand—will now account for 19% of overall emissions reductions by 2050, up from a previous estimate of 15%.

The road map touches on aviation's non-CO₂ effects as well for the first time, an area that is increasingly in focus, particularly since a requirement for European airlines to monitor and

report their non-CO₂ emissions came into force at the beginning of the year.

"We need a holistic approach that considers both CO₂ and non-CO₂ measures," van der Sman said.

The report underlines the importance of non-CO₂ effects, where much work remains to be done to deepen understanding and implement measures.

"Addressing non-CO₂ effects based on science in a holistic approach together with CO₂ emissions is crucial for achieving the broader climate goals set by international and regional

bodies, including the European Union's objective of climate neutrality by 2050," the road map noted.

The report recommends taking into account ongoing research as policy measures are gradually put in place.

"Whenever policy options are assessed, it will be essential to adopt a holistic approach considering both CO₂ and non-CO₂ to avoid negative trade-offs from one mitigation measure (for non-CO₂) on the other emission types (such as CO₂)," the road map states. ☒

To be sure, the start of the new Trump administration, with its tariff threats and other potential inflationary actions, have caused some observers to rethink growth expectations. Pannacciulli said larger banks seem to have at least paused loosening of their lending standards, and a few may be tightening again.

Later in the conference, Paul Michaels, a director at Jamco America and a PNAA board member, requested a show of hands from audience members who expected tariffs to affect their business results this year, triggering affirmations from the vast majority. "Pretty much everyone," he noted.

AeroDynamic Advisory Managing Director Kevin Michaels cited data that said tariffs on Canada and Mexico as proposed by President Trump could equate to a \$4 billion tax on the aerospace and defense industry. "And the OEMs are going to have to eat that," Michaels said.

Still, Ron Epstein, senior equity analyst at Bank of America, stressed that it was unclear what effect tariffs would have due to other possible mitigating factors. For one, the administration may try to offset any tariffs with tax cuts. Also, targeted countries such as Canada, Mexico and China "have seen the playbook" from Trump's first term and are expected to respond and retaliate. "You have to look at the data points and then kind of make your own judgment on how you want to run your business," he said.

For larger M&A investors such as big private equity firms, however, momentum appears only to be building. One example is the Feb. 3 announcement of Warburg Pincus and Berkshire Partners' roughly \$3 billion buyout of Tier 2 supplier Triumph Group.

"Triumph is exactly the kind of company that private equity can help," said Jim Corridore, Pitchbook's senior industrials analyst for aerospace and defense. "They have long been an underperforming A&D company that has already gone a long way to optimize their portfolio, but could [be helped] from more expertise in cutting unproductive assets and costs and combining with other aerospace parts makers for better scale. We think the relatively large premium reflects Triumph's position on a lot of Boeing aircraft,

as well as the potential to improve operations over time."

The Triumph deal follows other notable high-figure acquisitions of well-known aerospace and defense brands by private equity, including Apollo Global Management's plans to take engineered parts provider Barnes private for \$3.6 billion. Through September, Pitchbook had tracked 249 deals announced or closed, meaning by the end of the third quarter, 2024 already had surpassed 2023 (220 estimated deals) and 2022 (229). The private investments are driven by healthy underlying business fundamentals, such as record commercial passenger traffic and growing national defense and space budgets, coupled with opportunities created by supply chain issues and Boeing's problems.

"At a time when [private equity] platform and realization activity has been weak and overall portfolio ages have risen sharply, the resilience of this space over the past few years cannot be overstated," Corridore said in a November Pitchbook report. The same trends should continue in 2025.

"The strength of fundamental demand drivers in A&D has given buyers the confidence to pay strong multiples even despite broader market dislocation," the report states. "We expect that continued sponsor-to-sponsor platform trades will fuel activity in A&D in 2025 and that valuations will rise over time."

Dealmakers such as Black, Perry and Pannacciulli offer well-trodden advice for sellers to make the most of the coming wave of M&A: Have diverse revenue streams, preferably with proprietary intellectual property and aftermarket elements, and be sure to clean up balance sheets, customer agreements and other risky pain points, such as your company's labor needs and cybersecurity. Finally, start planning a couple years ahead of any planned sale to get your company in shape and to get a reality check about valuation.

"Never too early, really, to have a perspective," Perry said. ☒

"The strength of fundamental demand drivers in aerospace and defense

has given buyers the confidence to pay strong multiples even despite broader market dislocation."

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BUDGET BATTLES

- > U.S. BUDGET AIRLINES EVOLVE TO COMPETE WITH ECONOMY PRODUCTS OF LARGER CARRIERS
- > STRUGGLING SPIRIT AIRLINES REBUFFS A THIRD MERGER OFFER FROM FRONTIER
- > SOUTHWEST WILL LAY OFF STAFF FOR THE FIRST TIME SINCE ITS FOUNDING

Christine Boynton Boston and **Lori Ranson** Washington

Striving to maintain low costs and find new revenue streams, ultra-low-cost carriers in the U.S. are working to transform their businesses to counter growing skepticism regarding their viability.

The changing ultra-low-cost carrier (ULCC) landscape has presented many challenges for budget airlines. Basic economy products have flourished at larger mainline competitors while post-pandemic travel has created surging competitive capacity on domestic leisure routes. The largest U.S. ULCC, Spirit Airlines, is working through bankruptcy, while smaller rivals are finding ways to diversify revenue and bolster profits with products inside and outside the cabin.

For Spirit, the year began with a curveball as rival budget carrier Frontier Airlines made a fresh offer to acquire it. Spirit is endeavoring to exit its Chapter 11 restructuring in the first quarter of this year, confident that the process will deleverage and position the company for long-term success (*AW&ST* Nov. 25-Dec. 8, 2024, p. 18).

Spirit has continued operations, selling aircraft, deferring deliveries and pursuing sale-leaseback transactions to cut costs and boost revenue. New premium products are aimed at consumer preferences following the COVID-19 pandemic, including the launch of fare tiers with bundled offerings and a blocked middle seat in certain rows. The airline achieved an announced cost-reduction target in

January when it eliminated approximately 200 nonunion positions and ramped down flight volume after furloughing about 170 pilots in the fall.

Frontier also has adjusted network, loyalty and merchandising programs as it looks to improve profitability and customer experience. Transforming what it means to be a ULCC, the airline will introduce two-by-two first-class seating late this year.

Frontier also is striving to unlock more value from its loyalty program and cobranded credit card. In the fourth quarter of 2024, it achieved a record total operating revenue of \$1 billion, up 12% year over year on 2% lower capacity and a net income of \$54 million versus its year-ago quarterly net loss of \$37 million. The carrier is aiming for double-digit adjusted pretax margins by the summer.

"We were encouraged by Frontier's results but would like to see continued execution in the coming months before becoming bull[ish]," TD Cowen analyst Thomas Fitzgerald wrote after the carrier's recent earnings call.

Pleased by its plan, preliminary results and improved revenue environment, the Denver-based airline began reexamining an opportunity to achieve scale through a merger with Spirit.

Frontier first pursued the deal in 2022 before losing a bidding war to JetBlue Airways. After the U.S. Justice Department blocked the JetBlue-Spirit deal on antitrust grounds, the budget carriers resumed their conversations in the summer and fall of 2024, reaching an agreement in principle that would have offered Spirit stakeholders 26.5% of the equity of the combined company and \$580 million of takeback debt. However, Frontier chose not to move forward, and Spirit filed for Chapter 11.

Returning to the table for talks in early January, Frontier presented a reduced offer that Spirit perceived as "both inadequate and unactionable" and declined without countering but invited a revised proposal, which came from Frontier in early February.

Although holding firm on its January offer of 19% equity in the combined company and \$400 million in takeback debt, Frontier's new deal would not have required Spirit to complete a \$350 million equity rights offering, the deadline for which Spirit had pushed back twice. Frontier's up-



JOE RAEDLE/GETTY IMAGES

dated bid also sought a waiver of the \$35 million breakup fee that would otherwise be owed for terminating the equity rights offering.

Remaining unimpressed with the terms, Spirit also cited uncertainty about necessary approvals and feared the deal could result in longer and more costly Chapter 11 proceedings. But this time around, it countered, asking Frontier to pay the breakup charge and commit to a reverse termination fee should the merger fail on regulatory grounds. Spirit also sought to raise the debt offer to \$600 million and equity to \$1.185 billion, describing that aggregate value as “equal to the amount of value that Frontier claimed it was providing to Spirit stakeholders” under its revised proposal.

“Time is of the essence as we speedily approach confirmation of our stand-alone plan,” Spirit CEO Ted Christie noted in offering the counter. Frontier rejected the counterproposal on Feb. 10.

“As we advised you when we sent our last proposal, eliminating the \$350 million equity rights offering was a sig-

nificant concession, and we would not agree to materially alter any of the other commercial terms of our proposal,” Frontier CEO Barry Biffle and Chairman Bill Franke stated in an email disclosed in filings. “As compared to your standalone plan, we remain of the view that this represents a superior proposal to your various stakeholders.”

A bankruptcy court hearing to confirm Spirit’s plan of reorganization proceeded as planned on Feb. 13.

Recent analysis from Raymond James observes that although the two carriers differ on the economics of the offer, they appear to agree on the underlying logic of a deal. Raymond James views the merger as the best long-term option for all constituents. “We are not alone in being skeptical of Spirit’s stand-alone plan,” analyst Savanthi Syth writes in the Jan. 30 report. “And believe that if proposed initiatives do not bear fruit soon and current trends hold, the possibility of a Chapter 7 filing in 2026 is no longer unthinkable.”

While Frontier and Spirit have gar-

nered a lot of attention during the last couple of years regarding their ability to compete at scale as ULCCs in the U.S., their smaller counterparts are poised to capitalize on their own strengths.

Perhaps no other ULCC in the country has proven more resilient than Minneapolis-based Sun Country Airlines. The company’s 2020 launch of cargo operations on Boeing 737-800Fs for Amazon proved fortuitous during the depths of the COVID-19 pandemic and the industry’s recovery from the crisis.

“We view the airline as having carved out an attractive, lower-risk niche for itself,” Fitzgerald states.

Sun Country marked its fourth consecutive year of profitability in 2024, and the airline is benefiting this year from a revamped agreement with Amazon that expands its aircraft flown for the e-commerce giant grows its fleet to 20 from 12 by year-end. CEO Jude Bricker expects cargo revenue will have roughly doubled by this time next year. For the fourth quarter of 2024, Sun Country posted a 13% increase in its cargo revenue year over year to nearly \$27 million.

Although Sun Country’s scheduled service capacity is forecast to fall 3-5% in 2025, the carrier is seeing strength in its profitable first quarter as Minneapolis residents travel to warm-weather destinations.

“While we anticipate very rapid growth in our cargo segment in 2025, the timing of the new freighter deliveries should allow us to maximize scheduled service flying in the first quarter,” Chief Financial Officer David Davis said.

Sun Country also has solidified its fleet composition for the next few years as the first of five Boeing 737-900ERs returns off lease from Oman Air. After opting to extend return dates for three aircraft, the carrier has scheduled the remaining four narrowbodies to join the fleet one at a time in May, September and November this year and in November 2026.

“These aircraft will provide the growth in our passenger fleet in the coming years,” Bricker said. “Including the freighters, we’ll be able to grow block hours by about 30% through 2027 without a change in utilization or additional aircraft acquisitions.” The Aviation Week Network’s Fleet Discovery database shows Sun Country operates 41 737-800s and 11 -800Fs.

Spirit Airlines has rejected a third acquisition offer from Frontier Airlines as it works through Chapter 11 restructuring.



Six aircraft are inactive, including the 737-900ER that has returned off lease.

Sun Country's diversified businesses—which also include charters—plus the favorable industry landscape for scheduled service operations and expansion of its Amazon contract put the carrier in an advantageous position. TD Cowen expects margins should “expand significantly” in 2025 and 2026 as the company “takes on more freighters and its cargo rates reset higher,” Fitzgerald notes. Sun Country's latest guidance for the first quarter of 2025 projects an operating margin of 17-21%, which ranges from down one percentage point to up three year over year.

Fitzgerald says he remains “more cautious” on shares of Allegiant Travel Co. and that he “would like to see execution on its utilization plan before gaining more conviction.”

Unlike Sun Country, Las Vegas-based Allegiant has contended with an unpredictable supply chain in the buildup of its Boeing 737 MAX fleet. The carrier opted to shift from its strategy of operating used aircraft when it placed an order for 50 MAX narrowbodies in 2022, and it currently has 45 737-8-200s on firm order, according to Fleet Discovery.

Allegiant endured some delays in receiving its first MAX, but it operates five 737-8-200s in addition to 29 Airbus A319s and 81 A320neos, with 10 aircraft parked, according to Fleet Discovery.

Although Allegiant is taking a con-

servative approach to Boeing's estimates of 12 aircraft deliveries in 2025, it is conducting strategic sales of older, underutilized A320s in a favorable market to generate cash and deleverage its balance sheet. “The sale of these assets is aligned with our growing confidence in the delivery schedule from Boeing,” Allegiant CEO Gregory Anderson noted during a recent earnings discussion.

“Management anticipates leverage to have peaked at 4.1x in [the third quarter of 2024]. It finished 2024 at 3.2x,” TD Cowen's Fitzgerald states in a report.

Additionally, those new aircraft are equipped with the premium seating “Allegiant Extra,” which is on 46% of the company's fleet now and is expected to be on 70% by year-end, Anderson said. “We continue to see strong demand from our customers for this premium seating as we expand the product more broadly across our network,” he added.

Another upside Allegiant sees in 2025 is restoring aircraft utilization during peak aircraft periods after achieving that goal in December. Anderson explained that the midpoint of Allegiant's full-year 2025 earnings per share guidance of \$9 “suggests an improvement in earnings of 50% compared with 2024.”

Meanwhile, Allegiant is aiming to sell at least a majority interest in its struggling Sunseeker Resort in Florida by the summer. Since opening in

December 2023, the property has been a drag on Allegiant's results. The company posted a net loss of \$216 million in the fourth quarter, but its airline-only net profit jumped roughly 250% year over year to \$55.6 million.

“We are pleased that management is working to transition Sunseeker off the company's balance sheet,” Fitzgerald said.

As larger U.S. ULCCs alter their business models, the country's low-cost pioneer, Southwest Airlines, plans to lay off roughly 1,750 employees beginning in late April, CEO Robert Jordan said. Almost all are corporate and leadership positions.

Dallas-based Southwest made the decision as investors question the airline's ability to execute several revenue and cost-cutting initiatives. Excluding fuel, its unit costs are projected to rise 7-9% year over year in the first quarter, and the carrier expects to end 2025 with year-over-year unit cost growth in the low single digits.

Southwest's cost guidance gave some investors pause, Raymond James' Syth states in the Jan. 30 report. They are skeptical about the airline's ability to achieve low single-digit cost growth targets on modest capacity increases this year. “Southwest is clearly a show-me story, but we see sufficient green shoots to remain cautiously optimistic against a backdrop of considerably negative investor sentiment,” Syth states. ☺

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Thierry Dubois Toulouse

Like all industry executives, ATR leaders want to remove barriers to selling more aircraft. While some headwinds can be managed, often problems are out of their hands.

Regional carriers frequently order new aircraft at short notice and then abandon the order when they find the announced delivery lead time is too long. That has been a serious problem for ATR, which insists it is preparing for a production ramp-up despite slow progress in solving supply chain issues.

ramp up production, we will sell more aircraft," she said. "Customers want their aircraft as soon as possible."

"We are supply-constrained," Chief Commercial Officer Alexis Vidal noted. He would like to see carriers ordering with a longer notice to allow time for ATR to organize. "We are raising awareness among our customers for planning capacity," he said.

The airframer accumulated 53 net orders for its turboprops in 2024, up from 40 in 2023. Gross orders com-

feasibility study. "Late in 2024, we determined with the engine-makers we were working with that service entry in 2032 was not realistic," Daniel Cuchet, ATR's senior vice president for engineering, tells Aviation Week.

Instead of a clean-sheet design for the engine, an existing Pratt & Whitney Canada turboprop will be modified. The target for a 15-20% reduction in CO₂ emissions is unchanged, Cuchet emphasized, although the initial goal was precisely 20%.

The new approach hinges on solid-state battery technology providing a suitable solution starting in 2035. The powerplant's current power level of 2 megawatts will be maintained, including 200-400 kW of electric power in a parallel hybrid configuration, Cuchet explains. The electric motor will contribute in particular at takeoff and top of climb for an overall improvement in fuel efficiency.

ATR has embarked on a 2-3-year project to solve maintenance issues, striving to reduce costs and make operations easier. The company is

As customers tend to order at short notice, ramping up production should generate sales, ATR executives say.

investing \$10-20 million in the effort, which aims to address customers' long-standing pain points, Tarnaud Laude said.

The improved nose landing gear (iNLG) was certified late last year, Cuchet says, extending the interval for heavy maintenance to 12 years from nine years. "That yields a 15-20% reduction in the maintenance cost of a major subsystem," he said. "We worked on materials and production techniques and made more calculations to justify that the iNLG can withstand more cycles."

Corrosion has been another focus. "We are collecting data from 30 customers who have their own maintenance workshops," Cuchet says. "Then we will decide how to prevent corrosion better—switching to another kind of aluminum, another metal such as titanium or composites, or modifying a component's shape." For example, rain may work its way into the airframe from an open passenger door and should be drained better, he noted. ☼

Many customers have expressed interest in a more sustainable aircraft design, such as a hybrid-electric architecture. However, ATR's engineers calculate that the performance and price of a short-term solution would be impractical. In small markets where customers have limited financial resources, recouping development costs is even more challenging.

The manufacturer of the 50-seat-class ATR 42 and the 70-seat-class ATR 72, both turboprops, is therefore aiming to improve customer satisfaction, and sales, by reducing maintenance costs.

The supply chain issues that ATR has been facing since the onset of the COVID-19 pandemic are not only causing late deliveries but also impeding sales, ATR CEO Nathalie Tarnaud Laude said Feb. 12 at the company's annual press conference. "If we can

prised five ATR 42s and 51 ATR 72s. The backlog stood at more than 150 aircraft as of Dec. 31.

ATR delivered 35 aircraft in 2024, similar to 2023 delivery figures, and Tarnaud Laude expects 2025 will be another year of stabilization.

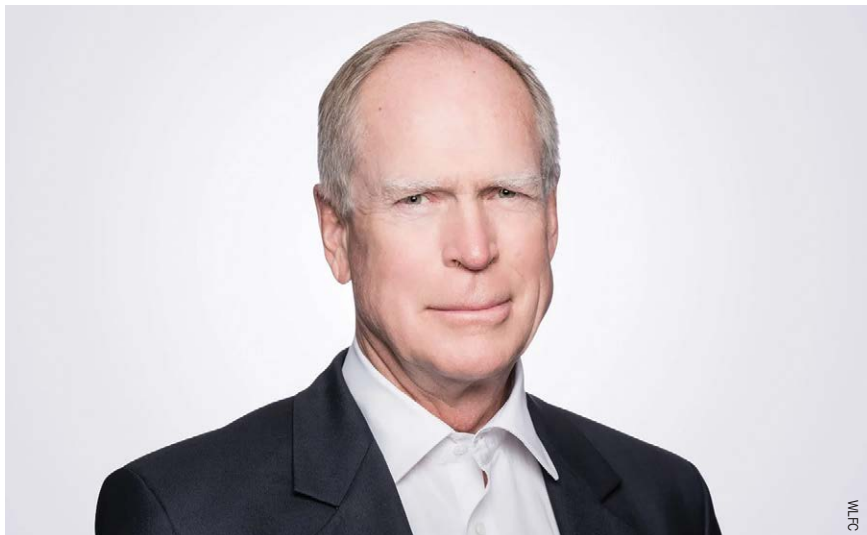
Deliveries have been behind schedule by a few months. Landing gear supplied by Safran Landing Systems are among the delayed components, she noted.

Some issues have been solved, giving Tarnaud Laude confidence that output could start increasing in 2026 and eventually meet the final assembly line's annual capacity of 60 aircraft.

Because batteries are expected to remain too heavy in the coming years, ATR has postponed the launch of a hybrid-electric version of the ATR 72 indefinitely. The development of the EVO was due to start this year after a



THIERRY DUBOIS/ANW&ST



'I Hope It Takes Them a Long Time'

Charles Willis, executive chairman of Willis Lease Finance Corp., has pioneered the engine leasing business, building his company over four decades into a leading player in the segment. After serving as CEO for 37 years, Willis transitioned to his current role in 2022 while his son Austin Willis took over. Willis, 77, spoke with Aviation Week Executive Editor for Commercial Aviation **Jens Flottau** about engine leasing today at the Aviation Week Network's Engine Leasing, Trading and Finance Americas conference in Fort Worth.

AW&ST: Can you remember any time in this industry when business was better than today? This is probably the seventh or eighth cycle that I've seen over the years. This is one of the more unusual ones. If you are an airline, in many respects it's a perfect storm. A lot of the stars are aligned. [You've] got the powder metal issue, you have the lack of [maintenance, repair and overhaul (MRO)] capacity, the lack of technical expertise, of serviceable material. You have new deliveries slowed down. You have old aircraft being extended. So all of these things together have made it an amazing year.

We are a public company, so I can't really tell you what we did in the fourth quarter, but if you annualize what we did [until the third], it's been one of the best years we've ever had. But every year seems to be get-

ting a little bit better, because we seem to do a few different things, like we do our own MRO, and we have our own parts companies. The vertical integration is actually working very nicely.

You are still primarily a lessor. Has demand for engines ever been as strong? I think 2019 was pretty strong, but I don't think we had the strength in pricing that we have today. About 50% of our business is short-term leasing, and 50% is longer-term leasing. For us, it is actually very attractive because as our engines on the short-term side came off lease, we were able to reprice them every 90 days. Whereas if you look at a lot of the people in the longer-term engine and aircraft leasing business, they sign up for 7-10 years, and they're locked in for those rates.

So probably 50% of our fleet will roll over within a 12-month period.

That must be great for you right now, given where rates are going.

Yes, lease rates have increased dramatically for some engine types. I don't see that stopping. We sort of renew our fleet all the time. We probably have 60-70% new-technology and probably 30-40% current-technology engines.

What is the share of your aftermarket business right now? It's around 15%. Five years ago, I said I wanted to see more of our business in aftermarket services. And this is slowly coming.

Where do you want it to be in a few years? I'd like to see it be 50-50. Our services really are very synergistic with the leasing business. And whenever we do something like when we went into the parts business, then other people decided they needed to be in the parts business. We have 60 or 70 engines with one company, 50 with another, I think 40 with another. And none of these engines would have been possible [to place] if we didn't have the synergistic services businesses that we do.

You talked about short-term leases. How short is short-term? The shortest term is that somebody wanted [an engine] for a ferry flight, but it was very expensive. They didn't like to have to pay that. But usually I would say 90 days. That's very short-term already. Sometimes airlines think their problem is a little bit shorter than it turns out to be. So sometimes people will say, "Our problem is going to be done in 30 days, so we only need a 30-day lease," and then it tends to roll over to 60 days and 90 days.

Many airlines have been buying used aircraft even from lessors lately to ensure they have enough capacity in spite of the delays in deliveries from the factories. Do you observe the same in engine leasing? We don't see that. In fact, going back 30 or 40 years ago with some of the OEMs, they actually used to think we were competing with them, and they made it a little bit difficult. But then times progressed, and engines became more expensive. We

just bought a quarter of a billion [dollars' worth of engines] the other day, and we probably bought \$2-3 billion of new-technology engines in the last 24 months. And a lot of these engines are engines that the airlines really either can't or don't want to afford.

In terms of returns, what are your favorite engines right now? We just sold a [CFM International] CFM56-7B [powering the Boeing 737NG] the other day for \$9 million, and I thought, "Good Lord, that's a lot more than I paid for it 30 years ago." So that tends to be the one I like the best from a return point of view. But the [geared turbofans (GTF)] are good; the [CFM International] Leaps are good. They have got their teething problems—and probably will for a while—but you have got to renew your fleet. You don't want to end up with a whole bunch of -7Bs, -5Bs and IAE V2500s [the latter two powering Airbus A320s] in five years because the amount of aircraft that are going to be retired in the next 10 years is going to surprise a lot of people. You

don't see it today, but it's happening.

What worries you most about the industry today? [In general,] I would maybe say financing. But it really is not [a worry] for us. We decided that it made more sense to develop a balance sheet, of sorts. When I started, I rented a desk from a Swedish fisherman in Seattle, and we had nothing. We built up the balance sheet, just one engine at a time. We went public in 1996 because we realized that we had to get a better balance sheet. Now we have a \$1.3 billion [revolving credit] and a warehouse [facility] of half a billion dollars. We can actually go right out there and write a check for half a billion or a billion.

What will be your fastest avenues of growth in the next few years? We see our core business as being a good, solid business that is growing so much. But we will be doing a lot more services.

In aircraft leasing, we have seen major consolidation moves with

AerCap taking over GE Capital Aviation Services (GECAS) and Dubai Aerospace buying Nordic Aviation Capital. Do you expect the same in engine leasing? I wanted to buy [a part of] GECAS, but they said that I have to buy the helicopter company, "you have got to buy this, you got to buy that." I said, "No, we just want this." They didn't want to do that. So as a result our biggest competitor, really, is AerCap. But to answer your question, I think you're going to see more [mergers and acquisitions] on the engine leasing side. It's just getting so expensive for people; the barriers to entry are really high.

What would be required for the GTF and Leap to reach the time on wing of the IAE V2500 and CFM56? When you find that out, you tell me. There is a new [upgrade of the] GTF coming out, and the Leap has a bunch of upgrades, as well. But I think that there's still a fair way to go. It's not really very nice to say, but I hope it takes them a long time. ☹

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Years before uncrewed systems populate tactical aviation fleets in large numbers, the U.S. Air Force must decide the right balance with a possible new generation of human-piloted fighters.

Steve Trimble Washington

Aparalyzing, monthslong debate over the future of the U.S. Air Force's next fighter is about to enter an intense, final phase, and it will have deep implications for the future of airpower and the U.S. defense industrial base.

Service leaders came within days of awarding a contract for the Next-Generation Air Dominance (NGAD) program last June. An engineering and manufacturing development phase worth more than \$20 billion awaited, requiring only the stroke of a pen. It was a moment a decade in the making, following a series of studies, demonstrators and an exhaustive source selection process. Anticipating victory, Boeing had broken ground on a 979,000-ft.² final assembly building and a 94,550-ft.² radar cross-section test site in St. Louis.

But then the Air Force blinked. Despite billions already spent on technology maturity and risk-reduction work for the NGAD airframe and a new form of adaptive turbofan propulsion, Air Force leaders put the program on hold.

The hiatus exposed a new wave of skepticism that had grown around the requirements within some corners of the Air Force. Practical questions

arose about the wisdom of operating warplanes several times more expensive than a Lockheed Martin F-35 from vulnerable forward bases, especially in the vast Indo-Pacific region. Vague warnings surfaced that developments in adversary air defenses posed new, existential threats to even the most advanced U.S. fighters. Having reviewed the best and final offers from Boeing and Lockheed, Air Force leaders blanched at the remaining costs to develop and field the successor to the Lockheed Martin F-22.

The months of internal reviews that followed came to a nuanced conclusion. Yes, the NGAD program's family of systems still mattered, but it could wait while the Air Force sorted out other budget priorities.

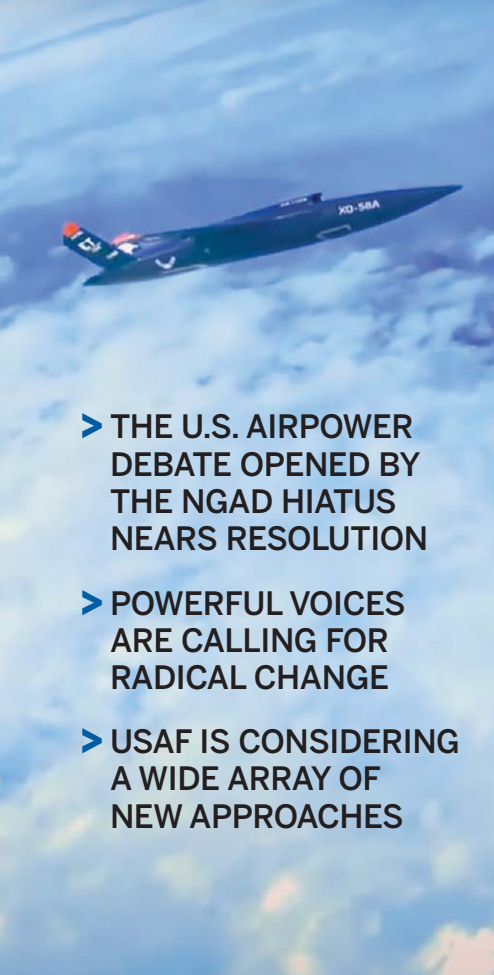
"At the end of the day, the consensus of that group was largely that there is value in going ahead with this, and there are some industrial-base reasons to go ahead, but there are other

priorities that we really need to fund first," Frank Kendall, who was then still Air Force Secretary, said at the Center for Strategic and International Studies (CSIS) on Jan 13.

But the original concept of an advanced crewed fighter at the heart of the NGAD's proposed capabilities may need to change. The requirements could be downgraded from an elite air superiority fighter—a worthy replacement for the mighty F-22, in other words—to an F-35-style, multirole aircraft, orchestrating long-range strikes from afar while managing autonomous Collaborative Combat Aircraft (CCA) tasked with the most dangerous aspects of the mission.

"The alternatives to the F-22 replacement concept include something that looks more like an F-35 follow-on; something that's much less expensive, something that's a multirole aircraft—a multirole aircraft that is designed to be a manager of CCAs," Kendall said. "And then there was another option we thought about, which is reliance more on long-range strike. It's relatively inexpensive and probably would make some sense to do more that way."

But the final decision is no longer in his hands. President Donald Trump



- > THE U.S. AIRPOWER DEBATE OPENED BY THE NGAD HIATUS NEARS RESOLUTION
- > POWERFUL VOICES ARE CALLING FOR RADICAL CHANGE
- > USAF IS CONSIDERING A WIDE ARRAY OF NEW APPROACHES

AIR FORCE RESEARCH LABORATORY

nominated Troy Meink, a former Boeing KC-135 navigator and the current principal deputy director of the National Reconnaissance Office, to be Kendall's successor.

All options remain on the table as Meink waits for the Senate to schedule a confirmation hearing. In December, the Air Force extended contracts with Boeing and Lockheed to keep their design teams intact, allowing a new cohort of civilian leadership to resume the same delayed source selection process after a pause of eight months (and counting). But if he is confirmed, Meink will face a cacophony of proposals to make changes.

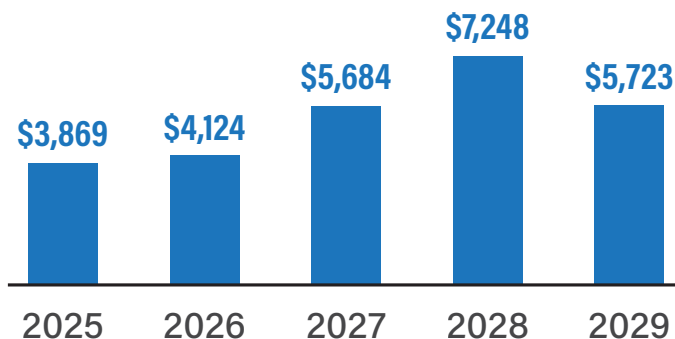
In the backdrop lurk widespread concerns about the state of the Air Force's tactical aviation fleet and whether it has become too small, expensive and inflexible for future needs.

Powerful voices, led by key Trump advisor Elon Musk, are calling for a radical shift to an all-autonomous fleet. Musk's ideas about the obsolescence of crewed fighters in modern combat predate his new role as director of the Department of Government Efficiency, an advisory body established by Trump. "The fighter jet era has passed," he told a gathering of thousands of Air

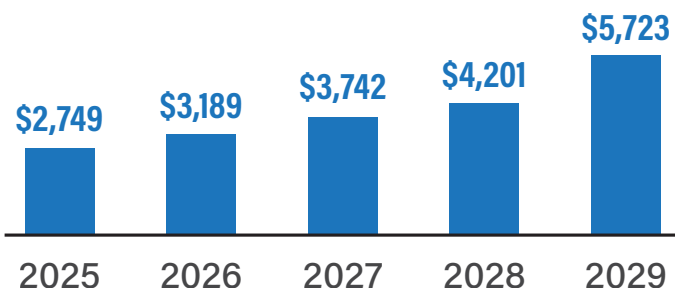
NGAD Spending Plan

(U.S. \$ Millions)

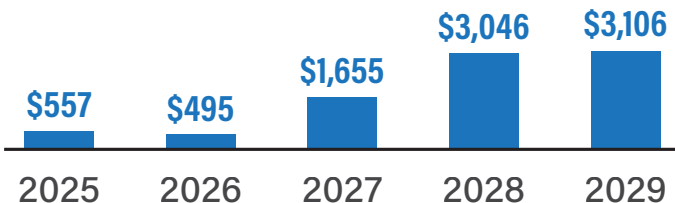
Overall Research, Development, Testing and Evaluation (RDT&E)



Next-Generation Air Dominance RDT&E



Collaborative Combat Aircraft RDT&E



Next-Generation Adaptive Propulsion RDT&E



Source: U.S. Air Force fiscal 2025 budget request

The Air Force's funding plans for the NGAD program could shift dramatically in the next spending cycle, but here is what was proposed for the current fiscal year.

Force pilots attending the 2020 Air Warfare Symposium. “Drone warfare is where the future will be. It’s not that I want the future to be—it’s just, this is what the future will be.”

With a new mandate from Trump to shake up military spending and programs, Musk has elaborated on his skepticism about the future relevance of all crewed combat aircraft, expressing a strong preference for autonomous vehicles and long-range, high-speed weapons.

“Future wars are all about drones & hypersonic missiles,” Musk wrote on social media platform X on Nov. 26. “Fighter jets piloted by humans will be destroyed very quickly.”

His views appear radical but are only slightly beyond the limits of Kendall’s interest in autonomous systems.

“People have talked about not doing another crewed aircraft,” Kendall said at the CSIS. “I don’t think we’re quite there yet. I think that could be considered. We could just continue to rely on the F-35 and keep it going in the foreseeable future and focus on CCAs. I’m not quite ready to do that personally, but the next administration could take a look at that.”

The highest-ranking Air Force generals, meanwhile, also appear to be open to breaking from traditional notions of air superiority, favoring approaches designed to achieve affordable mass on the scale of World War II-size fleets with an architecture that accommodates change on a pace not seen since the early days of the jet age.

In September, Gen. James Slife, the Air Force’s deputy chief of staff, penned a little-noticed essay in *Aether*, an in-house academic journal. While noting that “stalwart technologies of traditional aircraft” remain relevant, Slife noted how small uncrewed aircraft systems and a new class of cheap long-range munitions could reclaim World War II-style mass for future air campaigns.

“Now, with capabilities that traverse the trade space between platforms and munitions, affordable large-scale production runs are within our reach,” Slife wrote. “Mass is back. Let us imagine what we might do with it as airmen.”

The Air Force has new tools. The proposed CCA family seeks to deliver a diverse mix of platforms in the thousands to augment or replace crewed aircraft in modern combat. A new breed of affordable cruise missiles—

typified by the competition for the Enterprise Test Vehicle—offer the possibility of completing long-range strikes at a fraction of the cost of current munitions.

The question now is whether a direct replacement for the F-22 still has a role in this new mix of capabilities.

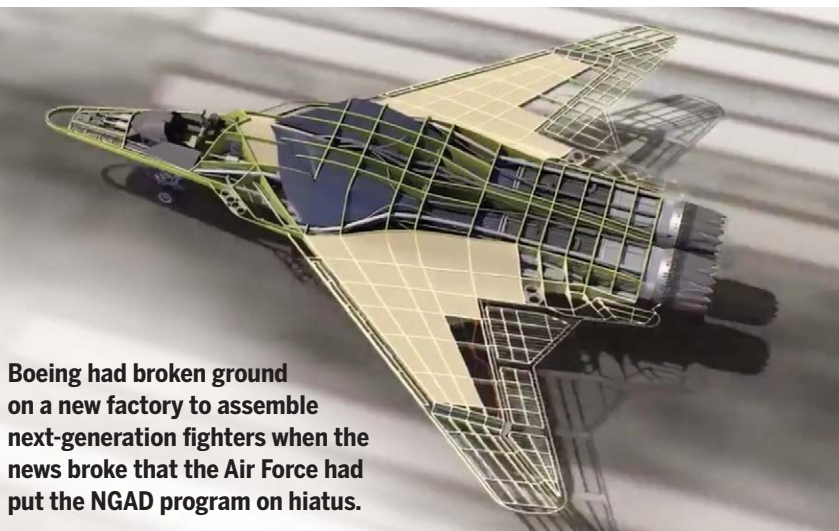
In 2017, the answer to that question for the Air Force was a resounding “yes.” The Air Superiority 2030 Flight Plan—the product of a yearlong analysis led by then-Brig. Gen. Alexis Grynkeiwich—validated a requirement for a Penetrating Counter-Air (PCA) capability.

“While PCA capability will certainly have a role in targeting and engaging, it also has a significant role as a node in the network, providing data from its

looking to translate the PCA capability into requirements for NGAD hardware within a year.

That is when the program was hit by the first of three lengthy delays. When Will Roper became assistant secretary of the Air Force for acquisition, technology and logistics in 2018, he did not like the result of the AOA process for the NGAD program. The classified recommendations pushed for a solution that Roper regarded as too conventional. The former physics professor, missile defense architect and Strategic Capabilities Office founder had something more radical in mind.

In the waning months of the first Trump administration, Roper laid out an unorthodox vision for the future of the air superiority mission. In-



Boeing had broken ground on a new factory to assemble next-generation fighters when the news broke that the Air Force had put the NGAD program on hiatus.

penetrating sensors to enable employment using either standoff or stand-in weapons,” Grynkeiwich wrote in the now eight-year-old Flight Plan.

At the time, the PCA represented a list of attributes to be acquired, not an aircraft, crewed or uncrewed. In a future air war, the Northrop Grumman B-21 would leverage its heavier munitions load to target an enemy’s airfields and key logistics nodes. The PCA capability, meanwhile, would support the bomber, not unlike how North American P-51s assisted Boeing B-17s on long-range bombing missions in Europe during World War II. In whatever form it would take, the PCA was envisioned as sweeping enemy fighters from the skies and suppressing or destroying air defenses on the ground.

The Air Force then launched an analysis of alternatives (AOA) in 2017,

stead of buying a direct F-22 replacement intended to last for decades, he proposed a complete break from the traditional process. His Digital Century Series proposal called for buying multiple different platforms every two years and retiring them within 16 years. The goal was to keep the hardware as fresh and relevant as possible, allowing the platforms to take full advantage of new advances in software-driven capabilities.

But Roper’s job in government came to an end in January 2021 as President Joe Biden took office. Kendall entered office in August 2021 with a skeptical view of the Digital Century Series approach for the entire NGAD program, although a version of the overall concept lives on in the CCA acquisition strategy. He ordered the Air Force to launch a conventional acquisition

process to field a straightforward F-22 replacement in the 2030s.

"The Air Force wrote requirements for an aircraft that is essentially an F-22 replacement," Kendall said at the CSIS. "And for the last few years, that's what we've been working on."

The defense industry shared that vision a decade ago, producing renderings of advanced fighters invariably lacking vertical tails. To support the flying-wing B-21 on long-range missions in the Indo-Pacific, such aircraft would also likely be much larger than the F-22. The Air Force only confirmed one feature of the NGAD platform: The engine would feature the GE Aerospace A102 or Pratt & Whitney A103, introducing adaptive turbofans with fuel-efficient, variable-bypass streams.

In many ways, the Air Force's original vision for the F-22 replacement is not unique. The U.S. Navy, for example, is close to selecting a crewed fighter to replace the Boeing F/A-18E/F Super Hornet on carrier decks in the 2030s. The Air Force's vision also is not dissimilar to the requirements that informed the design of the Franco-German-Spanish Future Combat Air System or the UK-Italian-Japanese Global Combat Air Program. The similarities even extend to potential adversaries. Two Chinese Air Force prototypes revealed on Dec. 26—the so-called J-36 and J-50—confirm Beijing's pursuit of crewed next-generation fighters, which is likely part of a family of systems.

Hovering over the Air Force's decision-making is the NGAD program's cost. In 2019, the Congressional Budget Office estimated the price of the advanced fighter at up to \$300 million each. Kendall has complained that the fighter would cost "several hundred million" dollars and "multiples of an F-35," which today runs to \$94 million each for the Air Force version.

"Maybe that was kind of a thought process that this was too expensive for us to actually produce in any numbers that would make a difference," says John Venable, a senior fellow at the Mitchell Institute for Aerospace Studies.

In Venable's view, the choice is a false one. The B-21 bomber program proved the feasibility of using digital design and manufacturing tools to lower the final price of an advanced new warplane. And some of the same techniques can be adopted to lower the price of a next-generation fighter. For example,

the initial version of the next-generation fighter could leverage the mission systems developed for the F-35 Block 4 rather than a new suite, Venable says. "You're not talking about \$300 million then," he explains. "Now you're talking about in the game of an F-35."

For arguably the first time in its history, the Air Force appears to be willing to consider a wide array of new

approaches to achieving air superiority. As Slife reminded us in his essay, much depends on finding the correct solution for the NGAD program.

"Are we pursuing sixth-generation air superiority capabilities, or only a sixth-generation aircraft?" Slife asked. "Our force cannot responsibly bet that we will have the time and space to recover from getting this one wrong." ❧

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- > THE FLIGHT-SAFE DISCARDING SABOT ENCLOSES A DART-LIKE FLECHETTE PENETRATOR

Graham Warwick Orlando, Florida

Space-based interceptors might have jumped to the top of the U.S. defense wish list, but a group of researchers argues it is time to bring aerial gunnery into the 21st century.

These researchers are calling for new operational requirements for aerial gunnery that would spark development and production of hypersonic ammunition that could significantly increase the capability of gunships, attack helicopters and even future fighters.

The appeal for support is based on academia's successful prototyping of discarding-sabot ammunition for hypersonic aerial gunnery that dramatically reduces time of flight and increases range, accuracy and lethality.

The researchers bemoan a three-decade lack of investment in ammunition development since leadership of the aerial gunnery mission was transferred to the U.S. Army from the U.S. Air Force. They say the time is ready, as a first step, to develop new hypersonic ammunition to upgrade the lethality of Air Force Special Operations Command Lockheed Martin AC-130s and Army Boeing AH-64s.

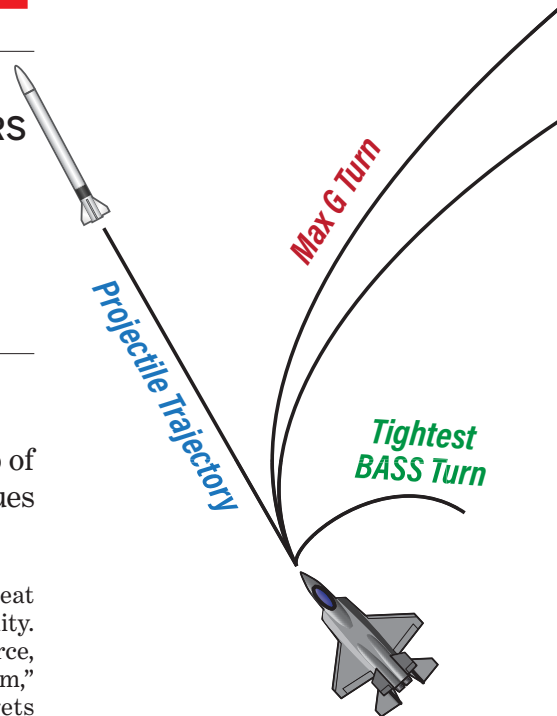
Standard 20mm and 30mm aerial rounds used by the U.S. and NATO trace their lineage back to the early 1970s. Ballistic coefficients have not improved, while those for Army and U.S. Navy midcaliber ammunition are now "an order of magnitude better," Ronald Barrett-Gonzalez, professor of aerospace engineering at the University of Kansas, told the American Institute of Aeronautics and Astronautics' SciTech Forum in Orlando, Florida, in January.

Barrett-Gonzalez blamed the lack of innovation on Defense Department

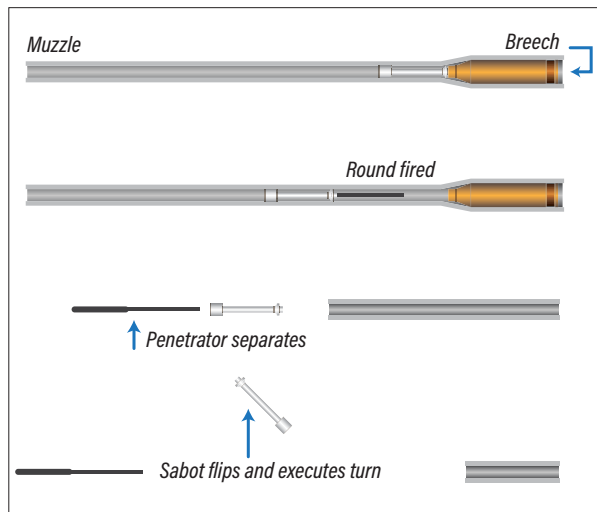
procurement practices, which treat aerial ammunition as a commodity. "We have a split, almost dual-source, no-compete contracting mechanism," he said. "Northrop Grumman gets roughly half of it. General Dynamics gets the other half. They don't have to evolve anything. So we have antique ammunition, and I think it's time to change."

The kinetic energy and supersonic drag of current ammunition determine its range, time of flight, accuracy and penetration. With the aerodynamic center ahead of the center of gravity, gusts destabilize the round, creating windage effects, such as precession and nutation, that increase circular error probable (CEP), degrading accuracy.

The hypersonic ammunition invented by Barrett-Gonzalez and Lauren Schumacher, senior systems engineer at RTX, uses an aeromechanically stable flechette. The dart-like penetrator is long and thin for lower supersonic drag. The center of gravity is ahead of the aerodynamic center, so a gust creates a stabilizing moment, nulling flightpath deviations and reducing CEP. The result is improved accuracy even at longer ranges.



Source for all: University of Kansas. Illustrations: Colin Throm/AW&ST



Sabot decouples the projectile caliber from the barrel bore, enabling higher muzzle exit velocities for longer range.

The sabot is a jacket that fits around the narrow flechette so it can be fired from a larger-bore barrel for higher acceleration and kinetic energy. The sabot is discarded after the projectile exits the muzzle.

Discarding-sabot ammunition decouples barrel bore and projectile caliber. For the same muzzle energy

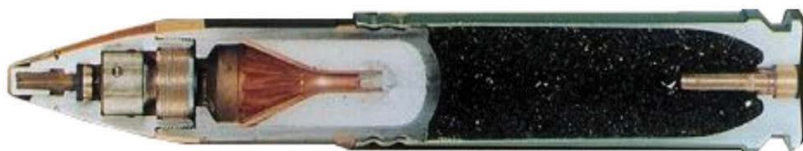


Widest BASS Turn

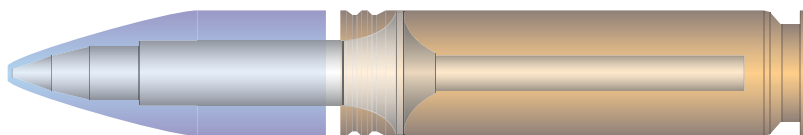
BASS Rounds Design the Sabot To Clear the Launching Aircraft

The ballistic aeromechanically stable sabot (BASS) has a predictable flightpath, keeping the launching aircraft clear of any impact hazard.

Today's 30mm aerial gunnery round



BASS Round: Subcaliber flechette goes into powder, seated in sabot



Hypersonic flechette has lower supersonic drag and higher stability than a conventional round, improving accuracy.

and recoil force, large gains in muzzle velocity are possible. But impact with the rapidly decelerating sabot poses a hazard to the launching aircraft.

The Air Force abandoned development of discarding-sabot aerial ammunition in 1998, when leadership was transferred to the Army. "This has led to a 27-year gap in aerial gunnery ammunition," Barrett-Gonzalez said. "The only place where research was kept alive was in academia.

"Then, in 2016, we made a breakthrough," said Barrett-Gonzalez, who is also director of the University of Kansas' Adaptive Aerostructures and Aircraft Design Laboratories. "We discovered how to make discarding-sabot aerial gunnery ammunition. The Air Force had tried for 50 years and failed."

Conventional sabots are unstable so they will separate from the projectile, and they tumble and can strike the aircraft. Barrett-Gonzalez's team

has developed ballistic aeromechanically stable sabot (BASS) and maneuvering aeromechanically stable sabot (MASS) ammunition that can be unguided or guided.

On firing, while the flechette flies downrange at hypersonic speed, the sabot separates, flips around and turns away. The launching aircraft makes a maximum-G turn that is safely outside the widest and tightest turns the sabot can make (see diagram). "So the sabot is an aircraft unto itself," he said.

Combining the flight-safe sabot with a traveling charge—solid propulsion that accelerates the projectile along the barrel—would produce "hard launch" hypersonic ammunition with much shorter time of flight than today's rounds over longer ranges with increased lethality at range.

The researchers have prototyped 10mm, 20mm and 30mm rounds with tungsten flechette penetrators and

conducted ground firing tests. "These rounds go 1-2 mi./sec.," Barrett-Gonzalez said. "When you are firing them from the AC-130, your windage effects essentially go away. Your CEPs are a lot tighter."

A 20mm hypersonic round eclipses the penetration capability of the Fairchild Republic A-10's 30mm round. "T-72 [tank] top armor is sliced through with a 20mm round," he said. "A 20mm round being more lethal than a 30mm round is unheard of. It means the gun doesn't have to be as big, and recoil forces are less.

"We can put the AC-130 well outside [man-portable air defense system] threat zones," Barrett-Gonzalez added. "Conventional rounds run out of kinetic energy quickly. [With BASS rounds], you can make the entire ground you're fighting over safe with one aircraft."

Hypersonic rounds are compatible with muzzle flash suppressors. "At night, AC-130s light themselves up. They basically become flying targets. Because these rounds are suppressor-compatible, you swallow that fireball, and the AC-130 stays dark," he said.

For short-range countermissile use, "we fire these at a Mach greater than 5," he added. "The missile homes on the flechette, and the flechette homes on the missile. They are drawn toward each other. Be it an infrared or a radio-frequency seeker, you can tune them to act as an attractant."

At very short range, the flechette flies line-of-sight out to 10 km (6.2 mi.). "Long range is different," Barrett-Gonzalez said. "You fire a trio of rounds, at least, and they form a synthetic aperture that guides them on to the target beyond 100 nm. We are working on all of these."

BASS rounds also can be used to counter drones. "You have to reduce the caliber so that you undermatch the aircraft you are going after in terms of cost, weight and size," he said. "So the 10mm round is intended for counterdrone, and it can also go after soft targets."

In an advanced fighter application, higher-caliber hard-launch hypersonic ammunition could provide ranges in excess of 100 km, Barrett-Gonzalez said. But he does not expect to see application to air combat before a putative seventh-generation fighter because of institutional barriers. "It's not for sixth-gen," he said. "There are too many firewalls." 🚫

U.S. Mystery Missile Revealed as the Red Wolf Multirole System

> THE MISSILE OFFERS 150-NM RANGE

> VTOL AND FIXED-WING APPLICATIONS ARE IN DEVELOPMENT

Steve Trimble Washington

A redacted photo released by the U.S. Navy reveals a hybrid, air-launched vehicle from an unlikely supplier that can function as a missile or expendable aerial vehicle, with potential applications on helicopters and fixed-wing aircraft for the Air Force, Army and Marine Corps.

Naval Air Systems Command did not identify the L3Harris Red Wolf missile in the photo it released Feb. 13, which shows two identical Long-Range Precision Fire munitions on the outboard pylons of a Bell AH-1Z Viper attack helicopter. The Navy described the missiles only as capable of striking maritime and land targets at ranges up to 150 nm, far beyond the current 5-mi. reach of the Viper's Lockheed Martin AGM-114 Hellfire and AGM-179 Joint Air-to-Ground Missile.

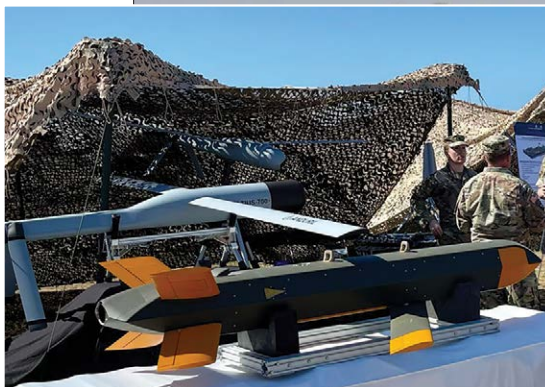
But L3Harris confirmed four days later that the photo depicted a new version of the Red Wolf. The disclosure adds another piece to the scant record of the Red Wolf program's secretive, four-year journey from experimental munition to operational system.

"L3Harris has developed a family of products to address long-range precision fire requirements for manned and unmanned platforms and will address a variety of customer demands," a company spokesperson tells Aviation Week. "An adaptation of Red Wolf, this system helps the warfighter handle increasingly sophisticated threats and avoid entering into adversary engagement zones."

The origins of the turbojet-powered Red Wolf predate L3Harris' acquisition of Aerojet Rocketdyne, a propulsion supplier for several types of ballistic and maneuvering hypersonic missiles. It came as other companies, such as Lockheed, unveiled similar concepts for a new type of

vehicle that could function as a missile, decoy or expendable intelligence, surveillance and reconnaissance system. Lockheed's Skunk Works revealed the Speed Racer

This Navy photo of two Red Wolves on an AH-1Z (right) masks sensitive components. The Army released a clearer image of a version of the Red Wolf (inset) last year.



U.S. ARMY

vehicle in 2021 and demonstrated the system in 2022, but its current status is not clear. Both concepts represent a new class of low-cost, multirole and multiservice vehicles.

The Red Wolf made a semipublic debut in May 2021 during the U.S. Army's Experimental Demonstration Gateway Event at Dugway Proving Ground, Utah. Then powered by a small German-made turbojet engine, the missile was showcased as a potential air-launched effect (ALE) for the Army's rotorcraft fleet by the Strategic Capabilities Office (SCO), an organization chartered to repackaging existing capabilities to suit new operational roles. An SCO representative told Aviation Week at the event about plans to reengineer the Red Wolf with a U.S.-made turbojet but declined to release other details, citing classification rules.

An identical-looking missile next turned up in the Army's Project Convergence Capstone 4 in March 2024, when the Red Wolf was shown as one of several ALE candidates.

The Army's interest in the Red Wolf orders remains unclear, but the Marine Corps' enthusiasm surfaced for the first time a year ago. As part of its fiscal 2025 budget request, the service requested \$4 million for the Long-Range Attack Missile (LRAM) program. The Marines aim to develop a launcher and control interface for a version of the Red Wolf launched by



U.S. NAVY

vertical-takeoff-and-landing (VTOL) aircraft, along with a warhead and seeker for autonomous over-the-horizon strikes.

"Outfitting the VTOL fleet of tactical aircraft (H-1, H-60 series, AH-64 and Joint Future Vertical Lift) with this weaponized [uncrewed air system] dramatically increases the number of aircraft available for over-the-horizon strike," the Navy stated in budget documents released in March 2024.

The Red Wolf already may be operational outside the U.S. military VTOL fleet. Last May, then-Col. Eric Ropella, a Marine Corps acquisition officer, told Aviation Week that the service's LRAM program had leveraged a missile developed for the Air Force's fixed-wing fleet. Ropella's comments suggest that the Red Wolf program in the Air Force predated its appearance at the Army event in 2021. 🗳️

Edge Group Sets Its Sights on Engines and Satellite Markets

> “THIS IS NOT AN EASY JOURNEY,” EDGE EXECUTIVE SAYS

> SAR SATELLITE CONSTELLATION COULD LAUNCH IN 2026

Robert Wall Abu Dhabi

The United Arab Emirates is throttling up efforts to expand its defense industrial portfolio with the launch of the Powertech business, which aims to develop and field domestically produced engines to power everything from homegrown missiles to uncrewed combat aircraft.

Setting up Powertech is the latest twist in Edge Group’s five-year effort to become a major defense equipment supplier through acquisitions, partnerships and local efforts. About a year ago, the company realized that without controlling its fate on engines, it would never achieve the ultimate goal of self-reliance.

“For us, propulsion systems—from piston engines to microjets to medium-size jets to large turbofan, turbojet propulsion systems—are our destiny,” Khaled Al Zaabi, Edge’s president of platforms and systems, told Aviation Week at the IDEX defense show, held here Feb. 17-21. “Because unless we control that or work with partners that enable us to be able to design and develop them, we will never really be taken seriously in terms of delivering our own capabilities.”

The push also represents perhaps the most challenging hurdle the company is tackling, given problems other countries have faced in trying to establish autonomous propulsion capabilities. “We’re going into this with very wide eyes, wide open,” Al Zaabi said. “We know this is not an easy journey.”

Edge wants to be in the full value chain, from single-crystal turbine blades to high-pressure turbine disks and fan blades. While Powertech aims to cover a broad thrust range—up to around 35,000 lb.—it does not intend to take on leading aircraft engine-makers, such as GE Aerospace or Rolls-Royce.

Edge Chairman Faisal Al Bannai says Powertech was established after the company recognized during the first few years of building products and expanding sales that critical components still were missing.

The company may pursue differ-

ent paths to introduce other product types and is not ruling out acquisitions. “Some propulsion systems we may choose to fully develop in-house because we can,” Al Zaabi said. “Some propulsion systems might not make sense for us to fully develop in-house, either from a capability point of view or from an economical point of view.”

Edge has signed agreements with several potential strategic partners to explore opportunities for engine

FADA is looking for overseas industrial partners to build local expertise gradually in the UAE in order to develop satellite design and manufacturing capabilities in the country. Al Mesmari said the unit also is working with local partners, in particular the government-funded Technology Innovation Institute, to infuse large language models into its data analytics tools, among other efforts. While the core goal is to foster indigenous capacity, FADA plans to offer services to foreign customers as well.

The 10-year plan for the space unit, Al Mesmari said, is “to have a fully vertically integrated company that focuses on upstream capabilities, which [are] satellites and payloads; to have midstream capabilities, which focus on the manufacturing and the operation of the satellites; and to have



SONNY BUTTERNORTH/AVIATION WEEK NETWORK

Edge plans to fly its Jeniah uncrewed combat aircraft as early as next year and power it eventually with a locally made engine.

co-development, Al Zaabi said, and the company expects to finalize some in the next few months. Those partnerships could lead to joint ventures that develop their own intellectual property to address Edge’s needs initially but eventually go after business abroad, he said.

The partnership approach also underpins Edge’s space strategy. Its new space unit, FADA, launched in September, is likely to name an industrial partner for a synthetic aperture radar (SAR) satellite system in the coming weeks and for an electro-optical constellation later.

Edge plans to start deploying the SAR system, Sirb—Arabic for “a flock of birds”—toward the end of 2026 and the electro-optical system with submeter resolution in 2027, Waleid Al Mesmari, president of space and cybertechnologies, said at IDEX. The company also wants infrared-imaging spacecraft.

ground station capabilities, which will help in Earth observation, space situational awareness and space domain awareness.”

Launchers are absent from FADA’s near-term plans. Al Mesmari noted that the company does not want to focus on too many things, but he added, “We are not eliminating that option.”

Al Bannai signaled that he has been happy with Edge’s early growth period, noting that the company could top its ambition of securing up to 40% of deals from abroad. When the company was set up, only about 2% of its business came from overseas. That grew to 35% last year. “If we do close some of the deals we’re expecting to close this year, it could go to 50% or beyond 50% of our orders,” Al Bannai said.

The customer base has been broad, he noted, with sales coming from the Middle East, Asia, Europe and Latin America. Only the U.S. remains a blank for deals. ☛

Sikorsky Looks Abroad for the Future of Its X2 Rotor Technology

➤ TWO PROGRAM COMPETITIONS TOTAL MORE THAN 1,000 AIRCRAFT

➤ EMERGING REQUIREMENTS APPEAR SIMILAR TO THE DEFIANT

Brian Everstine West Palm Beach, Florida

Almost a decade after its first flight, Sikorsky's S-97 Raider again screamed across a flight line at about 200 kt. above the heads of potential customers as its pusher-propeller made its unique buzz.

Among those customers were representatives from several countries and other companies Sikorsky had

through development programs, and that's really what the engineering community needs—to have that continuous learning."

Without a new development win, Sikorsky's future is pinned on UH-60 Black Hawk upgrades, additional SH-60 Seahawk sales and the CH-53K heavy-lift helicopter. The CH-53K is

first is NATO's Next-Generation Rotorcraft (NGRC), which is slated to replace approximately 900 helicopters across member countries starting in 2035. That number would likely grow following the competition, with further procurement of the aircraft expected in Europe and beyond for other purposes, says Luigi Piantadosi, Lockheed's director of Future Vertical Lift International.

NATO is conducting a series of studies—both internal and contracted to industry, including Lockheed—to set requirements for the NGRC. While the requirements are not finalized, Piantadosi says NATO is looking at a helicopter of around 14 metric tons, approximately the size of the Defiant.



LOCKHEED MARTIN

Sikorsky's X2-based offering is a contender for NATO's Next-Generation Rotorcraft, which is slated to replace about 900 helicopters across member countries starting in 2035.

brought in as it makes a major push to find the first buyer of its X2 dual-compound-rotor technology in two competitions abroad after being shut out in the U.S.

On the heels of the U.S. Army's cancellation of the Future Attack Reconnaissance Aircraft program and about two years after the major Future Long-Range Assault Aircraft award went to Bell, Sikorsky is making its case to a NATO consortium and South Korea to win development work.

"Is it important? Absolutely," says Andrew Adams, vice president of Future Vertical Lift for Lockheed Martin's Rotary and Mission Systems, which includes Sikorsky. "What this does is keep our engineers going

poised to be the company's strongest growth opportunity in the near future before flattening out, Lockheed Chief Financial Officer Jay Malave told analysts Feb. 13.

As the X2 demonstration took place in mid-February, Sikorsky's FARA prototype, the Raider X, joined its FLRAA counterpart, the SB-1 Defiant, at the U.S. Army Aviation Museum at Fort Novosel in Alabama. Adams says the company has rebounded from the stinging FLRAA defeat, which was largely due to a different understanding of open-systems architecture requirements.

Sikorsky is directing its X2 technology and the approximate Defiant design toward two competitions. The

Partner countries—France, Germany, Italy, the Netherlands and the UK—have agreed to decide on a configuration before the end of 2027. Current plans envision a common airframe across battlefield and naval operations with a cruise speed of 180-220 kt.

Sikorsky's own analysis shows the best rotorcraft would be smaller, at about 12 tons, although "no one has generated a requirement like that," Piantadosi says.

While the Defiant was powered by Honeywell HTS7500 engines, Sikorsky has not selected a powerplant for the NGRC or other potential programs. Both GE Aerospace and Safran attended the X2 demonstration in February. GE developed the T901 as part

of the U.S. Army's Improved Turbine Engine Program. The turboshaft was slated for the FARA and will be installed in Boeing AH-64 Apaches and UH-60 Blackhawks. GE and Airbus announced in July the engine-maker also was working to develop a new rotary-wing turboshaft engine.

"We are trying to find the best fit," Piantadosi says. "I cannot disclose what Safran is doing in terms of a new engine, and maybe GE, but I can tell you that they're working on improved engines. And we will also listen to customers. If it's Europe . . . I guess maybe a European engine manufacturer will prevail."

Beyond NATO, Sikorsky is making a push for South Korea's High-Speed Medium Maneuverable Helicopter competition. This is slated to replace about 100 older Blackhawks, with another 200-300 to follow, Adams says, adding that South Korea is looking for a helicopter that "can operate in the mountains [and is] highly maneuverable and highly survivable."

The realities of operating in Europe

and on the Korean Peninsula have shifted Sikorsky's X2 pitch. For the FLRAA and FARA competitions, the company highlighted the type's potential range and speed improvements along with its ability to support air-launched effects and other high-tech improvements the Army was seeking. The key focus now is on the X2's maneuverability—the ability to make sharper turns and hug terrain over shorter distances. With the FLRAA program, the U.S. Army needed extended range over open water in the Indo-Pacific region. That is not a requirement for either NATO or South Korea, Sikorsky argues.

"The requirements are a little bit different than what the U.S. does," Adams says. "The U.S. can afford a very specific design; it doesn't have to be multirole. . . . NATO and Korea are looking for a little bit more of a multirole."

While Sikorsky is searching for an international buyer for the X2 technology, it is also pressing its engineers to move ahead on other new technologies, such as its rotor-blown wing, hybrid-

electric vertical-takeoff-and-landing demonstrator tiltwing and Matrix autonomy software.

William Fell, principal test pilot at Sikorsky's Development Flight Center, compares the current situation with February 2004, when the U.S. Army canceled the Boeing-Sikorsky RAH-66 Comanche program—another attempt, like the FARA, to develop a scout helicopter. The decision forced the company's engineers to look at other clean-sheet designs and led to the first X2 demonstrator, which flew in 2008 and developed into the S-97 Raider and later the Defiant. Sikorsky has spent more than \$1 billion developing the X2 technology, plus another \$1.5-2 billion from the U.S. government and partners.

"We have a great deal of depth in our community of engineers that are confident in developing clean-sheet aircraft," Fell says. "We're pretty deep in engineering. This would be spectacular, to win one of these contracts, but I think we could sustain a couple of lean years if necessary also." ☐

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Slow Tejas Deliveries Trouble Indian Air Force Commanders

- ENGINE DELAYS ARE BEHIND THE TEJAS MK. 1A LATE SERVICE ENTRY
- HAL IS PLANNING A DOMESTIC FIFTH-GEN FIGHTER FLIGHT IN 2028

Tony Osborne Bengaluru, India

For Hindustan Aeronautics Ltd., India's largest domestic aerospace company, this year's Aero India show was supposed to have been a showcase for the company as well as the country's rapidly developing aerospace technology. Instead, a long-brewing dispute over fighter program delays erupted into public view.

A hot mic caught Indian Air Chief Marshal Amar Preet Singh as he expressed frustration about delayed deliveries of the Hindustan Aeronautics Ltd. (HAL) Light Combat Aircraft (LCA), also known as the Tejas; a video was then uploaded online.

"I am just not confident in HAL," Singh told company Chairman and Managing Director D.K. Sunil while sitting in the cockpit of the airframer's IJT-36 jet trainer on the opening day of the event here.

"I can only tell you what our require-

ment and our worries are," Singh told Sunil. "You have to alleviate those worries and make us more confident."

Singh's concerns come after HAL failed to deliver the first examples of the Tejas Mk. 1A. Three of the production aircraft flew alongside the prototype in flybys at the air show, but others sit on the assembly line awaiting their F404 engines from U.S. supplier GE Aerospace after supply chain issues prevented their delivery in 2023.

"I was promised that when I come here on Feb. 11, Tejas Mk. 1As would be ready," Singh pointed out. "Not a single one is ready."

Singh is likely to get a dressing-down for his comments, particularly since Indian Defense Minister Rajnath Singh gave his backing to the LCA program the day before. During a visit

HAL and India's Aeronautical Development Agency displayed a model of the twin-engine AMCA at Aero India. The real thing is due to fly in 2028.



TONY OSBORNE/AW&ST PHOTOS

to HAL's plant in Bengaluru, the defense minister said the Tejas was the "pride of the nation" and will serve as the "backbone of the Indian Air Force for decades to come."

The air chief marshal's worries have been brewing for some time. His service is already struggling with a shortage of front-line combat aircraft and commanders who are looking nervously at the rapid developments of regional adversaries. Pakistan is evolving the JF-17 combat aircraft it developed with Beijing; it also has acquired a fleet of Chengdu J-10s and outlined plans to purchase the Shenyang J-35 low-observable fighter. Meanwhile, China is growing its fighter forces and in December flew what appeared to be a new fighter-



The Tejas LCA Mk. 1A improves on the original Mk. 1 with a lighter airframe, the integration of an active, electronically scanned array radar and additional weapons integrations.

bomber and a likely prototype or demonstrator for a sixth-generation fighter; reportedly designated the J-50 (AW&ST Jan. 13-26, p. 14).

Air Chief Marshal Singh said in January that India was too slow in aircraft development, arguing that blame must be shared among the military, government and industry.

At HAL's Feb. 11 press conference at Aero India, Sunil called the concerns "understandable" but said the delays were not simply attributable to "laziness" on behalf of industry.

Sunil argued that the very beginnings of the LCA program in 1984 were hampered by sanctions placed on India after nuclear tests, while numerous technical problems had precluded the first prototype from flying until 2001 and from entering service for another 14 years.

"The concern is well understood—as a team, we are focused on getting the aircraft delivered," Sunil said.

The Indian Air Force has 83 Tejas Mk. 1As on order, all of which HAL hopes to deliver over the next 3.5 years.

Sunil said the biggest factor in the late delivery of the first batch has been GE Aerospace's supply chain issues, which have left aircraft without engines. He told reporters that he had been assured those issues had been resolved and that 12 F404s would be delivered this year; the first is scheduled to arrive in March. Some 12 aircraft are to be delivered by year-end, and HAL hopes it can steadily ramp up to producing 24 per year with three production lines—two in Bengaluru and one in Nashik. Another government order for 97 Tejas is in the offing and is due to be contracted in the next 3-6 months.

Some observers say the delays are not due to supply chain issues alone.

They point to the highly bureaucratic management processes and mindset within the state-owned company, which have made it slow to respond to customer needs. This began to change after HAL was listed on India's National Stock Exchange in 2018. The company received Maharatna status in October, giving it higher standing among India's many state-owned entities, known as Public Sector Undertakings, and thus more autonomy in investments.

But that change is not occurring quickly enough, prompting some insiders, including the air chief marshal, to call for increased competition in the country's aviation industry and the opening of tenders to private companies. Tata Advanced Systems, for example, is working with Airbus on domestic assembly of C295 turbo-prop airlifters.

HAL is set to play an outsize role in the Indian Air Force's modernization in the coming years. Besides building the Tejas Mk. 1/1A fleet, it will also build the larger Tejas Mk. 2, the first prototype of which is due to fly in 2026.

In addition, HAL is working on development of a domestic fifth-generation fighter, the twin-engine Advanced Medium Combat Aircraft (AMCA). Sunil said the first prototype is slated to fly in 2028, and production should start in 2034 or slightly earlier depending on the outcome of flight testing. The 25-metric-ton AMCA will be HAL's most advanced aircraft yet; the low-observable platform will require internal weapons carriage—something never seen before on an Indian-built aircraft. It will also use a diverterless supersonic inlet and serpentine duct to hide the engine fan from radar returns and will feature an integrated sensor suite and passive sensors.

New Delhi green-lighted HAL in March 2024 to proceed with the design

and development of five AMCA prototypes in a contract worth 150 billion rupees (\$1.8 billion). According to Sunil, most of the platform's detailed design is already complete.

Much of the AMCA's avionics and systems will have been developed for the Tejas Mk. 2, helping to reduce the development risk, Sunil told Aviation Week.

Both the Tejas Mk. 2 and the first batches of the AMCA will use GE's F414 engine. Work is underway between the Indian and U.S. governments to enable HAL to produce the turbofan in India to serve the programs until a domestic engine is available (AW&ST Feb. 10-23, p. 48).

HAL is also upgrading the Indian Air Force's Sukhoi Su-30MKI fleet while license-building more of them, continuing upgrade work on the Sepecat Jaguar fleet and exploring upgrades to the locally assembled BAE Systems Hawk jet trainer to eliminate obsolescence.

But it is not only HAL's fighter programs that have had a difficult history. During Aero India, the company announced the rebranding of the IJT-36 Sitara jet trainer to Yashas, reflecting a redesign of the platform more than 20 years after its first flight in 2023.

Test pilots found that the IJT-36 lacked the predictable stall and spin characteristics required of a training aircraft. A major redesign lengthened the fuselage, adding ventral fins to the rear just forward of the engine exhaust nozzle. Additional fins were fitted to the underside of the horizontal stabilizers, while wing fences were added to the main, and wing droop was increased to improve lift.

The Indian Air Force is now looking to lease several Yashas from HAL to experiment with them before it decides to proceed with an acquisition, Sunil told journalists.

"We have had some setbacks, but we have fixed those problems," he said. "It is now a very capable aircraft." 🌐

CCA Could Grow the Indian Navy's Aerial Mass

> THE INDIAN NAVY CHOOSES NEWSpace FOR ITS COLLABORATIVE COMBAT AIRCRAFT INITIATIVE

> INDIA HAS DEVELOPED SWARMING AND AUTONOMY TECHNOLOGIES

Tony Osborne Bengaluru, India

The Indian Navy is looking to grow the capacity of its aircraft carriers and give its embarked combat aircraft an edge as regional adversaries build confidence in their own carrier aviation capabilities.

With the service committed to its existing fleet of short-takeoff-but-arrested-recovery (Stobar) carriers for the next 20-30 years, commanders say uncrewed collaborative combat aircraft (CCA) could provide the additional mass the service has been seeking to augment the relatively small numbers of combat aircraft each ship can carry. To begin to address the issue, the navy has turned to private Indian company NewSpace Re-

search and Technologies to provide a minimum viable product CCA within three years. The company will start by using its internally developed jet-powered Abhimanyu uncrewed aircraft system (UAS) to meet the country's Naval Collaborative Combat Air Vehicle (N-CCAV) need.

Bengaluru-based NewSpace secured the contract after responding to an Indian Navy problem statement made through the Indian Defense Ministry's Acing Development of Innovative Technologies with iDEX initiative to encourage private industry to accelerate development of defense technologies.

"The key thing is not the amounts of money, but the commitment to acquisition," Jaideep Maolankar, NewSpace's vice president for technology development, told Aviation Week on the sidelines of the Aero India show here in mid-February.

Maolankar is a former chief test pilot for the naval Light Combat Aircraft program and made the first landing of the indigenous fighter on the Indian aircraft carrier Vikramaditya in January 2020. He said the navy has been wise to "not be overly restrictive and prescriptive in their requirements" for the CCA program.

"The navy understands that they have a finite amount of capability they can pack into their aircraft carrier," he said, adding that the Stobar approach to carrier operations also brings payload disadvantages.

Another challenge for the service is understanding the price thresholds for whether a platform is expendable,

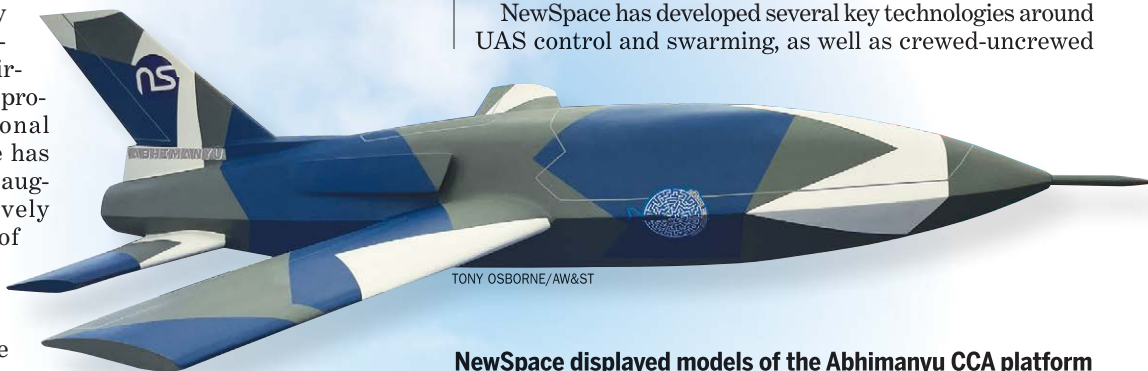
attritable or exquisite, the three primary categories of survivability and capability into which CCA and related autonomous collaborative platforms are being coalesced. After all, a platform that costs \$5-10 million might be considered expendable by U.S. commanders but less so by the Indian Navy.

With a 4-m (13-ft.) wingspan, the Abhimanyu UAS is at the smaller end relative to CCA being studied by other nations, but NewSpace sees it as a steppingstone toward platforms with increased capabilities.

Nonetheless, the company says the aircraft can achieve ranges of up to 1,000 km (620 mi.) and operating altitudes of up to 20,000 ft. The platform's small size means a ship could carry more of them and be more aggressive when needed, Maolankar said.

"We are catching up with others using smaller platforms, and if the government sees the potential, we can move to a larger segment," says Sameer Joshi, NewSpace's CEO and director.

NewSpace has developed several key technologies around UAS control and swarming, as well as crewed-uncrewed



TONY OSBORNE/AW&T

NewSpace displayed models of the Abhimanyu CCA platform it will use for the N-CCAV project at the Aero India show.

teaming and mesh networking, that allow all the air vehicles to become nodes in an information-sharing network. The company is also exploring the level of autonomy and automation required for the platform. Joshi says it hopes to get "clarity" on that as soon as possible. How the CCA will work together with a crewed fighter is part of what NewSpace brings to the table. Maolankar said the company is determined not to breach certification boundaries with the crewed aircraft and to perform as minimal a change as possible to enable joint operations.

Initial missions for the CCA will be intelligence, surveillance and reconnaissance and supporting air-to-surface tasks before spiral upgrades will enable them to support the air-to-air mission.

NewSpace is not alone in developing a CCA capability in India. The company has also worked closely with Hindustan Aeronautics Ltd. (HAL) on the Combat Air Teaming System (CATS) before working independently on the Indian Navy's project. HAL is marketing CATS to the Indian Air Force to help solve the service's combat air mass shortfall. Compared with the NewSpace N-CCAV, CATS uses a much larger platform, the CATS Warrior, which weighs in at two metric tons and is powered by two turbojet engines.

The prototype CATS Warrior, which was powered up for the first time in January ahead of Aero India, is with HAL and undergoing testing of the software and flight control systems on an adapted Kiran jet trainer. A first flight of the CCA is expected this year. 🌐

AI Program Can Modify Accents in Pilot and ATC Audio in Real Time

> TECHNOLOGY COULD ASSIST CREWED-UNCREWED TEAMING

> SOFTWARE CONVERTS SPEECH DISTINCTIONS IN LESS THAN ONE-THIRD OF A SECOND

Garrett Reim Seattle

For those amused by radio recordings of American pilots trying to communicate with heavily accented French air traffic controllers, your fun may soon be coming to an end.

Honeywell is working on an artificial intelligence (AI) program that would almost instantaneously modify even the heaviest of accents—U.S., French or otherwise—in radio transmissions. The company says the software could reduce pilot-to-air traffic control (ATC) readbacks and miscommunication and perhaps make flying safer.

Honeywell's RASP technology would modify accents that can complicate communication between pilots and air traffic controllers.

The technology has an unusual origin. Honeywell announced on Feb. 11 that the Intelligence Advanced Research Projects Activity had awarded it a multimillion-dollar contract to develop the speech modification program to anonymize individuals' voices. Anonymizing a voice might hide distinctive features, such as dialect, gender and age, from foreign intelligence.

However, Honeywell says the Real-time Anonymization & Speech Protection (RASP) program has aviation applications, too. Although international pilots and air traffic controllers are required to be able to speak Aviation English at a level 4 proficiency rating, accents pose communications problems. RASP could modify accents to improve communications between pilots and ATC—and perhaps one day with autonomous aircraft.

Honeywell's RASP works by modulating several distinct characteristics of the human voice such as pitch, timbre and rhythm. "Our approach is not

necessarily to target features individually but by applying speech representation [AI] learning models," Tor Finseth, Honeywell Aerospace Technologies' principal investigator for RASP, tells Aviation Week. "We can begin to model at a very large scale



RICHARDBAKERISK/ALAMY STOCK PHOTO

how all these features come together to result in different accents."

The company uses multiple AI models to create RASP, including convolutional neural networks and self-supervised speech representation learning models. Honeywell is also looking at using generative adversarial networks for the software, Finseth says. AI models are trained on thousands of voices. Several demonstrations heard by Aviation Week sounded fairly natural, and the words were easily understood.

Honeywell decided it could not transcribe speech and then convert it back into an artificial voice; a multistep process would take too long, and the listener would notice. "We've got to go straight audio-to-audio by morphing the acoustics," Finseth says.

Some aspects of speech are easier to change than others. For example,

pitch—often correlated with gender—has been modulated by musicians like Cher and T-Pain for decades using Auto-Tune.

"Age is a little harder," Finseth says. "Because of your larynx structure, your muscles get looser over time, and you start having kind of a gargling noise."

RASP could prove to be a building block for cleaner audio transcription, something useful for analyzing piles of pilot-to-ATC communications. Clearer speech might also be vital to providing commands to uncrewed air vehicles. The U.S. Air Force is examining how best to coordinate crewed and uncrewed aircraft with the minimum

additional cognitive load for pilots, for example. Using voice commands interpreted by a large-language-model AI program is one approach. The FAA is also studying how to direct uncrewed cargo drones and, eventually, air taxis with ATC.

Finseth declines to discuss FAA certification plans for RASP but notes that it could be incorporated into a pilot's iPad-based scratchpad as an app. The software might also be integrated into avionics or hosted in the cloud via satellite connection, although the latter would depend on latency, he adds.

The University of Rochester, Texas A&M University and the University of Texas-Dallas will also contribute to RASP's development. Honeywell plans to focus development of RASP on English, with Spanish and other languages coming later. 🗣️

QUIET PATHFINDER

- > THE X-37B ORBITAL TEST VEHICLE IS SHAPING THE FUTURE OF THE U.S. SPACE FORCE
- > THE SERVICE IS USING THE SPACEPLANE'S DATA TO INFORM NEXT-GEN CAPABILITY DEVELOPMENT
- > A NEW AUTOMATED SYSTEM TRACKED MILLIONS OF COLLISION AVOIDANCE OPPORTUNITIES

Vivienne Machi Los Angeles

As the Pentagon explores how to fight future wars in space, it is leaning on a mysterious platform that has logged a record-setting number of years quietly operating in space. The X-37B Orbital Test Vehicle—a 29-ft.-long experimental spacecraft that can reenter the Earth's atmosphere autonomously—has emerged as a critical tool for the U.S. Space Force's future planning.

The real-world data collector is helping the five-year-old service learn how to operate in a domain that is increasingly crowded with small satellites and orbital debris from a widening net of state-owned and commercial assets.

"When I have a platform like the X-37B, my mouth starts to water," Chief of Space Operations Gen. Chance Saltzman told Aviation Week in an exclusive interview Jan. 31. Saltzman faces critical decisions in the next couple of years about how best to equip the service to give the U.S. a military edge in the contested domain.

During the first six missions, the X-37B spent more than 3,774 days in orbit. It launched on its current mission, OTV-7, on Dec. 28, 2023, and passed 400 days in orbit on Jan. 31. By comparison, the space shuttle spent 1,323 days in space during NASA shuttle flights between April 1981 and July 2011.

The Boeing-built spacecraft is derived from NASA's original X-37 program, which ran from 1999 to 2004. It was then transferred to DARPA before being taken over by the Air Force Rapid Capabilities Office (RCO) in 2010. The spacecraft launches vertically atop a rocket but lands horizontally on a flight line, like an airplane.

Space observers openly speculate about the spacecraft's range of mis-

sion areas and technology, especially as the onboard payloads have remained largely undisclosed. The Air Force has long maintained that the platform is intended to demonstrate reliable, reusable spacecraft capabilities and support experiments that can be brought back to Earth.

Along with its reusability, the X-37B is more maneuverable and agile than most spacecraft, and on its longest mission to date it orbited nearly 2.5 years before returning to terra firma.

The Space Force is gathering data from both the onboard experiments inside the spacecraft and in an attached service module that was introduced on its sixth mission.

Saltzman said those findings will inform the service's path forward across a number of space-based mission areas and future satellite programs. "It allows me then to apply physics-based, real-world data as we look . . . to create more resilient architectures," he said.

Since launching the first mission in 2010, the U.S. military has kept the X-37B's movements under wraps, waiting until the spacecraft has landed before announcing its return to Earth.

In a break from that pattern, the Space Force announced in October that the spaceplane would perform an aerobraking maneuver for the first time

during its ongoing mission, performing radiation effect experiments and test space domain awareness technologies in a highly elliptical orbit (HEO).

The X-37B was planned to use the drag of Earth's atmosphere to dip into low Earth orbit (LEO) long enough to dispose of its service module safely, then resume its testing and experimentation efforts in HEO.

The OTV-7 mission is the first on which the X-37B is operating in HEO rather than solely in LEO. Former Air Force Secretary Heather Wilson previously hinted at the spaceplane's ability to perform "an orbit that looks like an egg" and maneuver itself once it is close enough to the atmosphere.

That means adversaries would not know where it will reappear on orbit, Wilson told the audience at the 2019 Aspen Security Forum. "And we know that that drives them nuts, and I'm really glad about that," she added.

The move to HEO has allowed the RCO and Space Force to observe the spaceplane's exposure to new orbital regimes. The upper range of LEO is 2,000 km (1,240 mi.), whereas the perigee of an elliptical HEO orbit is about 1,000 km, and the apogee is more than 35,786 km.

The aerobraking maneuver capability required modifications to the spaceplane, namely for fault protection, autonomy and collision avoidance. Boeing developed a new collision avoidance system ahead of OTV-7, said Michelle Parker, company vice president for space mission systems.

Autonomy is critical as space becomes more congested and the spaceplane operates in various regimes, Parker told Aviation Week at Boeing's satellite facilities in El Segundo, California, on Feb. 3.

Over the course of the X-37B's current mission, the Space Force identified about 1.7 million collision avoidance opportunities, Saltzman said, noting, "When we talk about data, I'm not talking about four or five numbers on a spreadsheet."

The aerobraking maneuver has allowed Saltzman to evaluate the service's Space Surveillance Network, a global collective of optical and radar

About the X-37B

The X-37 was first known as the Future-X Pathfinder when NASA launched the effort to study more than 40 airframe, propulsion and operations technologies, seeking to lower the cost of access to space. The agency ran the program from 1999 until September 2004, when it was transferred to DARPA. NASA also performed low-speed and low-altitude tests in 1998-2001 using the X-40A, a subscale version of the X-37 developed by the Air Force Research Laboratory. DARPA then performed several captive-carry and drop tests of the Boeing-built X-37A in 2005-06, prompting the Air Force's announcement to begin the X-37B Orbital Test Vehicle program in November 2006.

To date, the X-37B has completed six missions, beginning with its first launch on a United Launch Alliance Atlas V 501 rocket on April 22, 2010, from Cape Canaveral SFS. A SpaceX Falcon Heavy rocket launched it on its current mission on Dec. 28, 2023, and it passed 400 days in orbit on Jan. 31.

X-37B General Characteristics

Primary Mission: Experimental test vehicle

Prime Contractor: Boeing

Height 9 ft. 6 in. (2.9 m)

Length 29 ft. 3 in. (8.9 m)

Wingspan 14 ft. 11 in. (4.5 m)

Launch Weight 11,000 lb. (4,990 kg)

Power Gallium arsenide solar cells
with lithium-ion batteries

Launch Vehicles ULA Atlas V 501,
SpaceX Falcon 9

Source: U.S. Air Force



An onboard camera captured the X-37B and Earth on its current mission, during which it also performed an aerobraking maneuver for the first time.



U.S. SPACE FORCE

X-37B Missions

Flight	Vehicle	Launch Date	Landing Date	Launcher	Mission	Duration	Notes
OTV-1	1	April 22, 2010	Dec. 3, 2010	Atlas V 501	USA-212	224 days, 9 hr.	- First launch of Atlas V 501 configuration - First autonomous orbital runway landing in U.S. - First X-37B flight
OTV-2	2	March 5, 2011	June 16, 2012	Atlas V 501	USA-226	468 days, 14 hr.	First flight of second X-37B
OTV-3	1	Dec. 11, 2012	Oct. 17, 2014	Atlas V 501	USA-240	674 days, 22 hr.	Second flight of first X-37B
OTV-4	2	May 20, 2015	May 7, 2017	Atlas V 501	USA-261	717 days, 20 hr.	Second flight of second X-37B
OTV-5	2	Sept. 7, 2017	Oct. 27, 2019	Falcon 9	USA-277	779 days, 17 hr.	First launch of an X-37B on SpaceX Falcon 9
OTV-6	1	May 17, 2020	Nov. 12, 2022	Atlas V 501	USA-299/ USSF-7	908 days, 21 hr.	- Longest mission to date - First mission with service module
OTV-7	2	Dec. 29, 2023	TBD	Falcon Heavy	USSF-52	Undetermined	First X-37B aerobraking maneuver

sensors that detect, track, identify and catalog all human-made objects on orbit. Through the experiment, he is able to observe how other such sensors are able to find and track the spaceplane's new orbit, he said.

Collecting such real-world data on orbital maneuvering is key for the Space Force to avoid operational surprise from peer adversaries.

The China Aerospace Science and Technology Corp. has developed its own experimental reusable spaceplane, known as the Shenlong. It has

As the service prepares for the possibility of a war in space, having an experimental platform has become "even more valuable than maybe it was when [space] was a benign environment," he said.

The X-37B will be instrumental as the Space Force establishes its latest field command over the next year. Space Futures Command will help the service forecast the space threat environment, conduct wargaming and training, and develop and validate mission area design.

launched within one year of its predecessor's return to Earth, except for the latest mission, which launched 13 months later.

Boeing has maintained the X-37B via continual upgrades, Parker said. The spaceplane is on its second generation of batteries and third generation of solar cells, supplied by Boeing subsidiary Spectrolab.

"Even though it may look the same, a lot of the innards have been upgraded and then can continue to fly for a significant amount of time," Parker said.

That refurbishment has helped the X-37B team keep the program cost-effective, Saltzman and Parker both note, declining to share funding details.

While Parker emphasized that the X-37B is a government platform, she said that its attributes could one day be applied to commercial platforms to support on-orbit refueling and experimentation or debris collection.

"As the space industry and the space ecosystem expands, I think the opportunities for something that you can do on a returnable platform . . . expand as well," she said.

The patent on the new automated collision avoidance system is pending, and Boeing says the system is not being incorporated into other platforms at this time.

Space Force leaders have endeavored to speak more bluntly about its mission areas and capabilities amid growing competition with China and Russia. When Saltzman was working as a Minuteman III launch officer and satellite operator for the National Reconnaissance Office, the U.S. military never described space as a warfighting domain, he said.

"It was static, to some degree, in the sense that our goal was to launch satellites to orbit that would last forever—if we could make it happen," he said.

The service saw the benefit of inching back the curtain on the X-37B in October to disclose the planned series of aerobraking maneuvers, especially as safe maneuvering on orbit is critical for spaceflight operations, Saltzman said.

"We wanted to let everybody know that we were going to do it," he said. "We want other nations to observe it. We want to share the data." 🗣️

Check 6 *Aviation Week editors discuss if the U.S. could lose its leadership in space: [AviationWeek.com/Check6](https://www.aviationweek.com/Check6)*

The Space Force is collecting reams of data from each X-37B mission and using it to inform future space operations.



U.S. SPACE FORCE

completed three missions, performing what observers have determined to be rendezvous and proximity operations and releasing small satellites or objects into orbit.

Beijing has maintained strict secrecy around the spacecraft, which is believed to be analogous to the X-37B. The two spaceplanes launched within two weeks of each other in December 2023. The Shenlong deorbited in September, but the X-37B is continuing its operations.

The Space Force has identified space domain awareness, resilient on-orbit architectures and "responsible" counterspace capabilities as its three main focus areas into its next five years, Saltzman said in December at the Space Force Association's Spacepower Conference in Orlando, Florida.

Saltzman said in the interview he has no plans to use the X-37B as an operational vehicle but will continue to use it to refine thinking about the potential capabilities and tactics of similar adversarial platforms and to design high-fidelity training environments.

Once formally set up, the command will leverage data and findings from the X-37B's on-orbit activities in concert with the Air Force RCO, Saltzman said.

"The RCO will hear what Futures Command sees as challenges; they'll see what technologies they think might be interesting, and they'll see if the X-37 can collect data that informs gaps that they have in their knowledge or operational concepts," he said.

The Space Force declined to share how data from the X-37B is informing future spacecraft design, as those discussions are early in the research-and-development phase, Saltzman noted. But he expects it could help evaluate the potential cost of servicing satellites on orbit rather than deorbiting them for depot-like refurbishment or a total platform refresh. "All of these options are available to us, but how much does it cost? Which one makes sense for which mission?" he said.

Saltzman demurred on when the spaceplane might return to Earth and when an eighth mission might begin. Historically, the next mission has

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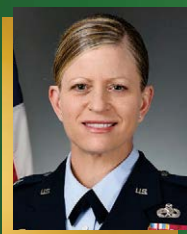
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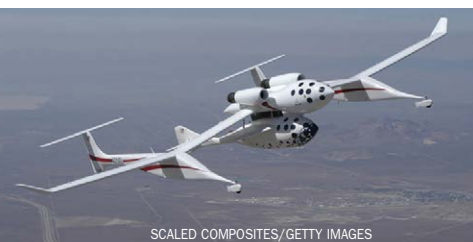
Irene Klotz Cape Canaveral and **Vivienne Machi** Los Angeles

Originally designed for NASA, the X-37B is a reusable, uncrewed spaceplane now operated by the U.S. Space Force, whose two vehicles have so far spent nearly 4,200 days in space during seven missions (see table on p. 45), the latest of which is ongoing. Their ability to deorbit autonomously, land like an airplane and launch again after a short refurbishment is largely due to thermal tile technology first developed by NASA and refined by X-37B prime contractor Boeing. The X-37B is not the first reusable spacecraft, nor will it be the last. Here is a look at other pioneering vehicles designed to travel beyond the atmosphere and back.



In the 1950s, North American Aviation built three X-15 research aircraft for the U.S. military and NASA, primarily to conduct exoatmospheric studies. Air-launched from modified Boeing B-52 Stratofortress aircraft, the X-15 reached a top speed of Mach 6.7 and maximum altitude of 354,200 ft. Due to their speed, the X-15s needed to be able to withstand aerodynamic temperatures of around 1,200F, prompting designers to turn to Inconel X, a high-strength nickel-chrome alloy for the outer skin. The aircraft also used a pink silicone elastomeric coating, applied at different depths to counter the specific heat load on each part of the vehicle.

The spaceplane's aluminum cabin was isolated from the outer structure to keep it cool, while a heat-sink structure in the leading edges of the wing absorbed and radiated heat. The three X-15s completed a total of 199 flights over nine years.



Commissioned by the late Microsoft co-founder Paul Allen, SpaceShipOne was an experimental, air-launched, reusable sub-orbital vehicle developed to compete in a privately financed competition to spur commercial human spaceflight. Allen partnered with renowned aircraft

designer Burt Rutan—founder and original owner of Mojave, California-based Scaled Composites—to build and fly a reusable, piloted ship into suborbital space twice in 14 days.

On June 21, 2004, SpaceShipOne reached suborbital space for the first time, marking the first privately funded human spaceflight. It then repeated the feat on Sept. 29 and Oct. 4, 2004, to clinch the \$10 million Ansari X Prize.

SpaceShipOne served as the prototype for the Richard Branson-backed Virgin Galactic space travel company's SpaceShipTwo. The vehicles feature a unique system for atmospheric reentry known as feathering, in which the vehicle's wings and tail booms fold 70 deg. upward to increase drag and improve stability during the plunge through the atmosphere.



KENNY ALLEN/NASA

NASA flew a total of 135 missions in low Earth orbit with its partly reusable crewed space shuttles, pioneering technologies for a fleet of successor vehicles, including Boeing's X-37B. During atmospheric reentry, the shuttles' surfaces could reach temperatures of nearly 2,700F. To protect their aluminum and graphite epoxy shells, NASA used High-Temperature Reusable Surface Insulation (HRSI) black tiles, which could withstand up to 2,300F, on the spaceplane's belly, landing gear doors, external tank umbilical connection doors, upper forward fuselage, orbital maneuvering system pods and other areas. Fibrous Refractory Composite Insulation (FRCI) tiles—reusable tiles made of aluminoborosilicate, Nextel and silica fibers—were used to replace damaged HRSI tiles.

Each shuttle was fitted with more than 24,000, 6 X 6-in. silica-fiber thermal barrier tiles, and each piece was custom-made to fit an exact location on the surface of the lower portion of the spacecraft. Technicians used a special adhesive to attach the individual tiles to the outer skin of each orbiter. Discovery, the fleet leader, which completed its 29th and final flight on March 9, 2011, is pictured above.

NASA's X-37A prototype orbital spaceplane paved the way for the X-37B (below), which made its space debut on April 22, 2010, to test technologies for reusable spacecraft and serve as a platform for classified experiments and systems. The vehicles are outfitted with thermal tiles made of Toughened Uni-Piece Fibrous Reinforced Oxidation-Resistant Composite (Tufroc)—an advancement of capabilities originally crafted for the space shuttle, says Michelle Parker, Boeing Defense and Space vice president for space mission systems. Tufroc tiles can handle reentry temperatures of up to around 3,600F, according to NASA, and are more durable and easier to handle than their shuttle predecessors.

Most of the X-37B's Tufroc tiles have not needed to be replaced after repeated missions in orbit. While a number of tiles may return damaged by micrometeoroid and orbital debris impact, Boeing can repair Tufroc surfaces and avoid a full tile replacement, "which really helps in the turnaround time and the cost that's required to get the vehicle ready to go again," Parker says.



STAFF SGT. ADAM SHANK/U.S. AIR FORCE



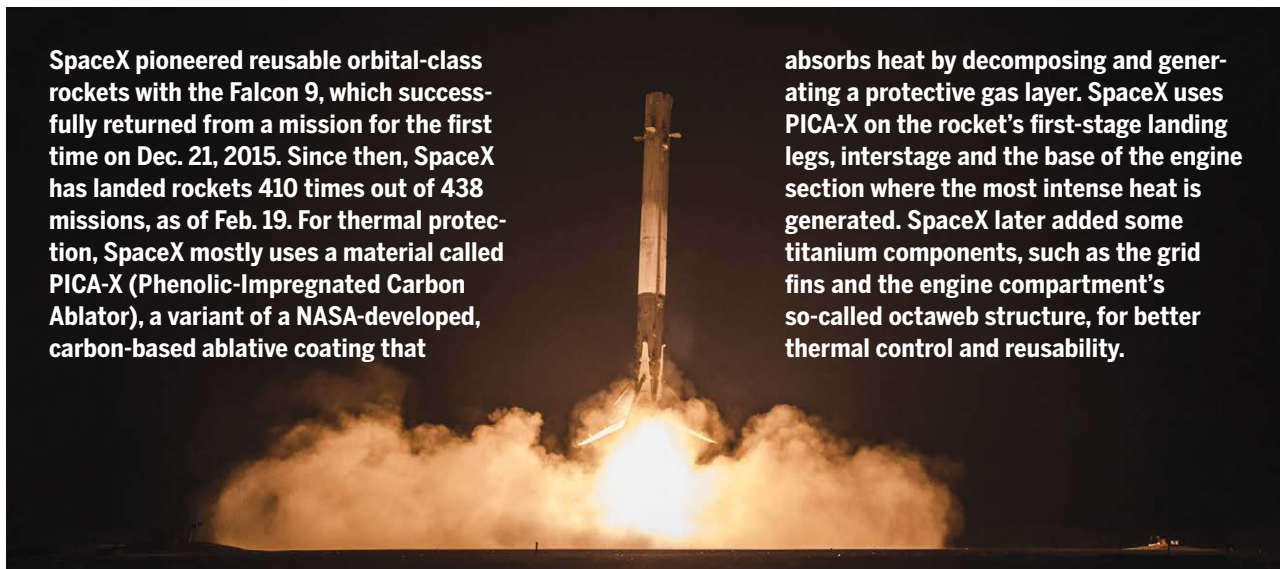
ESA

The U.S. is not alone in its efforts to develop reusable spacecraft. The European Space Agency (ESA), for example, launched its Intermediate Experimental Vehicle (IXV) on Feb. 11, 2015, for a 100-min. flight test. The experimental research vehicle made use of three types of insulation including high-temperature black panels made of ceramic matrix composites on the belly, nose and flaps. The IXV also had white cork and silicon insulation. The IXV research is being followed by ESA's Space Rider, an uncrewed reusable orbital

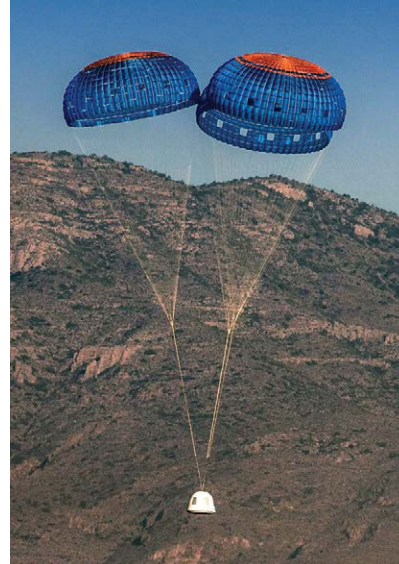
laboratory designed to ferry experiments between Earth and space multiple times. Europe also is using IXV research to help develop reusable launch systems.

SpaceX pioneered reusable orbital-class rockets with the Falcon 9, which successfully returned from a mission for the first time on Dec. 21, 2015. Since then, SpaceX has landed rockets 410 times out of 438 missions, as of Feb. 19. For thermal protection, SpaceX mostly uses a material called PICA-X (Phenolic-Impregnated Carbon Ablator), a variant of a NASA-developed, carbon-based ablative coating that

absorbs heat by decomposing and generating a protective gas layer. SpaceX uses PICA-X on the rocket's first-stage landing legs, interstage and the base of the engine section where the most intense heat is generated. SpaceX later added some titanium components, such as the grid fins and the engine compartment's so-called octaweb structure, for better thermal control and reusability.



SPACEX



BLUE ORIGIN/NASA

Billionsaire entrepreneur Jeff Bezos also opted to start his space venture, known as Blue Origin, with a reusable suborbital vehicle. Unlike the air-launched SpaceShipTwo, Blue Origin's New Shepard uses a liquid-powered rocket to lift off from the ground with an autonomously controlled capsule that can fly with or without passengers. New Shepard's first flight was on April 29, 2015. The company now has three capsules and two boosters in service and is preparing for its 30th mission. The capsule's thermal protection system consists mostly of ablative materials. Blue Origin is testing and designs, including ceramic-embedded fibrous insulation and flexible aerogel-reinforced insulation, to improve thermal protection.

MILITARY SPACE

➤ Aside from reusing the Falcon 9 first stages, SpaceX has extensive experience refurbishing and reflying its Dragon capsule fleet, which currently consists of three cargo and four crewed spacecraft. A fifth Crew Dragon is slated to debut this spring. The capsules' thermal protection system includes an ablative PICA-X heat shield, insulation and other systems. Unlike traditional ablative shields, the Dragon heat shield, which can withstand temperatures up to 3,620F, is reusable.



CHINESE INTERNET



➤ China's first reusable spacecraft, the Shenlong ("divine dragon") is believed to bear a strong resemblance to the U.S. X-37B spaceplane. Launched aboard Long March 2F rockets, China's vehicle made its first orbital flight in September 2020. That two-day test run was followed by a 276-day mission that launched Aug. 4, 2022. The Shenlong lifted off for a third time on Dec. 14, 2023, and landed 276 days later.

➤ Boeing's X-37B thermal protection system shares much in common with the system used on the Boeing-built CST-100 Starliner, a low-Earth-orbit crewed spacecraft designed and operated under a commercial services contract with NASA. The vehicle's different aerodynamic designs and temperature requirements drove some key changes, however. For example, the Starliner, which has made three flight tests, has an ablator in its base heat shield that can withstand higher temperatures than the X-37B's tiles.



NASA



SPACEX

SpaceX is working on a fully reusable, two-stage superheavy launch system capable of airplane-like turnaround times between flights. The Starship-Super Heavy underwent its first flight test on April 20, 2023. The Starship, which has yet to reach orbit, is covered with some 18,000 interlocking hexagonal tiles—made of silica and other proprietary materials—to protect the stainless steel vehicle during atmospheric reentry.



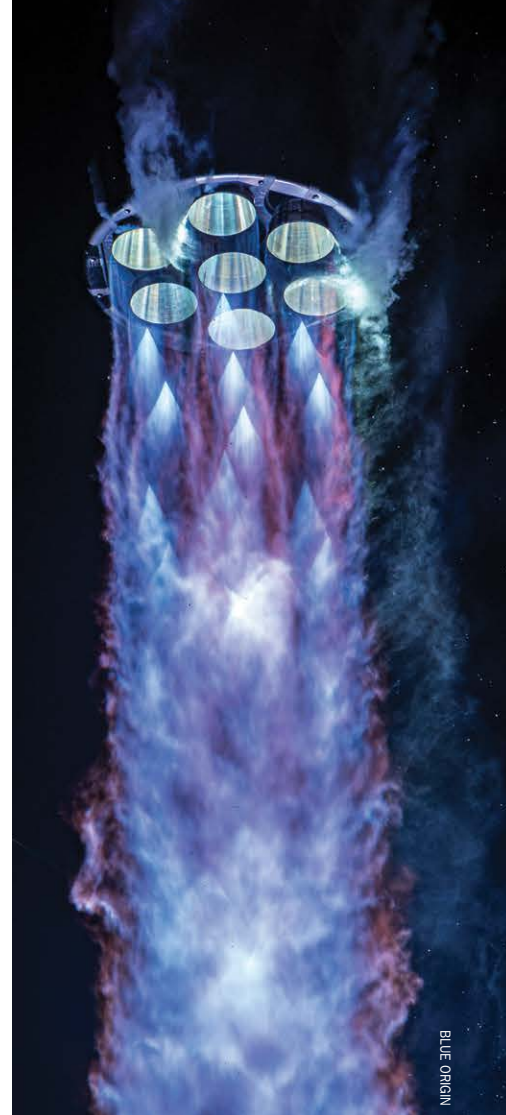
At the heart of NASA's Artemis lunar exploration program is the Orion spacecraft, a reusable capsule designed to fly a crew of four to and from Earth and low lunar orbit and to sustain them for up to 21 days in deep space. The Orion heat shield, designed to withstand reentry temperatures of around 5,000F, uses Avcoat—the same ablative material used for the 1969-72 Apollo Moon missions. Instead of individually filling 300,000 honeycomb cells with Avcoat, heat-curing the material and machining it to the proper shape, Avcoat for the Orion is produced in blocks that are premachined to fit into their positions and bonded in place on the heat shield's carbon-fiber skin. Fewer than 200 blocks are needed to protect the Orion's 16.5-ft.-dia. heat shield—the largest of its kind developed for crewed spacecraft.

The heat shield was tested during the Dec. 11, 2023, reentry of an uncrewed Orion capsule at the conclusion of the 25-day Artemis I flight test. A crewed flight test is expected next year.



Privately owned Sierra Space plans to debut a winged, lifting body reusable spacecraft during a cargo run to the International Space Station for NASA targeted for May. The Dream Chaser's thermal protection system uses a new type of tile made of silicon carbide and carbon fiber that was developed in partnership with the Oak Ridge National Laboratory. The materials are combined into a low-density, low-profile composite thermal barrier to provide insulation and to maintain the vehicle's smooth exterior surface for optimal flight dynamics and low maintenance between missions. 🚀

Building on expertise gleaned during the development and operation of its New Shepard suborbital system, Blue Origin's partly reusable, two-stage New Glenn rocket reached orbit for the first time on Jan. 16. The flight test included an attempt to land the New Glenn first stage, which was unsuccessful. The expendable upper stage reached its intended orbit. The rocket's thermal protection system includes a proprietary fabric-like material developed by Blue Origin called Comet that is applied to key areas, including the fins, forward module, strakes, tank tunnel and aft section of the rocket. The New Glenn is designed to be reusable with minimal refurbishment between flights.





Apollo 17 Cmdr. Gene Cernan was covered in lunar dust after his second moonwalk.

NASA PHOTOS

NASA Investigates the Promise and Peril of Moondust

- > FROZEN WATER MIXED INTO REGOLITH COULD SUSTAIN A SPACE-BASED ECONOMY
- > HEALTH HAZARDS OF POWDERY LUNAR SOIL ARE AN OPEN QUESTION

Garrett Reim Seattle

When Harrison Schmitt took off his helmet, he whiffed the same scent all other Apollo astronauts who walked on the Moon have smelled.

"All of the astronauts agreed it smelled like gunpowder," Schmitt, the Apollo 17 Lunar Module pilot, tells Aviation Week. "You know, we all had, at one time or another, been hunters."

What Schmitt and the other moonwalkers had smelled was lunar regolith: moondust. A gray, fluffy powder, regolith at the microscopic scale is jagged and clings to everything, sticking even to itself in ways not typical of its cousin on Earth.

Apollo 17 Cmdr. Gene Cernan saw lunar regolith as a major barrier. "I think dust is probably one of our great-

est inhibitors to a nominal operation on the Moon," he said in an Apollo 17 technical debrief. "I think we can overcome other physiological or physical or mechanical problems except dust."

As NASA plans to establish a permanent Moon base via its Artemis program, it is looking to avoid the dangers of lunar regolith, particularly its dusty form, health hazards, proneness to being kicked up by rocket motor thrust and damaging nearby equipment and fine grittiness that wears down tools, seals, joints and other equipment.

But the space agency and lunar wildcatters do not just want to mitigate lunar regolith—they want to exploit it. They see vast potential in the regolith as an ore that, once processed, could fuel and sustain a space-based

economy. To balance these opposing concerns, scientists are dreaming up a complex lunar infrastructure, including rocket blast berms, antiregolith spacesuits and laser power-beaming.

For his part, Schmitt, a trained geologist who has studied the composition of the Moon extensively, says the hazards of lunar regolith can be dealt with. "I think we're much more knowledgeable about its character, and as a consequence probably are in a good position to protect not only humans but machines from its adverse effects," he says.

Schmitt, also the last living member of the Apollo 17 crew, has talked for decades about mining lunar regolith for helium-3, a rare isotope with uses in emerging technologies such as quantum computing and nuclear fusion. In 2020, he co-founded Moon mining startup Interlune with Rob Meyerson, a former president of Blue Origin (AW&ST March 25-April 7, p. 46).

Others envision mining ice on the Moon, pulling hydrogen and oxygen from frozen water granules mixed into the sandy regolith. Lunar ice is not likely to be found in ice sheets, as billions of years of constant bombardment by micrometeoroids have churned the lunar soil, a process scientists call "lunar gardening."

If lunar colonists can find a way to excavate frozen H₂O molecules from moondust, melt them and crack them into hydrogen and oxygen, the elements could be used as rocket propellant, powering spacecraft ferrying people and space-manufactured goods to and from Earth and into deep space, including Mars. Oxygen and water also provide the basic elements for long-term human survival on the Moon.

Lockheed Martin in a white paper released last year notes that spacecraft mass mostly comes from propellants and that launch is the highest unavoidable cost for a space economy. "Eventually, performing that refueling using propellants already outside Earth's gravity well, produced from lunar water, avoids the Earth launch costs of delivering that propellant altogether," the prime manufacturer says in the paper, which envisions a lunar economy in the 2040s.

NASA has steadily been accumulating evidence of water on the Moon, but much of its prospecting is inferred from remote sensors. In 2020, the space agency revealed that data from

the Stratospheric Observatory for Infrared Astronomy—a Boeing 747SP aircraft modified to carry a 2.7-m (8.9-ft.) reflecting telescope—confirmed concentrations of water in the Clavius crater roughly equivalent to a 12-oz. water bottle per cubic meter of soil.

To get a close look at lunar water, NASA plans to launch Intuitive Machines' IM-2 lander to the lunar south pole as soon as this month. As part of the Commercial Lunar Payload Services (CLPS) program, the IM-2 lander is to carry the Polar Resources Ice Mining Experiment-1: a drill to extract regolith 3 ft. below the surface and a mass spectrometer to look for water.

"We don't have great data yet on the distribution of water ice on the Moon," Kate Watts, Lockheed Martin's vice president of mission strategy and advanced capabilities for human and scientific exploration, said at the American Institute of Aeronautics and Astronautics (AIAA) Ascend conference in July. "But what we do have suggests there is plenty—think over 1.3 trillion lb."

In October, NASA identified nine potential landing regions near the lunar south pole for its Artemis III mission, scheduled to be the first crewed landing on the Moon for the program in 2026. Sites were chosen partly because the locations were close enough to enable astronauts to walk to permanently shadowed regions, thought to contain significant amounts of ice, to gather regolith samples.

The lunar south pole features many permanently shadowed craters with steep walls and deep floors, such as the Shackleton crater, the interiors of which stay permanently dark. Sunlight never touches the floors of these depressions at the poles because the Moon's small axial tilt of 1.5 deg. means rays come in at very low angles.

Extracting water from shadowy craters could be tricky. The temperature in the cold, dark pits is thought to be about -370F, low enough to trap water molecules from icy comets and to be tough on electronics and batteries. Even charging lunar rovers with a power cable could be problematic.

"We don't want to be dragging hot cables around in the [permanently shadowed regions]," Rob Chambers, Lockheed Martin's director of strategy, human and scientific space exploration, said at the Ascend conference. "What we don't want to be doing is to

heat up the soil and outgassing a whole bunch of the same molecules that we're looking to get."

To avoid that problem, Lockheed Martin proposes a laser-based power-beaming concept to recharge lunar excavators in permanently shadowed regions. The company also sees nuclear fission power as critical to generating enough electricity to split water into hydrogen and oxygen in quantities sufficient to fuel crewed

ing lunar habitats, would necessitate sturdy roads to enable travel to remote mining sites, particularly to avoid heavy-duty lunar rovers kicking up moondust or being bogged down in lunar sand. Thankfully, the lunar surface is not all dust.

"The upper part of it was very fluffy and low-density. It's being continually stirred over geologic time by micrometeorite impacts," Schmitt says. "But below that it is highly compressed."



Harrison Schmitt's spacesuit became coated with dust as he collected lunar soil samples.

rockets to and from Mars—an important moneymaker in a future lunar economy, it says.

Lockheed Martin expects there to be many Moon mines by the 2040s digging up a couple of hundred metric



The upper layer of regolith is fluffy and light.

tons of water per year. Ice processing and electrolysis separation of hydrogen and oxygen would be done at a central location.

Centralized infrastructure, includ-

Because there is no atmospheric or water-based erosion on the Moon, all weathering on the surface is driven by meteorite impact and solar radiation, resulting in a mix of fine dust and coarser rock fragments. Larger rocks separated from the sandy regolith could be used as a sort of lunar macadam or gravel road, Schmitt proposes.

Thrust from the Apollo 17 Lunar Module's single engine as it descended blew a 360-deg. sheath of dust away from the landing site, Schmitt says, adding that the particles disappeared over the horizon at a high velocity. While the Apollo 17 crews' view on descent was not obstructed by a dust cloud, several other Apollo missions reported they could not see the surface as they touched down and that the debris interfered with landing radar.

The problem could become worse with the Artemis program's SpaceX Starship Human Landing System, which has six rocket motors, making its plume bigger and more complex. Interference between lunar missions, including avoiding plume surface interaction, is the No. 1 concern of Artemis Accord signatories, Pam Melroy, then-deputy NASA administrator,

told Aviation Week in June (*AW&ST* July 1-14, 2024, p. 13).

"We're starting to see some interesting science—some [of which] we knew actually from Apollo—that these particles stay suspended for longer periods of time than you might think," she said. CLPS lunar landers have been equipped with cameras to study plume surface interaction, Melroy added. Lunar landing sites would need to be hardened with landing pads and blast-protection berms to prevent moondust clouds from damaging nearby equipment or habitats.

Regolith can also sneak into mechanical pieces, such as bearings and seals, grinding up and jamming components. "Quick-disconnects for various tools that we had [on Apollo 17] gradually froze up because of the dust," Schmitt says. Using steel tools instead of aluminum ones ought to fix the problem, as the metal alloy is harder than moon-dust and would grind it up, he adds.

Dust easily finds its way into lunar crew cabins, too. Schmitt says he and fellow Apollo 17 astronauts tried to brush the regolith dust from their spacesuits prior to entering the lunar module but it was self-defeating, using up energy and embedding the dust deeper into the fabric. "The suit is your primary vector of dust into the cabin," he says. To keep the cabin clean, Schmitt says spacesuits should be negatively charged to reject regolith, which also has a negative charge.

A similar idea is to be tested soon. NASA launched Firefly Aerospace's Blue Ghost lunar lander to the Moon on Jan. 15 carrying two regolith test payloads, including an Electrodynamical Dust Shield demonstrator that might someday be able to repel lunar dust from spacesuits, helmet visors and boots as well as thermal radiators, solar panels and camera lenses. Blue Ghost is also carrying the Regolith Adherence Characterization payload, a sample of 15 materials—such as fabrics, optical systems, paint coatings, sensors and solar cells—to observe how lunar dust sticks to each surface.

"Dust is one of the biggest challenges from the Apollo era," Nicola Fox, associate administrator of NASA's Science Mission Directorate, told a Jan. 14 prelaunch briefing for the Blue Ghost. "It impacted the instruments onboard and the astronaut's health when it got stuck to their clothes, and they breathed it in when

within their spacecraft. Removing the dust will be revolutionary."

In fact, regolith is so sticky that it clings to itself in ways not typically seen with terrestrial sands, said

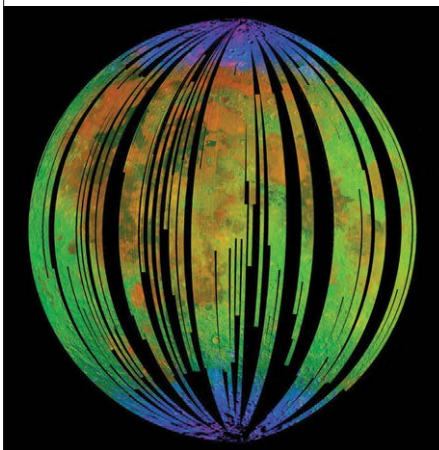
can get dust that sticks to itself with just one or two points of contact, rather than the typical three or more points of contact you have with something like gravel packing."

The effluence from SpaceX's Human Landing System could kick up a lot of moondust.



NASA IMAGES

Emma Quick, a modeling and simulations chemical engineer with Jacobs at NASA Johnson Space Center, who presented a paper at the AIAA Ascend conference. At the microscopic level, when observed with an electron microscope, regolith simulants create "fairy castles," she said.



The blue areas in this composite image created with data from NASA's Moon Mineralogy Mapper are where water ice is presumed to be present.

"Fairy castle structures are these complex, lacy, intricate structures that form when the particles are small enough and falling slowly enough that the intermolecular forces between the particles are stronger than the weight of those particles," Quick said. "When this happens, you

These Van der Waals intermolecular forces make it extremely difficult to brush off or clean surfaces of regolith, she said.

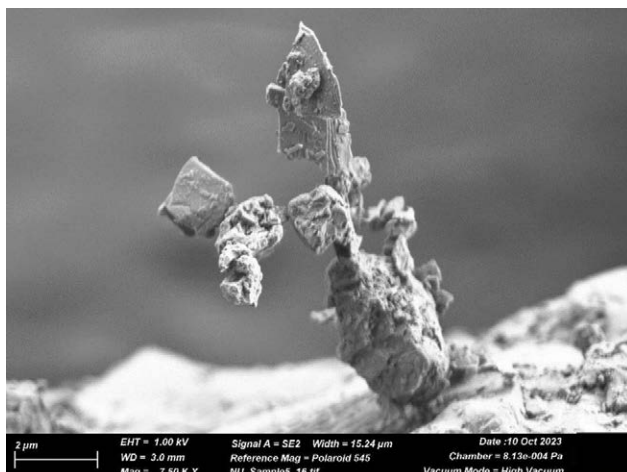
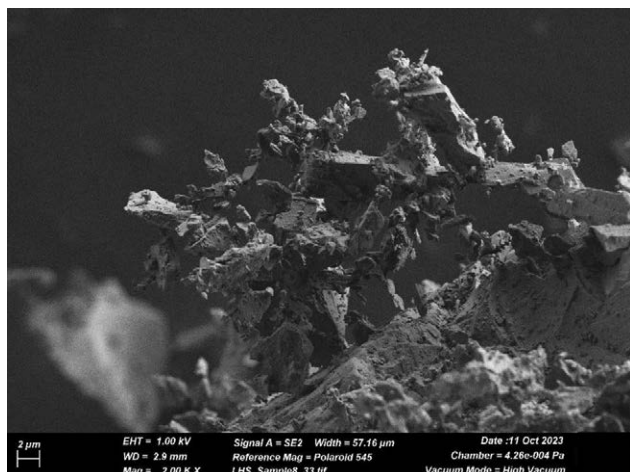
Regolith is also extremely small—particles are 60-80 micrometers on average. Individual lunar regolith dust particles are typically made of sharp fragments of minerals and glass.

"The smaller particle sizes are actually the bigger problem. The smaller the particle size, the easier it is to get it into your lungs," says Kim Prisk, pulmonary physiologist and professor emeritus of medicine at the University of California, San Diego. Prisk contributed to a European Space Agency research program on lunar dust.

Human lungs—even more so than skin—have the most exposure to atmospheric toxins, Prisk says, noting that the surface area of the lungs, if ironed out, would be about the size of a tennis court. "There's a huge surface area, and the smaller the particle, the more easy it is to be carried by airflow."

After returning from extravehicular activity on the Moon and removing their helmets inside the lunar module cabin, Schmitt and other astronauts experienced what he called "lunar hay fever," such as sinus and nostril irritation, that dissipated after several hours. A flight surgeon back on Earth who retrieved spacesuits from the return capsule had a more severe allergic reaction to the moondust that worsened each time he was exposed to it.

Studies of rats exposed to lunar



NASA, JOHNSON SPACE CENTER AND TEXAS A&M UNIVERSITY

Lunar regolith sticks to everything—including to itself in unusual ways, creating “fairy castles.”

regolith and simulants have shown that regolith is not as harmful as freshly fractured silica, a substance found in some engineered kitchen countertops, but it is worse than nuisance dust. The risk is somewhere in between, Prisk says.

Yet studies on the health hazards of regolith typically use simulants or samples returned from the Apollo

mission, that despite scientist’s best efforts, are not perfectly preserved. How deep into the lungs pristine moondust floating in the Moon’s one-sixth gravity might go and what its effect is on astronaut health after months of exposure are open questions, Prisk says.

“It’s not like it’s a showstopper, but it’s not something you’d ignore either,”

Prisk says, noting that the Apollo crews did fine with relatively short exposures. “If we’re talking about six-month stays on the lunar surface, where you’re doing an [extravehicular activity] multiple times a week, each one of those is going to be an exposure. How much effort and how much mission cost do you have to put into mitigating that exposure to dust?”

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Tomorrow's Trailblazers

Lindsay Bjerregaard and Mike McClary

The aerospace and defense industry is experiencing rapid change as next-generation flight technologies take to the skies and traverse the Solar System. In tandem, the next generation of industry leaders is performing innovative research to meet tomorrow's challenges.

Students pursuing aerospace and defense careers are researching technologies that will progress sustainable flight and the burgeoning advanced air mobility industry. They are also solving space exploration challenges, such as the frequency of rocket explosions and congestion from the growing number of objects in orbit.

The Aviation Week Network's annual 20 Twenties program recognizes young, rising stars within the industry. We collaborate with universities around the world to identify 20 exceptional undergraduate students or those in graduate degree programs who are working to solve challenges within aerospace and defense. A panel composed of hiring managers, engineers and academics evaluates and scores nominees based on academic performance, civic contribution, obstacles to success and the value of each

student's research or design project.

Now in its 11th year, the 20 Twenties program includes winners from 11 schools across the U.S. who hail from six countries as well as nominees from 16.

Beyond dreaming of the future, these innovators are focused on improving aerospace safety and learning from the industry's mistakes.

"As the industry continues to commercialize extreme environments like space and the deep sea, a shift in mindset is necessary to prevent future catastrophes," winner Liz M. Bosch Aponte says. "It's not just operator error that must be considered—modern vehicles are increasingly automated, and their robustness relies on thorough systems engineering processes."

Many of this year's winners are using their personal challenges as inspiration to drive opportunities for others who may follow in their footsteps.

Aviation Week Network recognizes 20 exceptional students leading change in the aerospace and defense industry.

From helping international students and underrepresented demographics pursue science, technology, engineering and math (STEM) opportunities to balancing the rigors of military service, this year's winners have dedicated significant time and effort to improving their communities.

"It is never too early or too late to adopt an engineering mindset, and a passion for fixing the world can simultaneously unlock countless economic opportunities, particularly within underprivileged communities whose voice is often ignored," winner Jeremy J. Kuznetsov says.

"I am a firm believer in the value of space exploration when it comes to improving life here on Earth, helping us to tackle global challenges in communication, climate, health and countless other areas," winner Kathryn Lampo adds.

This year's winners will be recognized during the 20 Twenties Awards Luncheon and Aviation Week Network's 67th Annual Laureates Awards on March 6 in Washington.

The 20 Twenties program is held in partnership with Accenture.

20 TWENTIES JUDGES

Amy Bahrani

Senior Manager, Defense and Intel, Accenture

Kevin Duda

Senior Program Manager, Distinguished Engineer—Space Systems, Draper Laboratory

Fernando L. Figueroa

Senior Manager, Aerospace and Defense, Accenture

Craig Gottlieb

Managing Director, Aerospace and Defense, Accenture

Col. (Ret.) Eric Jackson

Senior Program Manager, Lockheed Martin

Daniel Jensen

Global Chief of Capability—Control Systems, Rolls-Royce

Nimeesha Kuntawala

Flight Sciences—Product Development Team Lead, Gulfstream Aerospace

Joe Landon

Co-Founder, Rendezvous Robotics

Ho-Jun Lee

Lead Aerospace Engineer, NASA Johnson Space Center

Kathy Mulvaney

Manager, Systems Engineering, Northrop Grumman

Courtney Schultz

Manager, Aerospace and Defense, Accenture

Kristina Williams

Chief Operating Officer, Jetaire Group

DIMITRIOS66/GETTY IMAGES



Sinan M. Abdulhak

University of Michigan
Graduate Student, Industrial
and Operations Engineering
Class of 2025 • B.S.E.,
Industrial and Operations
Engineering • Class of 2024

Through his graduate research, Abdulhak is investigating how to use generative models for simulating disruptive aircraft events to prepare air traffic managers better. His team won the FAA TFM-AID Design Challenge to create a new user interface to unify mission-critical air traffic management applications and simplify training requirements for air traffic managers. Leidos chose him to spearhead the design of a \$500 million bid submitted to the FAA for an improved interface.

Abdulhak has worked at Leidos, Delta Air Lines and Textron Aviation. After a 7.8-magnitude earthquake struck Syria and Turkey in 2023, he used his flight planning experience and airline resources to organize a last-minute medical mission that flew U.S. physicians to Turkey to perform life-saving surgeries. He was selected that same year by GE Aerospace and the Chancellery of Poland for a presidential immersion trip to exchange cross-cultural aerospace ideas.



Kristen Ahner

University of Colorado, Boulder • Graduate Student, Aerospace Engineering Sciences • Class of 2028
Princeton University
B.S.E., Mechanical and Aerospace Engineering
Class of 2023

Ahner is working to address the complications of cislunar space and near-Earth orbits growing further congested with increasing satellites and human presence. Her research is focused on developing robust, autonomous guidance algorithms that will help spacecraft maneuver to avoid collisions, lowering the risk of mission failure. Ahner has completed co-ops and internships at Boeing, the Air Force Institute of Technology and Radiance Technologies.

As president of Princeton's Engineers Without Borders chapter, Ahner oversaw sustainable water projects in Ecuador, Kenya and Peru. She has volunteered with the Society of Women Engineers to develop STEM programming for high school girls. And as a member of CU Boulder's Aerospace Graduate Student Organization, Ahner is working to build up the local community and ensure all graduate students feel supported.



Lin Ai Atik

Georgia Institute of Technology • Graduate Student, Aerospace Engineering • Class of 2025
Institut Supérieur de l'Aéronautique et de l'Espace
Graduate Student, Aerospace Engineering • Class of 2025
Sorbonne University
B.S., Mechanical Engineering and Physics • Class of 2021

Atik is pursuing graduate studies simultaneously at Georgia Tech and Institut Supérieur de l'Aéronautique et de l'Espace (ISAE-Supaero) in Toulouse. At Georgia Tech, she leads a design space exploration project in partnership with Airbus using model-based systems engineering to assess industrial system robustness for potential future A320-family aircraft. She has won two Grand Challenges: one sponsored by Airbus, centered on improving disabled passengers' experience, and the other by Boeing and Rolls-Royce, on analyzing and mitigating supply chain disruptions.

As president of ISAE-Supaero's GALA Supernova, Atik organized events and seminars to connect students in STEM with industry professionals. She was also secretary general for the Supaero Junior Conseil, guiding teams to deliver projects to companies such as Airbus and Safran.



Abraham O. Atte

Georgia Institute of Technology • Graduate Student, Aerospace Engineering • Class of 2026
University of Kansas
B.S., Aerospace Engineering
Class of 2020

Atte's research on multirotor interactional aerodynamics aims to optimize rotor configuration design and control systems for electric vertical-takeoff-and-landing (eVTOL) aircraft. The research is funded by the Vertical Lift Research Center of Excellence, a collaboration between the U.S. Army, U.S. Navy and NASA. Atte has published and presented his research several times at the Vertical Flight Society Annual Forum.

Inspired by his challenges transitioning from Nigeria to academic life in the U.S., Atte joined the Georgia Tech International Ambassadors program to connect international students with resources. He is president of the Aerospace Engineering Student Ambassadors, where he leads a team promoting the program to prospective students, donors and visitors. Atte also volunteers through the Georgia Space Grant Program and the Tau Beta Pi honor society to provide STEM training to children and young professionals.



Srihari Balaji

Columbia University

M.S., Mechanical Engineering
Class of 2024

Union College

B.S., Mechanical Engineering
Class of 2023

Balaji's undergraduate research at NASA Marshall Space Flight Center focused on the challenge of frequent rocket explosions. He led a team that developed more than 100 3D models of titanium alloys, which ultimately increased titanium corrosion resistance by 92%, enhanced structural durability of titanium alloys used in rockets by 70% and quadrupled rocket safety ratings. His graduate research has developed new technologies for real-time feedback during nighttime lunar landings.

Balaji is passionate about providing educational opportunities to youth in India. In high school, he published a book about inequalities in India's education system, and his recommendations contributed to educational reform bills. As brand ambassador for the Next Genius Foundation, his work supported students in rural areas with college applications and contributed to securing full scholarships to U.S. universities for more than 500 Indian students.



Liz M. Bosch Aponte

Embry-Riddle Aeronautical University • Graduate

Student, Systems Engineering • Class of 2026 • B.S., Aerospace Engineering and Astronautics • Class of 2024

Bosch Aponte is an on-orbit maintenance and repair engineer at Axiom Space. As a spacecraft systems engineering intern at NASA, she used her experience to identify system safety gaps in her university's curriculum. Her research project developed a proposed curriculum module to address those gaps by integrating case studies of space-related accidents, incidents and close calls.

Bosch Aponte won a U.S. State Department scholarship to support her study abroad program in Germany. As part of Embry-Riddle's Turtle Tech project with Northrop Grumman and a local zoo that tracks sea turtle behavior using drones, she led a team that developed payloads for uncrewed aircraft systems. As a member of the Society of Women Engineers' Outreach Committee, Bosch Aponte developed STEM activities to inspire young women to pursue engineering careers.



Patrick E. Corrigan

Virginia Tech • Graduate

Student, Aerospace Engineering • Class of 2025
B.S., Aerospace Engineering
Class of 2024

Corrigan is a second lieutenant in the U.S. Air Force. Through the service's DAWN-ED (Developing the Airmen We Need/Education) fellowship, he is studying challenges around aerodynamic modeling and control for autonomous flight. During his internships at NASA Langley Research Center, Corrigan developed a reduced-scale eVTOL aircraft system to support the agency's RAVEN (Research Aircraft for eVTOL Enabling techNologies) program.

Corrigan was executive officer for a 250-member battalion in the Virginia Tech Corps of Cadets as well as regimental bugler, performing on campus and during community ceremonies. He is an ambassador for the university's Aerospace and Ocean Engineering Department and has volunteered at a youth drone camp organized by the Tuskegee Airmen. Corrigan plans to pursue a second graduate degree in flight-test engineering.



Anderson "Sonny" Grooms

Miami University • Graduate
Student, Electrical and Computer Engineering
Class of 2025 • B.S., Electrical Engineering
Class of 2023

Grooms won the Air Force Research Laboratory/Defense Associated Graduate Student Innovators student-faculty scholarship. He is researching optimal signal design for joint radar and communication systems to improve efficiency and reduce interference through simultaneous radar and communication signals. He also designed a novel randomized channel assignment method that increases data security.

Grooms was a hardware design engineering intern at GIRD Systems and a technical analyst/specialist intern at IS4S. As president of Miami University's chapter of the Institute of Electrical and Electronics Engineers, he increased membership and launched initiatives including providing free workshops for new engineering students on topics such as circuitry, coding and signal analysis. Through the chapter, Grooms also volunteers at Miami University's open house events to share STEM experiences with prospective students.



Yair N. Guerrero
University of Illinois Urbana-Champaign • Undergraduate Student, Aerospace Engineering • Class of 2025

As an undergraduate researcher in the Laboratory for Electric Aircraft Design and Sustainability, Guerrero is developing frameworks for assessing urban air mobility noise, including through a \$750,000 grant to study aviation noise impact in Los Angeles. During internships, he validated maintenance procedures for Boeing 777X aircraft, programmed test automation systems at Northrop Grumman and enhanced propulsion testing capabilities at NASA Glenn Research Center.

Guerrero is passionate about creating positive change in aerospace and empowering underrepresented minorities in STEM. As president of the Society of Hispanic Professional Engineers, he leads a 300-plus-member organization and has secured more than \$80,000 in funding to support Hispanic engineering students. After completing his undergraduate degree, he will pursue a Ph.D. in aerospace engineering to continue his work at the intersection of sustainable aviation, aeroacoustics and social equity.



William Kline
Massachusetts Institute of Technology • Graduate Student, Aeronautics and Astronautics • Class of 2025
Yale University • B.S., Applied Mathematics Class of 2023

Kline is using his applied mathematics background to tackle one of space's most pressing sustainability challenges: improving trajectory predictions for the growing number of objects in orbit. His research at MIT's Astrodynamics, Space Robotics and Controls Lab applies machine learning to improve predictions of satellite maneuvers and space weather perturbations, addressing the critical "custody problem" of tracking objects during out-of-sight trajectory changes. Kline's work aims to reduce false-positive collision warnings and enhance space safety for both commercial operators and military assets.

Kline is a space operations officer in the U.S. Space Force and vice president of MIT's Graduate Association of Aeronautics and Astronautics, where he manages a \$44,000 budget to create opportunities for more than 250 graduate students. As an intern at Munich-based Vyoma, he developed thermal models for satellites and researched international space policy.



Akshaj "Akku" Kumar
Texas A&M University
 Graduate Student, Aerospace Engineering Class of 2025
 B.S., Aerospace Engineering Class of 2024

Kumar has developed AI-based computer vision systems for autonomous landing of VTOL aircraft, addressing critical challenges in maritime operations and GPS-denied environments. He led a 20-member capstone team that won the grand prize at Texas A&M's College of Engineering showcase for developing and testing an uncrewed hybrid-electric VTOL vehicle. As president of the Texas A&M Vertical Flight Society, he secured thousands in funding and led his team to first place in an international design-build competition.

As CEO and founder of Arrow Analytics, working with Southwest Airlines, Kumar continues to push boundaries in aerospace innovation while creating opportunities for others. He leads entrepreneurship initiatives, such as student pitch competitions, and runs programming camps for middle school students. His efforts to bridge socioeconomic barriers in technology earned him PennLive's Best and Brightest honors in 2021.



Jeremy J. Kuznetsov
University of Maryland
 Undergraduate Student, Aerospace Engineering and Mathematics • Class of 2025

Kuznetsov's work developing AI-based disaster response systems using Boston Dynamics SPOT robots earned his team third place in the DARPA Triage Challenge. His contributions to the NASA Jet Propulsion Laboratory Venus Aerobot project advanced the technology readiness level of planetary balloon systems, and he led UMD's Balloon Payload Program, designing an ascent-rate control system for high altitudes that eight university teams adopted for NASA's Nationwide Eclipse Ballooning Project. His research has already yielded peer-reviewed publications and presentations at major aerospace conferences.

Kuznetsov is committed to expanding STEM access for underserved communities. Drawing on his experience as a Russian-Jewish immigrant, his outreach serves diverse populations with multiple languages and abilities. He launched UMD's first student-initiated aerospace manufacturing course, an adult workforce coding program and partnerships with libraries to provide free hands-on workshops.



Kathryn Lampo

Columbia University
Undergraduate Student,
Mechanical Engineering
Class of 2025

Through her work in Columbia's Robotic Manipulation and Mobility Lab, Lampo is driving innovation in space robotics and satellite systems. Her work at Carnegie Mellon University developing inverted GPS tracking technology for wildlife monitoring earned publication in IEEE Aerospace. During internships at NASA Ames Research Center and Lockheed Martin Space, she optimized rotor designs for the Dragonfly mission to Saturn's moon Titan and tested satellite uplink configuration code.

Lampo served as co-president of the Columbia Space Initiative, which she helped transform into the university's largest engineering organization, growing membership to more than 300 students across 13 technical projects. Her model rocketry program has enabled hundreds of Title I school students to design and launch their own rockets. She is helping to establish Columbia's first aerospace engineering program, conducting research and developing a curriculum that will shape future generations of space engineers.

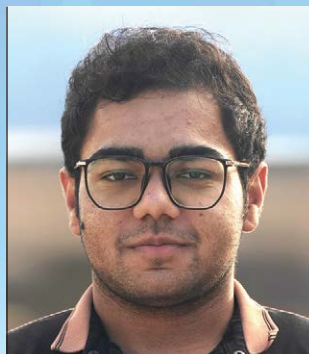


Abigail Lee

Massachusetts Institute of Technology
Graduate Student, Aerospace Engineering • Class of 2026
Queen's University • B.A.S., Mechanical Engineering Class of 2024

At MIT's STAR Lab, Lee is accelerating advances in satellite optical systems and laser communications. Her work on radiation-hardened star trackers at Sinclair Interplanetary earned first place in the SmallSat Student Competition, where she competed as an undergraduate against graduate students. Lee is now developing next-generation optical terminals for NASA's CubeSat Laser Infrared Crosslink mission to enable high-speed laser communications between cubesats.

As president of Queen's University's Rocket Engineering Team, Lee led the team to victory at the Spaceport America Cup and secured it a \$2 million sponsorship commitment. Driven by her own journey from aspiring pilot to aerospace engineer, Lee is dedicated to creating pathways for underrepresented groups in the field. As a Zenith Canada Pathways Foundation Mentorship Team volunteer, she has expanded her outreach activities to university students.



Henil Patel

Embry-Riddle Aeronautical University
Undergraduate Student,
Aerospace Engineering
Class of 2025

Working at the intersection of innovation and safety, Patel is developing aircraft battery technology at Embry Riddle's Boeing Center for Aerospace and Aviation Safety. His research designing lightweight, additively manufactured battery cases with integrated cooling channels aims to prevent thermal runaway incidents like those that grounded the Boeing 787 fleet.

As a two-time NASA RASC-AL Design Competition finalist, Patel has led teams in developing space technologies from resource utilization on Mars to service stations in cislunar space. Driven by his own journey navigating aerospace industry challenges, Patel dedicates himself to creating pathways to success for others. Through his work with Embry-Riddle's Career Services and as a physics teaching assistant, he mentors international students and educates recruiters on the formal process of hiring international students.



Vikas Patel

Embry-Riddle Aeronautical University • B.S., Aerospace Engineering • Class of 2024

At Embry-Riddle's Space Technologies Laboratory, Patel led power systems development for Llamas (Literally Looking At More Astronauts in Space), the first student-built payload to fly inside SpaceX's Dragon capsule during a crewed mission. His battery validation approach for human spaceflight, which won the American Institute of Aeronautics and Astronautics' 2024 Best Student Paper in Power Systems award, is helping to make space hardware development more accessible to university teams. His work with NASA on image-based navigation for Artemis missions builds on his experience developing space-rated camera systems as he continues pushing boundaries in human space-flight technology.

Inspired by astronaut Nicole Stott's fusion of art and science, Patel founded The Drive to Fly, an aerospace-themed art competition that awarded scholarships to local high school students. Through this initiative and his role teaching STEM workshops, he strives to make aerospace accessible to all. Patel is also a two-time Astronaut Scholar.



Manmeet Pelia

Georgia Institute of Technology • M.S., Aerospace Engineering • Class of 2024
U.S. Air Force Academy
B.S., Electrical and Computer Engineering • Class of 2023

Pelia is bridging the gap between technical systems and humanitarian needs, creating methodologies that transform how organizations from the U.S. Office of Naval Research to NATO approach complex operational challenges. At Georgia Tech's Aerospace Systems Design Laboratory, she developed interactive tabletop exercises to help military leaders evaluate disaster relief operations. Her work with the Carter Center mapped unexploded ordnance in conflict zones.

Pelia is an inaugural Quad Fellow and the first female cadet graduate chosen as a Brooke Owens Fellow. A proud Sikh-American and advocate for inclusion, she has volunteered for initiatives supporting veterans, women in military aviation and STEM education. As a NASA Solar System Ambassador and Science ATL volunteer, Pelia brings space science to K-12 classrooms, while her work with the Women's Initiative Team aims to reshape sexual assault prevention policies across the military.



Monica Shanmugam

Virginia Tech • M.S., Aerospace Engineering
Class of 2024 • Shanmugha Arts, Science, Technology and Research Academy
B.Tech, Aerospace Engineering • Class of 2022

Leading research on NASA's Benchmark Validation Experiments for RANS/LES Investigations project, Shanmugam spearheaded experimental methods to validate computational models for complex aircraft aerodynamics. Her novel application of laser Doppler velocimetry for near-surface flow measurements established new benchmarks in predicting high-lift device performance, advancing aircraft safety and efficiency. Her current research is developing digital twins for aircraft engine health monitoring.

As head of media for Women of Aeronautics and Astronautics India, she amplified diverse voices in aerospace, fostered inclusivity through hands-on outreach and helped organize the Indian Women in Space Conference. She also volunteered with Virginia Tech's Center for the Enhancement of Engineering Diversity and on the Aerospace and Ocean Engineering department's DEI Committee.



Trevor Simoneau

Embry-Riddle Aeronautical University • Graduate Student, Aviation/Aerospace Safety Systems • Class of 2025 • B.S., Aeronautics
Class of 2023

Simoneau leads research at Embry-Riddle's Boeing Center for Aviation and Aerospace Safety, analyzing FAA enforcement actions against drone operators and helping to shape national policy for uncrewed aircraft system integration. His study examining regulatory compliance challenges has been downloaded more than 2,000 times and is informing how the aviation industry approaches drone safety oversight.

Having founded the Chart It All business at age 11 to fund his education, Simoneau is giving back to the community. During the COVID-19 pandemic, he led an initiative donating more than \$45,000 in face masks to first responders and essential workers. As adjutant for the Commemorative Air Force Florida Wing, he supports education programs for middle and high school students. Simoneau also teaches free aviation communications and flight planning sessions to students through his Experimental Aircraft Association Chapter's Introduction to Aviation series.



Elijah Simpson

University of Michigan
Undergraduate Student,
Aerospace Engineering
Class of 2025

During his undergraduate studies, Simpson has launched a cubesat payload on Blue Origin's New Shepard Payload Support System and spearheaded diversity initiatives in aerospace. His expertise spans avionics design, systems integration and launch vehicle operations, demonstrated through multiple Blue Origin internships, including work on New Glenn stage integration. He was also a technical engineering intern at Northrop Grumman.

As president of Black Students in Aerospace, Simpson transformed the organization's reach and impact, establishing the annual Social Justice in Aerospace event and developing hands-on engineering programs for underrepresented students. He serves on the Michigan Aerospace Department Community Success and Outreach Committee, and his efforts to create equitable opportunities earned him the 2024 North Campus Deans' MLK Spirit Award. Through the Patti Grace Smith Fellowship and extensive mentorship work, he builds sustainable pathways for diverse talent in aerospace. ✪

TECH TAKE

By **Graham Warwick**

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Autonomous Ag Aircraft Unveiled

Uncrewed aircraft developer Pyka has unveiled the Pelican 2, its next-generation autonomous aerial application aircraft. First flown in mid-2024, and with increased power, payload and spray area, the upgraded aircraft has replaced the original Pelican Spray in production.

Pyka



The Pelican 2 has increased payload capacity and swath width for aerial spraying.

The U.S. startup also has announced a 20-aircraft order from Latin American aviation company Synerjet to enable large-scale autonomous aerial application operations in Brazil.

The Pelican 2 has four-motor electric propulsion, up from three on the Pelican Spray, an increased 300-liter (79-gal.) payload capacity and an 18-m (59-ft.) swath width enabling a coverage rate up to 90 hectares (222 acres) per hour, Pyka says. The aircraft has radar and lidar sensors for autonomous day and night spraying and five hot-swappable battery packs to allow continuous operation.

The Alameda, California-based startup says it has secured FAA authorization for commercial operation of Pelican 2 in the U.S. "Pelican 2 is the largest [uncrewed aircraft] ever approved for commercial use by the FAA, followed only by the original Pelican," Pyka says.

The Pelican 2 replaced the original Pelican Spray in production with Serial No. 12, the company says. The startup also produces a Pelican Cargo version for uncrewed logistics and says it will soon announce developments for its cargo product line.

Pyka launched commercial Pelican operations in 2023 with Dole for banana

crop protection in Honduras. The company signed an agreement with Brazilian agricultural producer SLC Agricola in July to deliver aircraft for large-scale agricultural use. Pyka says it also has delivered aircraft to U.S. aerial application provider Heinen Brothers Agra Services.

Long-Range Hydrogen Aircraft Takes Shape

A year after launch of the project, Climate Impulse is reporting progress toward its goal of flying around the world nonstop on hydrogen-electric power in 2028.

The cockpit shell has been built, and engineering for the interior is complete, Climate Impulse reported on Feb. 13. Manufacture of the carbon-fiber spar for the 34-m-span (111-ft.) wing is underway ahead of planned mechanical strength and rupture testing.

The two-seat cockpit will be mounted atop the wing between twin fuselages, each housing an 11-m³ (390-ft.³) cryogenic liquid-hydrogen tank and high-temperature fuel cells powering a 200-kW electric engine. Final assembly and first flight are planned for 2026 at Chateauroux-Centre Airport in central France.

The round-the-world flight is expected to take nine days, cruising at around 180 kph (110 mph) and 10,000-ft. altitude, flown by Bertrand Piccard, a pilot for the Solar Impulse solar-electric round-the-world flights in 2015-16, and Climate Impulse designer Raphael Dinelli.



Co-pilot Bertrand Piccard with the completed cockpit shell for the Climate Impulse.

Bench testing of the hydrogen fuel cells and electric propulsion system is planned for this year. Testing will begin with the propeller, motor and battery for the initial all-electric flights before moving on to integrate and test the fuel cells and cryogenic tanks for hydrogen-electric flights.

Climate Impulse is developing the aircraft with main technology partner Syensqo, which is supplying the carbon-

fiber structural materials, adhesives, anti-ice and insect nonstick surface coatings, low-boil-off cryogenic tanks and membrane materials for the high-power-density fuel cells.

Syensqo is supplying lightweight composite materials and adhesives, a 600-kg (1,320-lb.) weight saving increasing range by 2,500 km (1,500 mi.), CEO Ilham Kadri says. The company, spun off from Solar Impulse partner Solvay, also has developed unimer materials that improve fuel efficiency and heat rejection as well as reduce the weight of the fuel cell system. A 5% increase in efficiency increases range 3,500 km, she says.

Climate Impulse's other partners include Moroccan fertilizer giant OCP Group, which is investing in renewable energy and plans to have green hydrogen production online by 2027 to support Climate Impulse flights. Morocco's Mohammed VI Polytechnic University is developing the autopilot and battery management systems. Technical advisors include Airbus, ArianeGroup (on liquid hydrogen), Safran (electric propulsion), Duc Helices (propellers), EKPO and GreenGT (fuel cells), AD Venta (fuel system), H2Pulse (hydrogen infrastructure) and SDMS.

Drone Launches Hybrid Powertrain

French startup Ascendance has collaborated with uncrewed aircraft manufacturer Delair to build a hybrid-electric drone demonstrator with funding from French defense procurement agency DGA.

Delair's DT46 long-range vertical-takeoff-and-landing (VTOL) drone has been equipped with a version of Ascendance's Sterna hybrid-electric propulsion system. Flight tests have been conducted in Toulouse.

Built around a small piston engine, Sterna for UAV is a smaller version of the turbine-based hybrid propulsion system under development to power Ascendance's planned Atea fan-in wing electric vertical-takeoff-and-landing aircraft, a full-scale prototype of which is planned to fly this year.

"The DT46 Hybrid demonstrates Sterna's ability to adapt to different sizes of aircraft—today on a drone and tomorrow on larger and larger aircraft—to optimize the technical performance as well as the carbon footprint,"

Ascendence Chief Commercial Officer Thibault Baldivia says.

The DT46 Hybrid has been developed to monitor tests conducted by DGA Missile Testing, which operates three ranges in the south of France. Intended for both military and civil long-range missions, the UAV also is planned to be used for large-scale maritime surveillance.

Hybrid propulsion increases the drone's flight endurance to more than 5.5 hr. in VTOL mode, with the option to recharge the battery in flight to enhance long-endurance performance further, the company says. The drone also has the ability to switch several times between hover and wingborne flight and between thermal propulsion for fast transit and quiet electric propulsion for unobtrusive observation.

DELAIR



Delair's DT46 is a long-range fixed-wing uncrewed aircraft with optional vertical-takeoff-and-landing capability.

Led by the Alienor innovation hub, development of the hybrid drone was initiated by DGA Missile Testing and funded by France's Defense Innovation Agency. The first qualifying flights are planned to take place in the spring in Biscarrosse, France, near Bordeaux.

Supernal's eVTOL Demo Breaks Cover

At first unidentified, a full-scale electric vertical-takeoff-and-landing aircraft has been photographed undergoing ground testing at Mojave Air & Space Port in California.

Captured by photographer Matt Hartman and seen anchored to the ground outside the former Rotary Rocket site near the end of the Mojave flight line, the aircraft has tilting propellers at the wingtips and four fixed lift propellers on booms that connect the wing to a high-set "Bronco tail"—named after the distinctive tail of the North American Rockwell OV-10 Bronco.

The aircraft was later identified as Hyundai subsidiary Supernal's full-scale



Supernal's full-scale technology demonstrator has been photographed at Mojave Air & Space Port.

technology demonstrator, as first reported by The Air Current.

Looking fairly large for an electric vertical-takeoff-and-landing (eVTOL) air taxi and clearly intended to be piloted, the aircraft has wide-set main gear. Portable electric fans are connected by ducts to the wingtip nacelles and wing booms, presumably to provide forced-air ventilation to the propulsion units.

Full-scale eVTOL prototypes known to be under development but yet to be seen include the Textron eAviation Nexus and Supernal S-A2. The aircraft resembles Nexus concept images, but with distinctive differences, and Textron eAviation confirmed the aircraft is not the Nexus. Resemblance to the S-A2 mockup Supernal unveiled in January 2024 is minimal, but the aircraft's identity was confirmed by a source with knowledge of the program.

This is not the first mystery eVTOL to be spotted at Mojave. A still-unidentified lift-plus-cruise aircraft was photographed flying at the airport in 2019. This had six lift props on booms joining the tips of tandem wings and on the V tail, plus an aft-fuselage pusher propeller. A fuel-cell-powered cargo eVTOL developed by Toyota was photographed flying at Mojave in 2020.

Operator Selects Natilus Cargo BWB

Canadian charter airline Nolinor Aviation has purchased multiple production slots for the Natilus Kona blended wing body regional freighter. Mirabel, Quebec-based Nolinor plans to use the aircraft to expand services to remote locations in Canada's Northwest Territories and Nunavut provinces.

Natilus says Nolinor has paid deposits securing an undisclosed number of slots in the initial production batch of Konas. The U.S. startup had previously

announced about 460 preorders from customers including U.S. cargo operator Ameriflight.

Nolinor operates the world's largest fleet of Boeing 737-200s as freighters, petroleum tankers, passenger aircraft and cargo-passenger combis. The airline also operates 737-300s, -400s and -800s. The aircraft are equipped to land on dirt, gravel or ice runways.

With mining activity across northern Canada growing to supply elements required for electrification, such as lithium and copper, Nolinor is experiencing increased demand to transport workers, equipment and supplies to areas with limited road infrastructure, Natilus says.

No delivery date has been given, but Natilus plans to begin production before the end of the decade. The startup says the Kona increases payload capacity 40% and reduces operating costs 50% compared with tube-and-wing aircraft of a similar size.

San Diego-based Natilus is building a full-scale prototype of the Kona, which is expected to fly in 2027. Powered by a pair of Pratt & Whitney Canada PT6A turboprops, the blended wing body (BWB) freighter is designed to fly 900 nm with 3.8 metric tons of payload in standard-size containers.



NATILUS

Nolinor plans to use the Kona blended wing body freighter to serve remote locations in northern Canada.

When it was founded in 2016, Natilus planned to build a family of increasingly large autonomous cargo BWBs, beginning with the regional Kona. But in November the startup announced plans to follow the Kona with a 200-seat BWB airliner, the Horizon, aimed at replacing the 737 and Airbus A320 in the early 2030s.

The Kona prototype will be piloted as will the initial production aircraft, including those for Nolinor. "The initial Kona aircraft will feature a traditional cockpit with human pilots, distinguishing these models from future autonomous configurations," Natilus co-founder and CEO Aleksey Matyushev says. ☪



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Airbus' Hydrogen Smoke and Mirrors

By William Todts

Two years ago, I denounced the fool's game Airbus was playing around its hydrogen airplane, accusing the company of building hydrogen hype, not airplanes. Everything makes sense now. Has Airbus invested the €15 billion (\$15.6 billion) we estimate would be required to develop a short-/medium-haul hydrogen aircraft? No. Will it support European regulation to ensure the development of the hydrogen market? No. Will it push Boeing to join the race for hydrogen aviation? Certainly not.

Airbus' quiet admission late on Feb. 7—a Friday evening—that it is delaying its hydrogen dream stands in stark contrast to the gushing press releases of previous years. After lulling us with stories of aviation at the cutting edge of innovation—brave like the Wright brothers, visionary like French aviator Jean Mermoz—the industry is now facing reality. In the end, Airbus is just another company guided by maximizing profits, whether that comes at the expense of the climate or not.

Did anyone really believe that without binding regulation a company like Airbus, which enjoys a near monopoly, would invest €15 billion in a risky endeavor that would be less profitable than its cash cow, the A320? Airbus is now hiding behind the excuse of the slow start of the hydrogen ecosystem to justify delaying its program, even though the first aircraft were supposed to be commercialized in 10 years. A signal from a major player could have the power to drive the rest of the aviation industry in the right direction on the path to sustainability—not the other way around.

Did French and European decision-makers believe in this fairy tale? I will leave it to French taxpayers to judge whether the €1.5 billion in public money handed to the sector under the guise of a “green plane” and a “decarbonized future for aviation” were well spent. What I see is a hydrogen airplane program that was used to distract political leaders. The sad reality is that now we will end up with more fossil-fuel-burning aircraft in the sky than ever before. We are no closer to a breakthrough: not on hydrogen, not on electric, not on hybrid

aircraft or new designs. It was all smoke and mirrors.

The news of the program's demise should serve as a wake-up call for French and European policymakers. As we have demonstrated, the sector's growth prospects are irreconcilable with climate goals. Abandoning the hydrogen aircraft only worsens the prospects of the sector reaching net-zero carbon emissions.

The first lesson is that the industry's promises are not worth the paper on which they are written. Only regulation can achieve environmental goals. This has been true for electric cars, clean energy and chemical pollution. Why would aircraft be an exception?

The second lesson is that no empire lasts forever. Just think of Europe's once proud automobile industry. Airbus reminds me of Volkswagen pre-Dieselsgate. It looks unassailable—but is it? It is only a matter of time before China joins the clean aviation race in earnest. Can the European aircraft manufacturing industry really afford to rest on its laurels?

The third lesson is that if we want change, governments need to act. Alongside regulation, there should be more targeted funding to deploy zero-emission aircraft,

looking at the most promising technology. Even if their contribution to reducing emissions may be limited, we should promote zero-emission aircraft, exempting them from airport charges, giving them free slots and prioritizing and ultimately requiring them on publicly funded routes (such as to islands). We should reward electric flying, not just biofuel, in the EU's Clean Aviation regulations, and we should accelerate the certification of new technologies and designs.

The time for grand promises is over; we need to face reality. Will the Paris Air Show in June be a grand celebration for green aviation or yet another farcical spectacle? I leave it up to governments to decide. ☸

William Todts is executive director at Transport & Environment, a Brussels-based organization that advocates for clean transport and energy.



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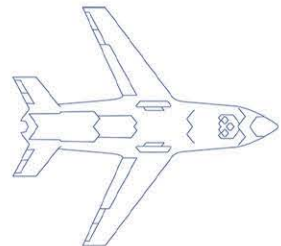
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