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& SPACE TECHNOLOGY

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With the first powered flight of its Talon test vehicle under its belt, aircraft developer Stratolaunch looks to demonstrate hypersonic flight by the end of 2025.

DOMENIC SAENZ MOEN/STRATOLAUNCH



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ON THE COVER

SpaceX's Starship-Super Heavy system took a step toward operational missions following a third integrated flight test on March 14. A camera mounted on the Starship's exterior imaged the fiery glow of a plasma bow wave in front of the reentering spacecraft and relayed the imagery in real time via a Starlink terminal on the vehicle. Senior Space Editor Irene Klotz's report begins on page 48. SpaceX photo.

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HOT FUEL

“Collins Unveils Proposed F-35 Cooling System Fix” (*Feb. 12-25, p. 26*) reminded me of quixotic turn-of-the-century grassroots efforts to suggest a different way of managing internal heat loads for the then-Joint Strike Fighter: Burn as much of the heat as possible through



THOMAS BARLEY/U.S. AIR FORCE

the engine combustors and design the aircraft cooling and fuel systems to deliver the hottest fuel possible (within engine limits) to the combustors for elimination of excess heat from the aircraft—forever—instead of dumping it into the fuel tanks’ “heat sink.”

Conservative back-of-the-envelope analysis of limited Boeing F/A-18 Super Hornet flight-test data showed potential savings of roughly 25kW per engine which, according to the article, ain’t chump change. One bystander even wondered about potential thrust benefits from burning hotter fuel, but that seems to be in the noise.

Jim Sandberg, former director, Joint Strike Fighter Integrated Test Force at NAS Patuxent River Chaptico, Maryland

BRING SAFETY BACK

The Up Front column “Crisis of Confidence” (*Feb. 12-25, p. 11*) by Anthony L. Velocci, Jr., on Boeing Co. mismanagement is a sad commentary on corporate America in general, too.

In the old days, the aviation industry was run by people who had a genuine love of aviation. Think of C. R. Smith of American Airlines, C. E. Woolman of Delta Air Lines, Charles C. Tillinghast of Trans World Airlines and William Patterson of United Airlines. They were the pioneers of today’s commercial aviation, and money was not the predominant factor in their decision-making. The same went for the Boeing Airplane Co., founded by Bill Boeing. Quality was everything, and everything about the aircraft was built by

Boeing, with the exception of the powerplants and avionics.

Unfortunately, today’s aviation industry is run by bean counters who laughingly call themselves CEOs and command millions of dollars in salary for their compensation. They are all about the bottom line and how much money they can make for themselves and the shareholders. We live in the greediest nation in the world, where the dollar is worshipped like a god. As a result, we subcontract out as much as we can to save a buck, safety be damned.

The Boeing 737 MAX program is a shining example of improper airframe manufacturing. I do blame Boeing in part for subcontracting out so much to Spirit AeroSystems, but that is the decision of the bean counters who run Boeing today.

Boeing will continue to decline to a point that portions of it may be sold off. The FAA is doing a good job in restricting the number of 737 MAX jets being produced due to new and much-needed inspection processes on the manufacturing lines. Hopefully, this will convince the bean counters to think more like aviation people and bring safety back to the Boeing factories.

Jean Publicover, Tucson, Arizona

OUT OF DATE

Reading “Schiphol Sets Out 2024 Capacity Amid Wider Environmental Scrutiny” (*Jan. 29-Feb. 11, p. 24*), the photo used to illustrate the article caught my eye—it was long overdue for retirement to join all the aircraft pictured in it.

At least it was nice to see a photo of a passenger-carrying McDonnell Douglas MD-11 for the first time in years. KLM retired the last of their 10 MD-11s almost a decade ago, in October 2014. That particular aircraft, PH-KCK, their last MD-11, delivered in 1997, was sent to the desert for scrapping then.

And regarding the three Boeing 747-400s in the background, KLM retired all of their passenger 747s at the start of the COVID-19 pandemic in 2020 (three freighters remain in service). Those aircraft also feature the old KLM

livery introduced in the mid-1970s, replaced in 2002 and updated slightly to the current version in 2014.

Ken Pickford, Nyon, Switzerland

Editor’s note: The reader is correct.

DESIGN PROBLEM

Regarding “Installation Investigation” (*Feb. 12-25, p. 18*) about the Jan. 5 Alaska Airlines Flight 1282 Boeing 737-9 midair door plug blowout, it seems that the root problem is that the door plug was designed to open out. If it were designed to open inward, the pressure would hold the door plug closed, regardless of bolts. The failure mode would have been eliminated.

I believe submarine hatches are designed so pressure, not bolts, holds them closed. It is a failure of engineering to design a system in which, if every one does everything just right, it is safe, as opposed to a system that doesn’t have that failure mode.

Terry Klein, Averill Park, New York

ARMY VERSUS AIR FORCE

Intentional or not, your editors succinctly illustrated in “FARA Out” (*Feb. 26-March 10, p. 14*) a stark contrast between the U.S. Army and U.S. Air Force acquisition teams’ abilities. The Army’s multidecade floundering in the rotary-wing arena when compared to the Air Force’s moving out smartly in a number of innovations is remarkable.

It reminds me of the squabbles in the 1930s between the Army Air Corps “Bomber Mafia” and the horse-mounted cavalry. It would be humorous if it weren’t impacting national capabilities and spending billions of the taxpayers’ money.

Art Wagner, Okatie, South Carolina

CORRECTION

“How Engineers Developed a GPS-Denied Drone for Less Than \$500” (*March 11-24, p. 44*) should have stated that Carl Schoeller is a mechanical engineering undergraduate at Stanford University.

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.

Eric Trappier has been appointed president and CEO at *Dassault Group* to succeed Charles Edelstenne in January 2025. Trappier currently serves as chairman and CEO of Dassault Aviation.



Bill Brown, the former executive chair and CEO of L3Harris Technologies, has been named CEO of *3M*. He succeeds **Michael Roman**, who held the role for more than 35 years, becomes executive chairman of the board. Both changes are effective May 1.

Oneworld has brought on **Nathaniel Pieper** as CEO, replacing Rob Gurney, who stepped down last year. Pieper joins from Alaska Airlines, where he was senior vice president of fleet, finance and alliances as well as treasurer. He previously worked at Delta Air Lines and Northwest Airlines.



Dwight Deneal has been appointed assistant administrator for NASA's Office of Small Business Programs, succeeding Glenn Delgado, who retired in December. Deneal was director of the Defense Logistics Agency's Office of Small Business Programs.

Marty St. George has become president of *JetBlue*. He was chief commercial officer at LATAM Airlines Group and worked at JetBlue for 13 years, including as executive vice president and chief commercial officer in 2015-19.



Peter Gerber has been appointed CEO of *Condor Airlines*, and **Heiko Holm** fills out the executive team as chief technology officer. Gerber joins from Brussels Airlines, where he held the same position; he also worked at Lufthansa Group and Lufthansa Cargo. Holm was central operations officer at Wizz Air after working at Lufthansa Technik.



Aura Aero has brought on **Drew McEwen** as chief commercial officer. He was vice president for international

direct sales at Piper Aircraft, where he worked for more than 13 years. Before that, he spent 27 years at Beechcraft.

Altamira Technologies CEO **Jane Chappell** has joined *Spirit AeroSystems'* board of directors, including the corporate governance and nominating committee and risk committee.



Blade Europe has named **Remi Bouysset** as CEO. He held the same position at Monacair Group, Blade's helicopter operating partner in France and Monaco. **Benoit Cocheteux** also joins as chief operating officer from AviaThor, which he founded.

Roberto Feijoo Lopez has been appointed chief financial officer of *Nomad Aviation*. He was managing director and a board member for Dnata Switzerland.



Maritime Launch Services has hired **Philip Jones** as chief financial officer. Bringing extensive experience in corporate finance, he served in the same position at Canadian wireless company TeraGo, Redline Communications, Maru/Blue and Mundo Media, among others.

Impres Technology Solutions has promoted **John Podolak** to chief revenue officer from vice president and general manager of Defense Department sales. Before joining the company, he worked at Dell, L-3 Communications and the U.S. Navy.

Michael Stratman has returned to *Menzies Aviation* as chief operating officer for Portugal, having previously worked there as vice president for Italy and vice president for operations for South Africa and Namibia.

Rui Gomes also joins as vice president for Portugal from Samsic Portugal, where he was chief operating officer, and **Scott Sirianni** becomes vice president of sales for the Americas after serving as American Airlines director of multinational accounts.

Mahr Inc. has hired **John Roberts** as general manager of sales. He joins from B&R Industrial Automation, where he worked for more than 33 years, most recently as a global product group manager.

Veronica Messersmith has been promoted to president of the Americas from acting president of the Americas and vice president for strategic relations for the Americas at *Sandvik Coromant*, a Swedish metalworking manufacturer where she has worked for 25 years. Before joining the company, she was an industrial engineer at Baker Atlas and Columbia Lighting.



Sagi Kfir has been tapped by space venture capital firm *SpaceFund* as general counsel. He brings an extensive background in providing legal counsel to commercial space clients, including as founder of Kfir PC, senior managing counsel at Blue Origin and general counsel, vice president for regulatory affairs and co-founder of Deep Space Industries.

The National Aviation Hall of Fame has appointed **Mary Miller** to its board of trustees. She is also Signature Aviation's vice president for industry and government affairs.

HONORS & ELECTIONS

The Wichita Aero Club has given its *2023 Wichita Aero Club Trophy* to Sen. **Jerry Moran** (R-Kan.), celebrating his work supporting the region's aviation industry, particularly through his positions on the Senate Appropriations Committee and Commerce, Science and Transportation Committee.

Larry Connor has received the National Aviation Hall of Fame's *2024 Armstrong Award* in recognition for his contributions to aerospace and aviation. The entrepreneur has flown 16 different aircraft, founded a real estate investment firm and supported initiatives that promote aviation and space exploration. ✪

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

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DEFENSE

Korea Aerospace Industries' KF-21 has conducted its first air-to-air refueling test with a Republic of Korea Air Force Airbus KC-330 Multi-Role Tanker Transport.

The fifth and final funded flight of the Lockheed Martin AGM-183A Air-launched Rapid Response Weapon on March 17 yielded "valuable, unique data," the U.S. Air Force says.

France has become the second-largest arms exporter after Russian sales plummeted in response to its 2022 invasion of Ukraine, the Stockholm International Peace Research Institute says.

The U.S. has approved Poland's purchase of more than 800 Lockheed Martin-built air-launched cruise missiles as part of a buildup of the country's weapons stocks.

The UK Defense Ministry has finalized a deal with Boeing to buy 14 MH-47G Block II Chinook heavy-lift helicopters after having deferred the purchase for three years.

The Lockheed Martin F-35 has been approved for full-rate production in a long-delayed decision that comes after delivery of more than 990 aircraft.

The U.S. Air Force has pushed back the in-service date for the Boeing T-7 Red Hawk trainer by about another year to 2028.

Turkey's Tusas Engine Industries has run the country's first indigenous turbofan, the 6,000-lb.-thrust-class TF6000.

India said on March 11 it had tested a multiple independently targetable re-entry vehicle capability on its Agni-5 intercontinental ballistic missile.

Stratolaunch conducted the first powered flight of its Talon TA-1 test vehicle on March 9, a key step toward a reusable hypersonic test capability (page 56).

Indian Air Force investigators are probing the March 12 crash of a HAL Tejas light combat aircraft—the first such accident since the aircraft's initial flight 23 years ago.

COMMERCIAL AVIATION

International Aero Engines has completed a test run on the V2500 engine using 100% sustainable aviation fuel at the Hanover, Germany, facility of MTU Maintenance.

Sweden's Braathens Regional Airlines has completed its court-led financial reorganization, concluding a process that began in October.

Air New Zealand is to temporarily suspend flights between Auckland and Chicago amid challenges with the serviceability of Rolls-Royce Trent 1000 engines.

A lack of planning for major incidents contributed to UK travel chaos in Au-

gust after a NATS air traffic control system meltdown, according to the Civil Aviation Authority.



RECENT

Southwest Airlines is exploring the feasibility of an interisland and intra-island seaglider network in Hawaii, using all-electric wing-in-ground-effect vehicles.

The long-awaited sale of 51% of South African Airways to Takatso Consortium has fallen through after both sides withdrew by mutual agreement.

Two Airbus A320 pilots on a Jan. 25 Batik Air flight to Jakarta simultaneously slept for about 28 min., prompting an Indonesian call for tighter cockpit and pilot checks.

VIEW FROM BRUSSELS

Shaming Single Sky Reform

With industry and politicians labeling the provisional agreement on Single European Sky reform a complete failure, UK-based low-cost carrier EasyJet plans to push for more ambitious action.

On the eve of a European Parliament vote on the proposed SES2+ Single European Sky reform, EasyJet announced it would begin calculating unnecessary emissions route by route and sharing the numbers with national governments.

EasyJet CEO Johan Lundgren said Europe's air traffic management inefficiencies are "an absolute waste" of CO₂.

The carrier will begin excess emissions reporting within a couple of months. EasyJet plans to "overlay" its actual emissions with potential savings that could be achieved with fully optimized air traffic management; the data may even be made public.

Lundgren estimates EasyJet creates at least 10% more emissions as a result of air traffic control inefficiencies. He hopes to use the data to illustrate the impact of European governments' failure to make sufficient progress with the SES2+ reforms (see page 51).

"I don't think that will hold up to scrutiny from any voter in Europe," he told delegates at the Airlines for Europe Summit in Brussels.

Korean Air plans to order 27 Airbus A350-1000s and six A350-900s in preparation for its proposed merger with A350 operator Asiana Airlines.

Japan Airlines has decided to add 21 Airbus A350-900s, 11 A321neos and 10 Boeing 787-9s as part of its fleet renewal plan.

Boeing and Spirit AeroSystems have “conviction” that a proposed recombination of the companies is the best move for ensuring safety and quality, Boeing Chief Financial Officer Brian West said March 20 (page 14).

SPACE



SPACEX

The SpaceX Starship upper stage reached its intended trajectory on its third flight test on March 14 while the Super Heavy booster came closer to a soft splashdown in the ocean (page 48).

China’s usually reliable Long March rocket fleet suffered a hiccup when a Long March 2C failed to put two lunar navigation test satellites into orbit on March 13.

Japanese startup Space One’s ambitions to launch a privately developed rocket into orbit suffered a setback after the Kairos exploded seconds after liftoff on March 13.

China on March 20 launched its Queqiao-2 communication relay satellite on a lunar transfer trajectory—a key element for the Chang’e-6 Moon landing mission later this year. 🌕

OBITUARIES



NASA/JSC

Thomas Stafford, a retired U.S. Air Force lieutenant general who commanded NASA’s Apollo 10 mission to the Moon and led an Apollo crew in a historic linkup with Soviet cosmonauts, died March 18. He was 93. An Air Force test pilot, Stafford was selected for NASA’s second group of astronauts in 1962. In December 1965, he launched on Gemini VI to conduct the first orbital rendezvous with a second spacecraft. In June 1966, Stafford commanded the Gemini IX mission to demonstrate rendezvous and docking procedures for future Apollo missions. On the May 1969 Apollo 10 mission, while orbiting the Moon, he and NASA astronaut Gene Cernan entered the lunar lander and descended to 9 mi. above the lunar surface. His fourth and final mission in July 1975 was the Apollo-Soyuz Test Project, an orbital linkup with Soviet cosmonauts aboard their Soyuz spacecraft. Stafford subsequently resigned from NASA to return to the Air Force and become commanding general of Edwards AFB, California, and later head of Air Force Research, Development and Acquisition. He retired from the military in 1979 and later chaired an independent advisory team on the execution of President George H.W. Bush’s Space Exploration Initiative. “We have lost a giant,” National Aeronautic Association Chair Jim Albaugh said. American Institute of Aeronautics and Astronautics CEO Dan Dumbacher said: “As a pilot who pushed the boundaries of air and space, he contributed in profound ways to our body of technical knowledge as well as through his decades of leadership.”



KYLE HULTQUIST

Bill Reavis, an aerospace industry media relations legend, died at home on March 15, age 77, after a yearslong battle with cancer. A Vietnam War combat veteran and broadcast news professional, he was admired widely within the aerospace industry for his professionalism, persistence and ferocious loyalty. Reavis retired from Honeywell Aerospace and legacy companies AlliedSignal and Bendix King in 2013 after 25 years of service. In that time, he established himself as one of the most credible public relations communicators in the industry. He was also known for his sharp wit and storytelling. In retirement, Reavis remained highly engaged. Last year, he telephoned *AW&ST* Editor-in-Chief Joe Anselmo to push for a prominent obituary for aviation safety legend and Honeywell veteran Don Bateman. The magazine acquiesced. Reavis also was credited with putting the auxiliary power unit on the map. “Bill was generous to a fault, a true professional and a great raconteur,” says *AW&ST* Senior Editor Guy Norris. “Bill was truly one of a kind . . . always the consummate, energetic professional,” says Karen Walker, Aviation Week Network air transport editor-in-chief. “He really believed in the products, the technology and their importance to the industry, and that never wavered.”

FOUR YEARS AGO IN AVIATION WEEK

When the COVID-19 outbreak in China morphed into a global pandemic in March 2020, the aviation industry imploded with astonishing speed. For the first time in its 104-year history, *Aviation Week* magazine had to be produced with its entire staff working from their homes. “The bad times have arrived, as any airline executive in the world can attest,” said the lead story in our March 23-April 5 edition, bylined by six editors on four continents. “Capacity cuts are reaching 90% of normal levels, and more than 40 airlines have stopped flying altogether . . . the longer the groundings continue, the less will be left of what had been a prospering industry.”

But an accompanying editorial sought to provide a dose of calm to a panicked industry. “Commercial aviation is a connective tissue that underpins global commerce, drives prosperity and supports many millions of jobs,” it read. “Allowing it to wither is not a realistic option. The coming days will be dark, but rest assured the industry will recover and once again prosper.”

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UP FRONT

RICHARD ABoulAFIA

**LAST MONTH, THE ARMY CANCELED**

its Future Attack Reconnaissance Aircraft (FARA) program. FARA was the service's fifth effort to replace its OH-58D Kiowa

Warrior Scout helicopter, so its cancellation is not a big surprise. But we can look back at FARA and identify five mistakes in thinking that help explain why it died:

❶ Ignoring cost realities. The price paid for something in the past is a pretty good indicator of the price the market will pay for its replacement in the future. The OH-58D would cost about \$12 million today. It might not have been realistic to expect its replacement to cost 3-4 times that, which was the likely FARA price tag. Similarly, the small-cabin, short-range vertical-takeoff-and-landing mission today, such as it is, is generally performed by \$500,000-1 million helicopters from Bell or Robinson Helicopter. Most electric vertical-takeoff-and-landing (eVTOL) aircraft under development look set to cost \$4-5 million or more.

❷ Ignoring alternatives with lower costs and risks. FARA, like the RAH-66 Comanche in the 1990s and early 2000s, looked impressive as a solution to the Army's need for airborne reconnaissance. But when the service and industry are focusing on a high-profile new platform (which, in FARA's case, also involved one contractor with a new vertical flight architecture), it's easy to ignore less expensive possibilities. Drones, perhaps operating in conjunction with enhanced AH-64s, might be the best way forward for the scout mission.

❸ Assuming new technologies and capabilities pay their way. Greater speed and range, achievable with tiltrotors, tiltwings and compound coaxial models, sound great. So do noise reduction, lower maintenance costs and getting rid of fuel bills and emissions, achievable with eVTOLs. But very little data shows what these things are worth to military and civil customers.

The U.S. Marines and joint service Special Operations Command, for example, were willing to pay a 2X premium relative to conventional models for speed and range with the Bell Boeing V-22 Osprey. But very few customers followed them. For the future, the Army will need to decide its force mix of Bell V-280s Valors and Sikorsky UH-60 Black Hawks, but their cabins are not all that different in size, and the V-280 will, again, cost at least twice as much. Similarly, Leonar-

do's AW609 civil tiltrotor offers a \$12 million cabin with a \$27 million price. Even conventional designs might not offer technologies that pay their way, which would explain why Airbus's X6—an H225 Super Puma replacement—died six years ago.

❹ Ignoring budget realities. The problem with new models is often more than just unit cost. Military budgets need to be viewed holistically, with an eye on affording other recapitalization priorities. The emerging narrative is that the upside of the FARA cancellation is the same as the upside of the Comanche cancellation:

the Army can now afford to fund new versions of the UH-60, Boeing CH-47 Chinook and other models. Yet this is somewhat backward. In reality, the Army needed to cancel FARA in part for the same reason it needed to cancel Comanche: to be able to afford the recapitalization of its workhorse fleets.

❺ Ignoring strategic drivers or mission requirements. Ten years ago, I argued that the Future Vertical Lift program—which produced FARA and the Army's Future Long-Range Assault Aircraft (FLRAA)—was likely to collapse due

to strategic irrelevance (*AW&ST* June 16, 2014, p. 18). Then, in 2022, I argued that the U.S. pivot to Asia was likely to rescue FLRAA, won by Bell's V-280 Valor (*AW&ST* Sept. 12-25, 2022, p. 11). But unlike FLRAA, the relatively short-range FARA was a bad fit with Pacific theater requirements. According to the Army, lessons learned in the Russia-Ukraine war also made FARA less relevant. These strategic priorities and lessons made for an easy kill.

The end of the Russian threat to Central Europe in the 1990s similarly helped kill Comanche. The return of the Russian threat to Europe, while concerning, is not pressing enough to convince U.S. force planners to change their development and acquisition priorities.

These five mistakes in thinking might provide useful lessons for vertical programs in the future. They help explain the "capabilities plateau" that rotorcraft seem stuck on. They might also indicate a day of reckoning ahead for the many startup companies aiming to introduce seemingly exciting new technologies and vehicles into this market. **✎**

Contributing columnist Richard Aboulafia is managing director at AeroDynamic Advisory.

Day of Reckoning

Five signs a rotorcraft program might be doomed



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EMBRAER'S FUTURE WILL BE

"brilliant," CEO Francisco Gomes Neto told analysts and reporters on March 18 while presenting the manufacturer's 2023 results. Having gone through some rough years in and after the coronavirus pandemic, the company can celebrate its 55th birthday "in very good shape," he said, adding that he is "extremely confident" about the 2024 guidance.

Gomes Neto's outlook is shared by at least one of the big rating agencies and a growing number of analysts. Standard & Poor's has given Embraer back its investment-grade rating, important for the company's image and of course financially, as it makes borrowing cheaper. And about a week ago, Morgan Stanley came out with an extremely positive research note making the company its "top pick in aerospace." Why? "After multiple investment cycles to broaden and deepen the portfolio in commercial aviation, executive aviation, defense and security, and services, Embraer is poised to thrive in this upcycle," Morgan Stanley states, asserting that the Brazilian manufacturer can "break into an aerospace duopoly"—referring to Boeing and Airbus.

After the report was published, Embraer's stock price surged 10% in a single day.

There may be good reasons for the enthusiasm. Executive jets sell well, the KC-390 has secured export orders, the services business is flourishing, and Embraer has a presence in the advanced air mobility market through its affiliate Eve. But it is also true that a lot of work remains to be done, particularly in the segment of commercial aviation. And some key questions remain unanswered.

Embraer delivered 64 commercial aircraft in 2023, seven more than a year earlier but also fewer than it had hoped. One challenge has been its supply chain; obtaining enough engines in particular has been extremely difficult. For 2024, the company anticipates a further increase—it plans to deliver 72-80 aircraft. In 2025 and 2026, Embraer aims to produce more than 100 commercial jets each year.

Of the 64 aircraft delivered last year, 25 were E175-E1s and 39 E2s (38 195-E2s and one E190-E2). Following the recent large order by American Airlines, the backlog is almost balanced between the E1 and E2.

That can be seen as a strength, indicating Embraer can deliver flexibly according to demand, or a weakness, as E2 sales lag the program's launch projections.

Gomes Neto contends that Embraer has opportunities to sell more than 200 aircraft. The E2 is competing mainly against the Airbus A220 for orders expected from LOT Polish Airlines and Lufthansa for 48 and 38 aircraft, respectively. He argues that one of Embraer's big pluses is how constrained aircraft supply is and will likely remain. "The 2026 window [for open production slots] is a big advantage," Gomes Neto said. "One-third

of demand worldwide is unmet; it is an opportunity to meet it through the E2 quickly."

That is another way of saying airlines that cannot secure early enough delivery slots for Airbus A320neos and Boeing 737 MAXs might then consider the E2. It is not exactly a great compliment to win orders in the absence of alternatives. Make no mistake: The E2 is a well-done, very advanced and efficient aircraft. Its problem has been that major airlines have not downsized their aircraft as Embraer had expected.

A key operator that might change this situation is Singapore Airlines affiliate Scoot. The airline is scheduled to receive its first E195-E2 in April, and it could use it to demonstrate how well the aircraft works on thinner routes.

Interestingly, the Morgan Stanley research does not refer to any potential new aircraft programs but to the likelihood of new orders for existing products. That is not how Embraer is thinking. "We continue to invest in innovation to close the technology gap and be ready for new programs in the near future," Gomes Neto said. "Market intelligence and engineering are studying new aircraft in the executive and commercial segments." But the CEO said he does not want to "risk the financial performance of the company" at the same time. He expects a decision to be made in 1.5-2 years.

The obvious question: Will Embraer dare to develop a larger commercial aircraft that would compete head-on with Airbus and Boeing? And if it does, what will the aircraft look like? The step would be a big risk—Bombardier tried that but ended up having to sell its C Series program to Airbus. The possibility also presents an opportunity. Embraer has excelled at developing programs on time and at relatively low cost in the past, which cannot be said about the C Series. ☛

Advantage Embraer

CEO and analysts are bullish
about the OEM's outlook



SCOOT

THE DEW LINE

STEVE TRIMBLE



A NEW KIND OF HYPERSONIC

vehicle could infiltrate an enemy's most defended area, strike a target and then—unlike the rest of the disposable

Mach 5+ missiles produced or acknowledged to date—return to base to fight another day.

For decades, the dream of a reusable hypersonic vehicle has seemed a step beyond the limit of practical technology or a customer's operational need. But it still came as a surprise when the Air Force Research Laboratory (AFRL) announced in February a pause of at least one year for the Mayhem program, the first acknowledged attempt to build a reusable hypersonic military aircraft in several decades.

With so many commercial vendors—ranging from startup airframers, such as Stratolaunch, Hermeus and Velontra, to new propulsion options, including General Electric's newly unveiled turbine-based combined-cycle (TBCC) engine demonstrator and Pratt & Whitney's Metacommet concept—industry finally seemed ready to meet the challenge.

But a new candidate to build a reusable hypersonic vehicle has emerged elsewhere in the U.S. Defense Department, and the project suggests cracks in the readiness of industry to supply such technology imminently.

DARPA has revealed new interest in launching the design of a Next-Generation Responsive Strike (Next-RS) Y-plane, or prototype. Buried in the third paragraph of a March 11 request for information (RFI) titled "Weight-Efficient Thermally Driven Reusable Airframe Technologies" is the agency's idea for a Mayhem-like vehicle with strike and intelligence, surveillance and reconnaissance (ISR) capabilities.

DARPA's Aerospace Projects Office (APO) "envision[s] reusable hypersonic aircraft attributes providing future multimission strike/ISR capabilities against targets protected by advanced defense systems," the agency states in the RFI. "APO seeks to close the gap between the state of the art in reusable hypersonics and the level of technical maturity required to initiate a NextRS Y-Plane design late this decade."

By suggesting the existence of a "gap," DARPA's language implies the agency's technologists are skeptical of U.S. industry's readiness to field a reusable hypersonic vehicle immediately. The high-temperature materials in production for several hypersonic weapons being developed or fielded by the Pentagon remain a step short of the demands for a hypersonic reusable vehicle, the agency's RFI adds.

A key issue DARPA identifies for hypersonic reusability is the ability to test and model structural behavior at hypersonic speed. Such tools today are optimized to discern structural factors—such as fatigue, creep and crack growth—at peak mechanical loads. But high-speed flight can induce higher loads from heat than from mechanical force, the agency says. New tools optimized for thermal load analysis may reveal that the advanced composite materials that have worked for disposable hypersonic missiles, such as carbon-carbon and ceramic matrix composites, may not work for reusable vehicles.

"The large sizes and acreages needed for a reusable hypersonic aircraft design are a far-term goal of most composite material development programs," the RFI states.

It then asks industry to explain how the envisioned airframes will use metallic materials and how to analyze the behavior of those materials when exposed to extreme thermal loads.

As DARPA reviews submissions, due by April 10, the AFRL will keep working on the Mayhem project. The initial task

order awarded to Leidos to complete a critical design review remains in effect. But follow-on orders, including a planned first flight in fiscal 2025, are on hold.

Instead, the AFRL's next move will be decided by Air Force Global Strike Command, which plans to field a family of long-range strike systems anchored by the subsonic, stealthy Northrop Grumman B-21 Raider. The command is conducting an analysis of alternatives this year to refine requirements for a high-speed strike system.

The Defense Department's interest in reusable, high-speed aircraft for reconnaissance and strike is not new. A decade ago, Lockheed Martin's Skunk Works revealed a concept for the hypersonic SR-72, an uncrewed, TBCC-powered aircraft.

As the concept matures, the proposed NextRS Y-plane may be able to leverage a portfolio of high-speed technology now in development.

In addition to the efforts of defense prime contractors and startups, DARPA has made other investments in hypersonic technologies including a recent project focused on aerostructures. A March 12 contract worth \$12.9 million to Spirit AeroSystems, for example, launched the Caliente program, which will "design, build, instrument and test a representatively large high-speed wing and control surface test structure," a DARPA spokesperson said. 🌐

Managed Mayhem

DARPA signals new interest in reusable hypersonic prototype



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QUALITY FIRST

- > BOEING PLEDGES FUNDAMENTAL CHANGE AMID 737 CRISIS
- > POSSIBLE SPIRIT MERGER SEEN AS KEY STEP
- > 737 PRODUCTION IS BELOW 38 PER MONTH

Sean Broderick and **Michael Bruno** Washington

Years of financially motivated prioritization of speed over quality has driven Boeing into a crisis that has put its flagship 737 MAX program under unprecedented FAA scrutiny and a voluntary production rate cap. Meaningful change—starting with an organizationwide culture shift—will be daunting but not impossible. Boeing’s top executives are taking the most important step: admitting they are a large part of the problem.

“For years, we prioritized the movement of the airplane through the factory over getting it done right,” Chief Financial Officer Brian West said March 20 at a Bank of America conference. “That’s got to change.”

West is right for several reasons. Once considered the world’s preeminent aircraft manufacturer, Boeing’s hallmark in recent years has been a chronic inability to deliver products built to its specifications on time. The underlying cause—insufficient emphasis on quality—played a key role in the Jan. 5 inflight loss of a door plug from a new Alaska Airlines 737-9 (AW&ST Feb. 12-25, p. 18).

That prompted an FAA crackdown, including a six-week audit that found “noncompliance issues in Boeing’s manufacturing process control, parts handling and storage, and product control,” the agency said. Boeing also agreed to keep new 737 production at or below 38 aircraft per month until it regains the FAA’s confidence.

Coupled with recently released results from an expert-panel review of Boeing’s safety culture ordered by U.S. lawmakers in 2020 and stemming from the 737 MAX grounding after two fatal crashes in 2018 and 2019, the OEM has a playbook for a much-needed Boeing Commercial Airplanes (BCA) organizational overhaul.

Among the initial changes: reducing traveled work, where nonconforming parts or entire aircraft move down the line and are fixed later. Some traveled work, which can help maintain normal production flow, is inevitable. But Boeing and key fuselage supplier Spirit AeroSystems have relied increasingly on the practice to make up for poor workmanship, inadequate training and other fundamental quality problems.

The ramifications are usually no worse than late deliveries and higher costs. But the Alaska 737-9 accident—which included an emergency landing but no serious injuries—demonstrated what can happen when quality is not prioritized.

Boeing discovered nonconforming rivets in the 737-9’s fuselage when the assembly arrived at its 737 production facility and flagged them for repairs. Accessing the rivets required opening a fuselage panel, or plug, blocking an unneeded exit. Once the repair was complete, someone forgot to reinstall the four bolts needed to secure the plug in place. The panel worked its way loose over some 150 flights and finally was ripped away.

The NTSB is in the early stages of its investigation and plans to conduct a hearing on the accident in August. Meanwhile, the FAA has given Boeing

until June to devise a plan to address the agency’s audit findings plus the expert panel’s recommendations.

West confirmed that Boeing has changed its master program supplier schedule to reflect what is shaping up to be an extended period of producing fewer than 38 737s per month.

The move suggests Boeing is not conducting business as usual. While suppliers deliver products at various rates based on a variety of factors, a program’s master schedule sets long-term monthly production targets. Amid rising FAA scrutiny, both CEO David Calhoun and West said in recent weeks that while monthly final assembly totals may hover below 38, suppliers would deliver at or above that figure per the master schedule.

In reality, the added scrutiny piled onto existing production problems means Boeing is building fewer aircraft than the agreed-upon limit—some-where around 25 airframes per month.

“We have recently updated our master schedule to reflect this slowdown,” West said. He suggested monthly production will edge up slowly, but only after Boeing and its suppliers demonstrate consistency.

“The way I think about it is: [In] the first half [of this year], the rates will be lower,” West said. “Second half, they’re going to be higher as we get toward that 38 per month. Beyond 38 per month will be up to the FAA.”

Among Boeing’s first steps on the road to reliable production was to stop accepting Spirit-made subassemblies that do not conform to design specifications.

“It had been going on too long,” West said. “Now we will only accept a fully conforming fuselage from Spirit, which means in the near term, there might be variability of supply. But long-term, the predictability that we’re going to get is dramatically better.”

While Spirit has been a consistent contributor to the OEM’s quality woes, it is only part of the problem. Boeing leadership’s lack of commitment to ensuring that its workers both understand their role in organizational safety and are empowered to speak up if issues are detected are

Boeing will not roll out 38 737s per month until late this year at the earliest.



SEATTLE TIMES POOL

larger—and in many ways more challenging—problems.

The expert panel's final report flagged a "disconnect" between management and the workforce on safety culture. Many of the panel's 53 recommendations to Boeing and the FAA concern the company's safety and quality management systems. Among the steps the manufacturer is taking are improving workforce training and ensuring front-line workers are heard so management "[picks] up the signals on the factory floor," West noted.

"We've got to listen and act on [the workforce's] behalf," he said. "This goes beyond the 737 program."

Reducing traveled work is seen as key to helping front-line workers perform better. Arguably more important is improving training on broad safety and quality programs as well as specific procedures like those flagged in the FAA audit.

One panel member believes a focused effort with Boeing management's full support could prompt meaningful factory floor changes quickly—perhaps within six months.

"The workforce is competent and dedicated," the panelist tells Aviation Week. "There is still plenty of 'if it ain't Boeing, we ain't going.' But they need better training and much more engaged leadership."

Management is saying the right things. While the depth of Boeing's dedication to fundamental transformation remains to be seen, change is coming.

Leaders at Boeing and Spirit have

"conviction" that a proposed merger of the two companies is a leap in the right direction, West said. "I'd point back to comments that [Calhoun] made in January around how Boeing more than 20 years ago probably got a little too far ahead of itself on the topic of outsourcing," he said. "And this is probably the example."

Boeing would buy back Spirit using cash and debt, West explained, declining to provide details. The comments surprised many financial analysts, some of whom assumed Boeing would pay for the Wichita-based aerostructures provider through common stock.

Using stock would dilute current shares and be unpopular with shareholders. Still, some analysts see the option as more viable, with Boeing's credit rating at the three major rating agencies just above junk status. Issuing more debt nominally could tip the rating to junk. The manufacturer has an unused credit line to tap, but it is unclear whether doing so would save it from a downgrade.

Boeing ended 2023 with almost \$16 billion in cash and could generate more by selling businesses. It has been exploring sales of some so-called non-core defense and space assets, Bloomberg reported.

West did not deny the reports when asked at the conference but said Boeing looks forward to being a major defense contractor regardless of divestitures. "We love our strategic position across our defense portfolio," he said.

West's comments about Spirit un-

derscored the OEM's seriousness in acquiring its most important supplier, which builds 70% of the 737 and feeds every BCA program. His input may quell suspicions that a push to buy Spirit is a ploy to satisfy the FAA or force rival Airbus—also a Spirit customer—to pony up even more money for the struggling supplier. Instead, West said the intent is to return Spirit to the long-running role it served before being spun out in 2005.

"Without going into the synergies and efficiencies, it's really about focus and running that business not as a business but as a factory," he explained. "Run it as a factory and stay focused on safety, on quality and stability. That opportunity sits there."

Nevertheless, growth will be slower than was expected even two months ago. While Boeing did not provide formal financial guidance for 2024 at its last quarterly teleconference in late January, West used the March 20 conference to reset expectations.

For the first quarter of 2024, ending March 31, Boeing expects to burn \$4-4.5 billion in cash. "That's higher than we originally planned back in January," West acknowledged. BCA margins likely will be -20% for the quarter and negative for the full year.

Meanwhile, full-year free cash flow generation is likely to be in the "low-single-digit" billions of dollars, West said. Analysts had been expecting around \$5 billion total this year on the way to a stated goal of \$10 billion by 2025-26. 🗳️

THE NEXT NARROW

- > AIRBUS, BOEING AND EMBRAER STUDY FUTURE NARROWBODIES
- > ENGINE ARCHITECTURE, WING AND AERODYNAMICS ARE KEY FEATURES
- > SERVICE ENTRY LIKELY AFTER 2035



BAUHAUS LUFTFAHRT

Jens Flottau Austin, Texas, and **Guy Norris** Colorado Springs

Across the tarmac from the Singapore Airshow chalets, the aerospace industry's newest narrowbody airliner was on full display. Four units are already in service and its manufacturer is beginning the challenging work of increasing production and trying to penetrate the global market. The aircraft was Comac's C919.

The C919 enters a market that has been a duopoly ever since the 1997 merger of Boeing and McDonnell Douglas. The only serious attempt at entering the narrowbody market, at least the lower end, finished in financial disaster for Bombardier and a further strengthening of Airbus, which picked up the former C Series program—now called the A220—essentially free of charge. Embraer watched and considered its options for some years before deciding to play it safe, developing the relatively small E-Jet E2 that would neither hurt Airbus or Boeing nor force them to move.

For one reason or another, Airbus and Boeing never moved ahead with all-new projects at the time. There was little movement, and if anything, Comac was trying to catch up to incumbents, not eclipse them. However, driven primarily by existential sustainability requirements, that era of incremental steps has come to an end.

In recent years, both Airbus and Boeing have begun to talk about successors for the A320neo and 737 MAX—all-new aircraft that they aim to introduce in the second half of the next decade. Given that development cycles have significantly lengthened to close to 10 years, including pre-launch work, the time to kick off serious development efforts is now. The E2 has not become the growth engine that Embraer had hoped for, so the Brazilian manufacturer is again looking at going bigger. Doing so, possibly as Airbus and Boeing move up in the market in terms of aircraft size, could also create a gap at the lower end of the market that Embraer might be able to fill. Furthermore, the JetZero blended wing body (BWB) project targets the same niche addressed by narrowbodies.

BOEING TRUSS-BRACED WING

Boeing's path to more concrete plans for a next-generation narrowbody has

been long and winding. Its customers argue that now is not the time for Boeing to dive into the project. First, the manufacturer must "get their house in order," Air Lease Corp. CEO John Plueger says.

Nonetheless, Boeing has begun the internal work needed, Darren Hulst, the OEM's vice president for commercial marketing, said at the recent ISTAT Americas conference in Austin, Texas. "But maybe [we're] not talking as much about it as Airbus," he added.

Boeing has built more than 11,700 737s and still holds the crown as the most popular single-aisle jet airliner in history. But the A320, launched 40 years ago, is catching up quickly and will likely overtake its archrival in production terms within the next year or two.

The vast production numbers accrued by the 737 owe as much to its longevity as its flexibility. The original project was given the go-ahead in 1964, long before Airbus even existed and 20 years before the A320 was launched on the back of only 96 orders. For much of the last 60 years, Boeing has looked hard at replacing the 737, but—just as the DC-3 frequently turned out to be the best replacement for the DC-3—the company concluded each time that the 737 was hard to beat and that reengining was the best solution.

BODY



Bauhaus Luftfahrt is one of many research institutions exploring future aircraft configurations.

When it came to the MAX, however, the decision was far from clear. Just weeks from Boeing's decision to green-light the MAX in July 2011, even the aircraft's engine provider CFM International was convinced that the airframe manufacturer was going to launch a competitor to the A320neo with an all-new design rather than follow the reengining route with its new Leap 1.

German aerospace research center DLR has been studying several alternative aircraft architectures.

In the weeks leading up to the contest that year for an American Airlines deal that triggered the launch of the MAX—and which Boeing ended up sharing with Airbus anyway—the smart money had been on a clean-sheet design targeted at service entry by about 2020. In April 2011, less than three months before launching the 737NE (New Engine), later renamed the 737 MAX, even Boeing admitted that the results of a reengining survey with operators had been “underwhelming.” In short, most airlines wanted an all-new design.

But the cost and timescale of a new product were too daunting for Boeing's management while the troublesome 787 program was already badly behind schedule and hugely over bud-

get. During the company's second-quarter earnings call in 2011, then-Boeing Chief Financial Officer James Bell said the development cost for the airframe portion of a reengining program would be 10-15% of the cost of a new program, estimated at \$10-12 billion at the time. Besides, Boeing believed that extending the 737 into a fourth generation would preserve market share—giving it several precious years to prepare a true replacement design.

However, with the benefit of hindsight, Boeing's 2011 decision to launch the MAX instead of pushing for a more ambitious clean-sheet design was a gamble with massive repercussions for the company and industry. Even without the debilitating impact of the COVID-19 pandemic, the simultaneous disaster of the MAX accidents in 2018 and 2019, and the subsequent grounding of the aircraft, the decision to proceed with the reengined 737 caused Boeing unparalleled financial and reputational damage.

with the MAX and its financial burden, where is the company now in its long-term ambitions for a 737 replacement? The answer lies firmly in the X-66A, an experimental aircraft in development with Boeing as part of NASA's Sustainable Flight Demonstrator (SFD) project. The slender-winged aircraft, a heavily modified MD-90, is the agency's first full-scale X-plane focused on helping the U.S. achieve its goal of net-zero aviation greenhouse gas emissions. For cash-strapped Boeing, it is also a golden opportunity to flight-test a sustainable design concept that could form the basis for a single-aisle 737 successor.

The roots of the design, also known as the transonic truss-braced wing (TTBW), go back to 2010, when Boeing's Research and Technology branch developed different configurations for a Subsonic Ultra-Green Aircraft Research (SUGAR) study with NASA. Inheriting ideas developed during the 2000s-era Yellowstone product development initiative that



In a financial filing this past February, Boeing reported having paid \$400 million to 737 MAX operators in 2023, after paying \$1 billion in 2022. Financial analysts quoted in a Feb. 5 report by *The New York Times* said the two 737 MAX crashes and the grounding of the fleet for nearly two years cost Boeing a staggering toll of about \$20 billion. Even with more than 4,300 aircraft in the current backlog—adjusted for accounting standards—it is unclear that Boeing will make good on the program in the long run.

Having boxed itself into a corner

also spawned the 787, SUGAR evolved into several high-aspect-ratio wing designs, the ultimate outcome of which gave rise to the TTBW.

Now launched as a full-scale demonstrator expected to fly in 2028, the NASA-Boeing program is the company's best hope of producing an all-new design with the efficiency levels required for service in the late 2030s. Previous 737 successor efforts, most notably the 737RS (Replacement Study), were abandoned in 2008 after all the technologies available generated fuel-burn savings of only about

8%. This figure was well below the 20% level Boeing had set itself against as the baseline performance target for the 737 Next Generation.

Other key factors will come into play as Boeing refines its 737 replacement plan around the technology suite in development for the X-66A. While the SFD aims to primarily prove the aerodynamic benefits of the slender TTBW wing, the configuration is essentially agnostic to the three main next-generation propulsion systems also in development. These include the GE

composites, and the concepts are aimed at technologies that will enable a production rate increase of 4-6 times without ramping up costs.

Just as important, the TTBW concept is also agnostic to fuselage cross-section and gives Boeing its first chance to adopt a wider, circular or ovoid cabin section. The change could replicate small twin-aisle configurations studied under earlier projects going back as far as the 7J7, a 727/737 replacement featuring propfans and a 188-in.-dia. fuselage evaluated in the

will have to be interim aircraft designs.”

Interim designs include a new, likely rather conventional tube-and-wing-shape aircraft featuring the latest in aerodynamic improvements, more efficient propulsion and full use of sustainable aviation fuel.

“That shows the industry is willing and the industry is prepared to keep moving toward net-zero,” Tusa says. “Producing A320s and 737s will attract an increasing amount of political pressure because it would suggest that the industry doesn’t care, and then they might be forced into something they really don’t want.”

What was previously called eAction is now the Next-Generation Single-Aisle (NGSA) project. It was moved into the general Airbus program organization under Philippe Mhun, executive vice president of programs and services, focusing it and the smaller ZEROe hydrogen aircraft on more concrete research and development. Airbus is working toward a service-entry date in the second half of the next decade. Given how long development and certification cycles have become, a launch decision would be required within the next three years.

There are relatively clear indications of what Airbus is looking at in principle, but the more detailed design questions are still wide open. “Strategically, the question is: What will follow the A321? Is it a conventional solution or are we already beginning [to introduce] disruptive technologies?” Scherer asked in his recent Aviation Week interview. “Probably it will be a bit of both. Two or three major innovations should flow into a new aircraft program.”

Consequently, it seems to be all but decided that the A320neo-family successor will start with a bigger baseline aircraft similar in size to today’s A321neo. The potential for a further stretch and possibly a smaller variant remains, although that seems to be a less pressing detail given that Airbus’ portfolio includes the A220, which could fill the gap left by the unwinding of A320neo production. “We need the right strategy, the right timing, and there are tactical considerations,” Scherer said.

Airbus has not revealed much yet about its thinking on what the next narrowbody looks like. “I think it starts at the A321 and goes higher,” Tusa says. “The market clearly



The X-66A truss-braced wing demonstrator is expected to fly in 2028.

Aerospace-Safran CFM joint venture’s RISE (Revolutionary Innovation for Sustainable Engines) open fan technology program, an advanced version of Pratt & Whitney’s PW1000G geared turbofan (GTF) and smaller versions of Rolls-Royce’s very-high-bypass UltraFan. All three initiatives are currently supported by research on both sides of the Atlantic and are targeted at the Airbus and Boeing next-generation, single-aisle aircraft requirements for the 2030s.

Additionally, next-generation studies incorporate Boeing’s involvement in other research efforts, such as NASA’s High-Rate Composite Aircraft Manufacturing (HiCAM) project. Boeing has gained experience in composite fuselage and wing production through the 787 and has taken composite wing production in-house with the 777X program, but the company knows that even more advanced technologies will be needed for future single-aisle manufacturing tempos. HiCAM’s production concepts center on next-generation thermosets as well as resin-infused and thermoplastic

1980s. The 7J7 in many ways represents a bellwether of what could come later this decade if Boeing finally commits to a new narrowbody design.

AGAINST THE GRAIN

Since Airbus’ market share is approaching 70%, conventional wisdom would have it that the OEM should not act at all. But Airbus Commercial CEO Christian Scherer and Airbus Group CEO Guillaume Faury are driving the company in a different direction.

“We are the market leader today,” Scherer told Aviation Week recently. “I am of the opinion that an even higher responsibility develops through that leading market position. We want to be the pioneer of the future. As a market leader, we should not react to the challenger but act ourselves.”

Sash Tusa, an aerospace analyst at Agency Partners, says the game is afoot in the market to develop a next-generation narrowbody aircraft. “Airbus cannot wait for Boeing to launch and credibly get this industry toward net-zero,” Tusa says. “I think there’s a realization now that there

wants larger aircraft.” That is not only because of the general upward trend in demand but also because environmental constraints imposed by European governments could lead to slot restrictions at large hub airports. Operating fewer flights with larger aircraft could mitigate the impact to a degree.

Although the size of Airbus’ next narrowbody could be in the 180-240-seat category, its shape largely depends on the engines. Airbus and GE Aerospace have been working closely on the feasibility of incorporating the RISE engine concept into the design of that new narrowbody. “It is going to be a much more challenging engineering process to put those on or under a wing,” Tusa says. Airbus will also ideally have to find an architecture that allows for engine choice even in the—so far likely—case that a competitor does not go for the open rotor idea.

Pratt & Whitney could offer a version of the GTF Advantage or whatever the second generation of its geared fan engine family looks like. Rolls-Royce has made clear that it is seeking reentry into the narrowbody market with its UltraFan technology. The two might join forces, as they have in the past on the International Aero Engines V2500 powerplant.

Wing design is another crucial feature for a next-generation narrowbody, given that it might have to accommodate very different large-diameter engines. A gull wing could be the solution, with the wing root attached to the lower fuselage but immediately rising upward to allow for much greater ground clearance. Wings are also likely to become much longer for higher efficiency, so folding wingtips might be a requirement to fit the aircraft into the existing gate infrastructure and could even be a tool in flight for more efficient cruise.

The question linked to wing design is whether Airbus will retain its dual engine source strategy. Faury and Scherer have said publicly that they prefer for their customers to have engine choice, a situation that would give it easier access to a broader base of airlines. But that comes with challenges, particularly if Airbus selects RISE and if the competing engine were to be a more conventional nacelle-covered powerplant. It would presumably be almost impossible to

optimize a wing for both engine types. The question then becomes whether going with a sole source would be less painful than accepting a compromise design.

The NGSA project is not only about the aircraft itself. For Airbus, it is the once-in-a-generation chance to look at and possibly revamp its complicated production system. “We should think about how we could be better organized industrially without necessarily continuing the old Airbus model,” Scherer said. “That should be treated as an open question, the same way as what the aircraft should look like. In any case, one should think about a different industrial setup in which competencies are no longer shared but are more efficiently put together.”

Getting the transition right from the current A320neo family to its successor is a much more challenging task than it was to move from the classic A320 to the reengined version. To build an all-new platform featuring new technologies is difficult enough, but the task must be accomplished at very high rates and without cannibalizing the current product too much.

Airbus aims to put out 75 A320neo aircraft per month in 2026. Although Faury has made clear that the rates are not going to go significantly higher anytime soon after that milestone has been reached, they are not planned to go down either. The only caveats to that planned production rate would be both a shift to help generate the cash flow to fund an expensive development program and simultaneous continued work on a smaller hydrogen-powered aircraft.

EMBRAER’S NEXT STEPS

Airbus and Boeing are no longer the only ones targeting the future narrowbody market (see page 12). The C919 is in service, while Airbus picked up Bombardier’s C Series, the only new Western single-aisle challenger since the end of the McDonnell Douglas era. The main question is: What will Embraer do? Before it launched the E2, the Brazilian manufacturer considered going bigger but ultimately decided against it, opting to stay under the radar of Airbus and Boeing for the time being.

As part of the planned commercial venture with Boeing, a role for Embraer in bigger aircraft was conceivable. Its engineers could have taken

part in the proposed New Mid-Market Airplane design work; as the new Boeing aircraft moved up in capacity, there could perhaps have been space at the lower end of the narrowbody market to jump into.

Industry sources say an internal debate is ongoing at Embraer discussing future options. One camp sees a window of opportunity now that Boeing might be too weak to fight two fronts at the same time: against Airbus for a share in the big jet market and against Embraer at the lower end. Of course, a larger Embraer commercial jet would compete head-to-head with the A220, which Airbus is positioning as a bridge aircraft for mainline airlines ahead of the introduction of the NGSA. It is not a comfortable place to be in—just ask Bombardier. A more disruptive design eclipsing A220 efficiency could be the solution.

Embraer CEO Fernando Gomes Neto says Embraer plans to make a decision “in a couple of years” about where to put its resources for its next aircraft development program. He sees executive and commercial aviation as possible sectors for the company’s next step.

“Embraer has the capability to do something bigger,” he says. “But we have no plans to do this right now. We understand the opportunities, but I really don’t want to put the company at risk.”

One new potential player that might affect the trajectory of the incumbents’ plans for the sector is California-based JetZero, which in 2023 announced plans to develop a full-scale multirole BWB demonstrator. Although sized for about 250 passengers and targeted at what JetZero says is the underserved middle tier of the market, the configuration is scalable and could be adapted to smaller designs.

Backed by an initial \$235 million U.S. Defense Innovation Unit contract and buoyed by potential interest as an airlifter-tanker for the U.S. Air Force, the JetZero concept therefore appears a realistic potential challenger to the duopoly—particularly since airlines are expressing strong interest in the BWB’s advertised sustainability goals. JetZero says the aircraft’s advanced aerodynamics and lightweight structure, combined with high-efficiency engines, could offer 50% lower fuel burn compared with current aircraft in its size class. 🌐

U.S. Pilot Class of 2023: Majors Gain and Regionals' Struggles Abate

➤ MAINLINE AIRLINE PILOT CORPS GROWS 22%

➤ REGIONAL CARRIERS STILL SEE HIGH ATTRITION RATES

Lori Ranson Washington and **Jens Flottau** Austin, Texas

A few months ago, the U.S. supply of pilots, particularly captains, remained a considerable challenge for airlines, especially regional and smaller carriers struggling to stabilize their ranks.

faced an existential crisis from the surge in pilot hiring post-COVID.”

Still, SkyWest's pilot attrition is at its lowest level in years, and the company is generating new captains each month. Better staffing at the Utah-

new pilots,” Sun Country President and Chief Financial Officer Dave Davis said at the recent International Society of Transport Aircraft Trading Americas conference. “Within the last six months, we filled all the classes we wanted to fill. Attrition is a lot lower. The biggest constraint has been captain availability, but it has become better. [There is still] a lot of first officer attrition.”

By the end of last year's fourth quarter, Sun Country was moving closer to optimal staffing levels, allowing the airline to allocate additional peak capacity into its scheduled service and charter operations.

“Sun Country's primary gating factor in 2023 was a lack of pilots,” Becker says. “Management reported that issue is improving and allowing the airline to fly more hours in peak-demand windows.” Peak flying for the airline will comprise a materially larger share of its operations in the first quarter, she notes. Current schedules show 41% of the airline's available seat miles are being deployed in March compared with 39% the year prior.

In early February, Sun Country executives said greater pilot availability resulted in fewer hours paid at premium rates and lower unit costs. Adjusted unit costs excluding fuel also fell 2.2% year over year in the fourth quarter of 2023 to 7.28 cents.

“Our pilot issues are resolved at this point,” Alaska Airlines Chief Operating Officer Constance von Muehlen said. “A lot of different pipelines are being built now. That is going to be a necessity.”

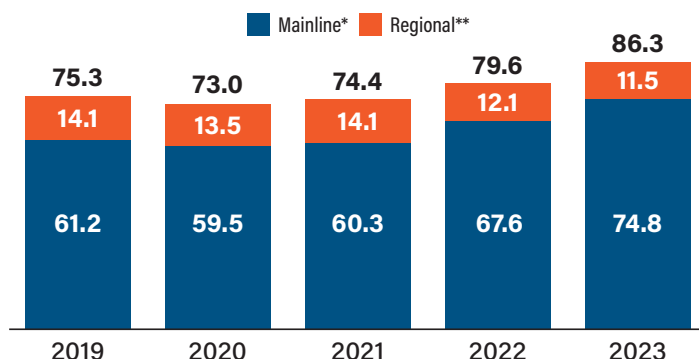
“You have got to pay enough,” Breeze Airways President Tom Doxey said. “We have had two increases on the pilot side. People are making 40-50% more than what they made early on.” He said one issue several airlines have is that “a lot of people pass captain positions for lifestyle” to stay in the right seat longer.

Other larger airlines are also slowing their pilot hiring for reasons including aircraft delivery delays and the grounding of Airbus A320neo-family jets for inspections of geared turbofan engines.

“We have seen a few airlines—JetBlue, Spirit, Southwest and United—pause pilot hiring or training due to delivery delays or grounded aircraft” over the past six months, Becker says.

United Airlines Vice President for Flight Operations Marc Champion

Year-End Active U.S. Passenger Airline Pilots
(in thousands)



*Mainline: Alaska, Allegiant American, Avelo, Breeze, Delta, Frontier, Hawaiian, JetBlue, Southwest, Spirit, Sun Country, United

**Regional: Endeavor, Envoy, Horizon, Mesa, Piedmont, PSA, SkyWest

Sources: Airlines for America and company SEC filings

Now as the first quarter of 2024 draws to a close, pilot staffing is improving. “We believe the worst of the pilot issues are behind the industry,” TD Cowen analyst Helane Becker states in a research report.

According to Airlines for America, U.S. carriers employed 86,300 pilots at the end of 2023, an increase of 8.4%, or 6,700, over 2022. The numbers are very different for mainline and regional carriers: The former increased their pilot corps by 22%, while the latter lost 18% of their cockpit workforce. SkyWest Airlines CEO Chip Childs reported at the Regional Airline Association's Leaders Conference in October that the company had roughly 4,300 pilots on its roster, far short of the number of pilots it employed in 2019, before the pandemic.

Even at regional and smaller carriers that have suffered high attrition rates, the situation appears to be improving. Becker explains in a separate report that “regional airlines

based carrier has resulted in “more flying, and the business can support 20% higher utilization with its current assets,” Becker writes.

Minneapolis-based Sun Country is another airline that has battled pilot staffing issues. Due to a lack of available captains, the carrier flew approximately 3,500 fewer block hours in the third quarter, mostly in July, CEO Jude Bricker said in a third-quarter earnings call. Had it operated in those block hours, Bricker said the company would have produced “somewhere in the range of \$7-10 million of operating earnings for the quarter.”

Sun Country's challenges last summer stemmed not from pilot hiring or attrition but from captain upgrades. Even though its pilot staffing problems continue, the airline's management reported some positive trends emerging based on actions undertaken in the past six months.

“The end of 2021 was the worst for us in terms of attrition and finding

and Vice President for Flight Operations Planning and Development Kirk Limacher sent a memo to the airline's flight operations team explaining it would slow pilot hiring this year "due to continued new aircraft certification and manufacturing delays at Boeing."

United was scheduled to accept delivery of 191 aircraft this year, but that has since dropped to 88. The adjustments are due to the January Boeing 737-9 groundings and related certification uncertainty of the Boeing 737-10, a variant since removed from United's internal plans without the order being canceled.

The airline's contractual aircraft deliveries for 2024 are listed as eight Boeing 787s, 157 MAXs (43 737-8s, 34 737-9s and 80 737-10s) and 26 Airbus A321neos. By the end of 2022, United had projected 127 deliveries in 2024 of eight 787s, 88 MAXs and 31 A321-

neos. Deliveries expected this year now number seven 787s, 56 MAXs (37 -8s, 19 -9s and no -10s) and 25 A321neos. In 2025, it projects 64 deliveries versus 135 contractual, having removed 71 -10s.

United's executives explained in the memo that the airline is pausing new-hire classes in May and June but expects to resume them in July. They added that the airline already has hired more than 450 pilots this year and is on track to "have hired over 800 by the end of April."

With hundreds of new aircraft on order, "we remain on a path to be the fastest-growing airline in the industry," the two executives added. "We just won't grow as fast as we thought we would in 2024 due to continued delays at Boeing."

"We now believe that demand is fulfilled and expect hiring to normal-

ize in 2024," Becker says. Airlines have been doing less flying with more pilots, "and will now look to grow into their employee base," she notes.

Yet even with trends on the upswing, U.S. pilot supply challenges will not be eliminated in the near-to-medium term. In an early February report, Jefferies estimated an undersupply of 6,000 pilots in 2025, growing to 11,000 in 2030.

"This is driven by additions as a percentage of the total base moderating while retirements continue to trend above 4% of the population per year," the report stated. "There continue to be questions around the availability of attracting new candidates into the profession given the pipeline and prohibitive costs to an individual, which has driven recent union pilot deal higher for both wages and work rules." ☞

Ultra-Low-Cost Carriers Confront Headwinds

> NORTH AMERICAN ULCCs FACE COMPLEX CHALLENGES

> BUDGET CARRIERS IN THE U.S. REMAIN BULLISH IN THEIR OUTLOOKS

Lori Ranson Washington and **Christine Boynton** Boston

Although 2023 marked the beginning of a return to stable profitability for many airlines, it marked an end for others.

Colombia's two ultra-low-cost carriers (ULCC), Viva and Ultra Air, ceased operations early last year, succumbing to rising costs and financial difficulties. Two months into 2024 and 4,000 mi. north, a third ULCC ceased operations: Lynx Air, citing high costs and a difficult economic and regulatory environment.

All three were working toward various forms of consolation as they struggled to survive, before deals fell through or headwinds proved too strong.

Before its exit, Lynx had never posted a profit. Even though one of its financial backers, Indigo Partners, has been instrumental in the success of other well-known ULCCs—including Frontier Airlines, Volaris and Wizz Air—conditions in Canada make it tough for the model to thrive.

"The fact that even with the help of an experienced investor Lynx Air was

unable to have success with its ultra-low-cost model strategy and was also unable to source additional capital to sustain its operations speaks to the challenges any startup airline faces in Canada," National Bank of Canada analyst Cameron Doerksen stated in a research note, citing such obstacles as higher airline industry costs than in other countries, fewer large routes to target and limited access to capital.

The immediate effect in Canada's market is a decrease in future capacity growth, Doerksen said, since Lynx had outlined plans to expand its fleet to 46 aircraft. At the time it ceased operations, the carrier operated nine Boeing 737-8 aircraft. Now that it has exited the Canadian market, "we could see a modestly positive impact on pricing in the shorter term," Doerksen said, adding that Lynx had been among the most aggressive on pricing on certain routes in Canada and to the U.S.

Colombia's first and second largest operators, Avianca and LATAM Air-

lines Colombia, have moved quickly to fill the void created by Viva and Ultra Air's exit. Data from Aviation Week Network's CAPA - Centre for Aviation show that Colombia's domestic available seat kilometers through early August are projected to increase over its 2022 levels before the two ULCCs' cessation of operations. Domestic capacity in the country also is trending well above 2019.

Canada's remaining pure-play ULCC, Flair Airlines, has encountered its own challenges in the past couple of years. In early 2023, Flair and aircraft leasing and asset manager Airborne Capital became embroiled in a public dispute over the latter's decision to seize four Boeing narrowbody aircraft from the airline. More recently, Flair has clarified that the Canadian government is not seizing its property over taxes owed. The airline has explained that it is current with its plan to repay the C\$67 million (\$50 million) that it owes to the Canada Revenue Agency.

Meanwhile, in the U.S., shared constraints led to a cost convergence by the end of 2023, narrowing the gap between low-cost and larger legacy airlines.

DOWN BUT NOT OUT

"After 20-plus years of working for lower-cost carriers, it has become ever more clear to me that we exist

in an uneven playing field,” Spirit Airlines CEO Ted Christie said during recent earnings calls. “Either through direct government intervention or lack thereof, the end result has been to perpetuate a small group of ‘haves’ that control the market at the expense of the ‘have-nots’ and the American consumer.”

Christie’s remarks came as he condemned the ruling that found his company’s proposed merger with Jet-Blue to be anticompetitive, a combination the two airlines had stressed was necessary to compete with the largest four mainline carriers. The two airlines have since terminated the merger agreement.

Despite Spirit’s nine consecutive unprofitable quarters, Christie has pushed back on dire industry projections for its future, describing the ULCC as well on its way to making the strategic shifts necessary for the current demand environment.

Spirit still has a few more cards to play “before we talk about restructuring,” Bloomberg Intelligence aviation analyst Francois Duflot says. The South Florida-based carrier still needs to forge a compensation agreement with Pratt & Whitney for grounded Airbus A320neo-family aircraft that are undergoing inspections on geared turbofan engines to determine if parts are made with contaminated powder metal. There have been no disclosures regarding the amount of compensation. Examining aircraft lease payments as a minimum baseline, Duflot says, a lease is \$4 million per aircraft per year. If Spirit has 26 aircraft grounded over the year on average, that could net the airline another \$110-115 million from the leases.

Spirit could garner a higher level of compensation since the airline is an important client for Pratt & Whitney, Duflot adds.

The ULCC also holds some aircraft as debt collateral and could do “what it did in December and then in January: Sell those aircraft, take the equity and get a sale-leaseback,” he explains. In early January, Spirit completed sale and leaseback transactions on 25 aircraft that netted cash proceeds of roughly \$419 million.

Additionally, Spirit has moved some of its flying to an out-and-back model and is working to better align its capacity with supply-demand trends. Similarly, Denver-based Frontier Air-



JOE PERSAVANTON.NET

Canada’s remaining pure-play ULCC, Flair Airlines, has encountered its own set of challenges in the past couple of years.

lines—which posted an \$11 million net loss for 2023—is pivoting from saturated markets and further simplifying its network by increasing its levels of out-and-back flying.

“We are simply going to deepen the modularity and go straight to a best-in-class ULCC model of Europe—we’re finally at a size and scale where that makes sense,” CEO Barry Biffle said, describing it as helping to “fuel the next stage of Frontier’s scalable growth.”

Frontier reported positive results halfway through the first quarter of 2024, “making the changes that we’ve got to do to make sure that we get back to our pre-pandemic margins,” Biffle says.

NEW ENTRANTS AND CATEGORIES

Two of the newest budget airlines in the U.S., Avelo Airlines and Breeze Airways, commenced operations around the same time in early COVID-19 years and are operating in-service fleets of 16 (seven 737-700s and nine 737-800s) and 36 (21 Airbus A220s, 10 Embraer 190s and five Embraer 195s), respectively, according to the Aviation Week Network Fleet Discovery Database. Both have struggled to turn a profit; Breeze posted heavy losses—a situation CEO and founder David Neeleman projects will turn around in the year ahead.

“We fully anticipate making a profit this year and then continue to make a profit . . . more and more in years to come,” he said in February.

Breeze reported a net loss of \$50.2 million in the third quarter on oper-

ating revenue of \$97.1 million, while Avelo posted a net loss of \$9.8 million for the quarter on operating revenue of \$63.2 million, Form 41 financial reports show for the privately owned airlines. Although data has yet to be posted for the final three months of 2023, Avelo in a February statement announced the period had been its first-ever profitable quarter. In 2023, the carrier said, it flew 2.3 million customers and generated \$265 million in revenue—up 74% from 2022. It reported nonfuel unit costs half that of the U.S. airline industry average, a gap it sees widening in 2024.

As larger ULCCs in the U.S. are working to restore confidence in the model, the country’s smaller budget airlines posted profits last year. Allegiant Air and Sun Country Airlines reported net incomes of \$118 million and \$72 million, respectively.

Out-and-back flying always has been a cornerstone of Allegiant’s strategy, and during a recent investor call, CEO Maurice Gallagher suggested his carrier exists in its own category. It, along with Sun Country, has posted an annual profit for the past three years.

“I understand there’s a new label as well for ULCCs circulating—LMAs, or low-margin airlines,” he said in November. “That description does not define, nor fit, our model. . . . I’m proposing a new label for us—no more ULCC and certainly no LMA. Our new label is PLFC: profitable leisure-focused carrier. That’s what we are to be called from now on. We are in a class of our own.” 🗣️

Cebu Pacific Targets 100-Aircraft Order To Meet Philippine Demand

- > CARRIER CONSIDERS BOTH AIRBUS AND BOEING FOR AN ORDER IT WILL ANNOUNCE BY MIDYEAR
- > NEW, EXPANDED MANILA AIRPORTS WILL ACCOMMODATE GROWTH

Adrian Schofield

Cebu Pacific is moving closer to placing a major narrowbody aircraft order, as it looks to exploit demand likely to be unlocked by long-overdue airport development in the Philippine capital Manila.

The Manila metro area ranks in the world's top 10 by population, but congestion at the city's main airport has constrained travel demand. This dynamic looks set to improve in coming years due to multiple airport projects that are underway.

Cebu, the dominant carrier in the Philippines domestic market, has signaled its intention to order narrowbodies to support plans to double its fleet size by 2035 (*AW&ST* Feb. 12-25, p. 50). Airline CEO Mike Szucs revealed more details about the prospective order and fleet strategy during a recent interview with *Aviation Week*.

The airline is still negotiating with aircraft and engine manufacturers before making its choice, Szucs says, with an announcement due in May or June. The deal will likely include 100 firm orders with additional options. While Cebu has an all-Airbus narrowbody fleet, this does not rule out a Boeing order, Szucs adds.

He notes that the construction of a second major airport for Manila means Cebu may have a split hub operation and could deploy a different fleet at the new location. The current Airbus fleet already is large enough to achieve economies of scale.

"So I'm fine if it's Airbus, but I'm also fine if it's Boeing," Szucs says. "What will drive the answer is what gives me the right economics."

The airline will include different-size models in the order, he says. This would mean the Airbus A320neo and the A321neo, or the Boeing 737-8200 and 737-10.

Such an order would dwarf Cebu's current fleet of 56 Airbus narrowbodies. It has another 27 on order, seven of which are due to be delivered this year. The airline also operates eight

Airbus A330neos and one A330-300. It will have a fleet of 10 A330neos by the end of this year with six more on order, Szucs says.

The country has a large and growing population of about 115 million, ranking 13th in the world—and relatively young and increasingly wealthy.

Congestion at Manila's Ninoy Aquino International Airport is spurring airport development in the metro area.



Its GDP has also returned to its pre-pandemic growth rate of about 6% per year. These factors indicate a rising propensity to travel, Szucs says.

Geography is another factor. Because the nation is an archipelago, air service is vital for domestic travel. Szucs notes there are 2 billion people within a four-hr. flight range from Manila. Overall, the domestic and short-haul international opportunities give Cebu Pacific "a massive addressable market," he says.

However, more airport capacity is required to tap into that potential. Manila's Ninoy Aquino International Airport (NAIA) was designed to handle 32 million passengers a year. It reached 48 million in 2019, and traffic has rebounded since the pandemic to about 45 million in 2023.

Traffic demand for the metro Manila area is expected to reach 90 million passengers a year by 2030. This

will be addressed through a multi-airport approach. Capacity will be increased at NAIA through a public-private partnership led by San Miguel Corp., which has been awarded a concession to run the airport. A range of planned improvements is expected to boost capacity to 62 million passengers per year.

A second major airport for the Manila metro area is being constructed at Bulacan about 35 km (22 mi.) north of the city. Known as the New Manila International Airport (NMIA), this will also be operated by San Miguel Corp. under a concession. NMIA is expected to be developed in phases, and an initial stage capable of handling 35 million passengers a year

could be completed as early as 2027. The ultimate goal would be for NMIA to handle 100 million passengers a year, making it Manila's main gateway.

Another development is underway to expand an airport at Sangley Point for commercial operations, although this is less advanced than the Bulacan project.

Szucs said the multi-airport approach in Manila could be viewed in the same way as the London area airport system or the Tokyo multihub approach.

Farther north is Clark International Airport, 80-90 km from Manila. While Clark has its own catchment area, it also draws traffic from the north of metro Manila.

Beyond the Manila area, upgrades also are underway at regional airports in the Philippines. Cebu Pacific intends to take advantage of this work by establishing more aircraft bases at regional airports, Szucs says. 🌐

PAYBACK TIME

> AIRCRAFT LESSORS
ANTICIPATE YEARS OF
STRONG DEMAND

> FEW SHORT-TERM
PRODUCTION SLOTS
REMAIN UNPLACED

> LEASE EXTENSIONS
REACH HISTORICALLY
HIGH RATE



Jens Flottau Austin, Texas

To say aircraft leasing is always a license to print money would be unfair to the industry. After all, it was lessors and governments that ensured most airlines survived the COVID-19 pandemic that started four years ago, at their own great expense. But when lessors and aircraft traders convened at the recent International Society of Transport Aircraft Trading Americas conference, the mood could not have been better.

As air travel continues to recover and grow, airlines seek additional capacity at almost all costs. Manufacturers are ramping up production more slowly than anticipated, and given the supply chain troubles dogging industry, no quick fix is anticipated. If anything, a look at Boeing's production crisis makes it likely that short supply will continue to hit very high demand for the foreseeable future.

More than any other sector, lessors benefit—and not only through their outstanding orderbooks. Their in-service fleets, including midlife and older aircraft, continue to gain value, reflected in the rising lease rates.

"We last saw a market like this before the global financial crisis," BOC Aviation CEO Steven Townend said.

"Now it's almost payback time," Alton Aviation Consultancy Managing Director Denis Hogan remarked. "This is as good as it gets." Alton has many lessor clients, and it is payback time after lessors agreed to many lease deferrals and restructuring of existing agreements during the pandemic. They even allowed zero-hour contracts, in which airlines paid them only when the aircraft were flying. These contracts have essentially expired.

To Hogan, a key element of the story is that "major lessors stayed

calm" at the peak of the crisis. Even a year ago, it was hard to place aircraft that were less favored by airlines. Now, he said, "most older leases are going to be extended" even for aircraft like first-generation Airbus A330s and Boeing 777s that would otherwise be headed for retirement.

"Lease rates are up, extension rates are extraordinarily high, and the structural constraints will not go away for a long time," Aviation Capital Group President and CEO Thomas Baker said. "Pricing discipline has returned to the [leasing] industry. Lessors have pricing power."

"Airlines can't get planes, and in the extension discussions, they are struggling to accept that they will have to pay higher rates," Orix Aviation Group CEO James Meyler said. "But the reality is that we have many other options. They have to move to the market lease rates."

"Lease rates have a bit more to go," Hogan noted. "Sale-and-leaseback rates go up because of [higher] inter-



JAROMIR CHALABALA/ALAMY STOCK PHOTO

est rates.” The rate increases vary by type. While latest-generation narrowbodies and widebodies are the most popular and thus most expensive, even midlife Airbus A320s and Boeing 737NGs are experiencing a recovery.

“Prices are where they should be based on demand,” Jetcraft Commercial President Raphael Haddad said. He estimated that values were up 35% year-over-year, adding: “Lessors that have inventory are having a blast. It is time to make money.”

“Demand continues to outstrip supply for aircraft, for engines and for helicopters,” AerCap CEO Aengus Kelly said in a recent investor briefing. “We expect this dynamic to persist for many years.”

Demand is so high that even lessors often cannot provide quick-fix solutions they would normally be able to offer. Airlines that need additional lift must wait two or more years for the next opportunity, even through the lessor channel. Orix is working on contracts that expire in 2027.

BOC Aviation is taking a more tactical and opportunistic approach. “We can still do 2025, pragmatically, because we think rates will go further up,” Townend said at the conference. “We could place much further out, but we hold on to some [aircraft].” Nonetheless, more than 90% of BOC’s lease expirations are staying with the same airlines.

Leasing executives doubt that Airbus, Boeing and the engine manufacturers can stick to their planned output increases. “Even if they do hit the numbers, we still see a shortage,” Townend said. “Not so much in this

As airlines desperately seek more aircraft, lessors benefit from much higher lease rates.

part of the world but in Asia and China. People are underordered. Parts of Asia are still behind 2019. We do see this continuing.”

Although many airlines have improved their balance sheets in the past year or two, Air Lease Corp. (ALC) CEO John Plueger believes that will not dent demand for leased aircraft for some time. “All predictions point to six out of 10 new aircraft deliveries in 2024 being leased in some way, shape or form,” he said. “While you would think that the stronger balance sheets might indicate a little bit less on the leasing side, we don’t see that yet. Airlines are still looking for airplanes from all sources.”

The leasing industry itself will continue to consolidate, prominent representatives believe. Meyler pointed out: Ten years ago, “you needed 100 aircraft to be a top 10 lessor—now it is 300.” But with consolidation, he predicted, several lessors will own fleets in excess of 1,000 aircraft.

Townend argued that bigger investment-grade lessors will have cheaper access to capital and therefore a competitive advantage over smaller ones. Those that are ranked around 15-30 “will have to make a decision. You don’t want to get stuck in the middle,” he said.

Some relevant structural shifts have occurred in the leasing sector. Over several years, a host of new Chinese lessors entered the market, ostensibly and gently guided by government policy that saw building exposure in the sector as a sensible move. But that phase is long over.

In addition, geopolitical tensions are rising, particularly between the U.S. and China. While falling short of a full decoupling, Chinese lessors have tried to dispose of more of their Western clients and to focus more on supporting the airline industry at home. They also have not placed any significant orders with the aircraft manufacturers for some time.

Others have stepped in. AviLease is a new player in the industry, supported by Saudi Arabia’s Public Investment Fund and quickly building a substantial fleet, much helped by the acquisition of Standard Chartered’s portfolio of 120 aircraft for \$3.6 billion. Dubai Aerospace Enterprise took over an order for 64 Boeing 737 MAXs from China Aircraft Leasing Group.

The boom also is kick-starting transactions between lessors, a market that has lagged over the past few years. Those that could afford to hold on to their fleet did so, hoping for better times. Many others could not afford expensive transactions even with interest rates at zero. Now, despite much higher interest rates, the inter-lessor market is picking up fast. ALC, for example, is seeing very high demand from other lessors, airlines and funds to buy aircraft from its fleet.

“They see a strong demand environment,” Plueger said. “And I think they see in 2024 the commencement of interest rate lowering, and they believe that demand will continue. So that’s a favorable environment.”

Selling part of its portfolio is standard ALC strategy for several reasons. The lessor has a large orderbook for new aircraft and wants to keep the fleet young. It typically sells when aircraft reach about 7-8 years of age and when multiyear leases are still attached. “It’s also a way to generate cash to keep our debt-to-equity ratio in line,” Plueger added.

During the COVID-19 years, ALC did not sell many aircraft. It is now interested in resuming that activity. “We tapered aircraft sales, and we did so because maybe the prices weren’t strong, because it was an uncertain time and we had airlines not flying,” he continued. “Airlines were figuring out if they could just stay in business. We have an investment-grade rating and a strong balance sheet. We were not in a forced sale position, and so we cut back a little bit.”

Azorra bought all of Egyptair's Airbus A220s to place them with new lessees.



AIRBUS

"On the trading side, we continue to see a healthy bid for aircraft from investors and other lessors and expect to see robust demand for aviation assets continuing throughout the year," Kelly concurred.

"There are still management teams out there looking to grow," Hogan said. "There are always niches."

One to watch: High Ridge Aviation, set up by former GE Capital Aviation Services CEO Greg Conlon, is looking at building a significant aircraft portfolio.

One of the buyers of aircraft portfolios is Azorra, which is trying to take advantage of the opportunity for fast growth. "We could easily double again to 400 or 500 aircraft," Azorra President Ron Baur said. "We have to add scale. We have a really exciting pipeline of opportunities." The lessor is looking at further sale-leaseback arrangements, portfolio acquisitions or a takeover of another lessor.

Azorra is a relatively new player in the leasing market, founded by CEO John Evans and backed by private equity firm Oaktree Capital Management. It has a fleet of just under 100 owned and managed aircraft, with commitments for a further 70. Among its backlog are direct orders for 35 Embraer 195-E2s and 22 Airbus A220s. Its direct competitors include Falko, Nordic Aviation Capital and TrueNoord.

The recent acquisition of a fleet of 16 aircraft from Voyager Aviation Holdings broadened Azorra's aircraft portfolio to include more widebodies, particularly A330s and 777-300ERs. Baur said he is happy with how that

segment is performing: "The wide-body market is really taking off; every lessee is extending. The market is really better than we had thought."

Azorra also stepped in when Egyptair wanted to sell a fleet of 12 Airbus A220s that were underperforming in its network and in the harsh climate in which they generally operate. Azorra saw a good market to place the aircraft with other airlines while Airbus sought to place A350s with Egyptair.

Although the strong demand and supply imbalance help support very high lease rates and minimize the risks of not placing aircraft that come off lease quickly, manufacturer delays are not all positive.

For starters, lessors are not sure what their investments will be even in the current year. ALC is a good example: It is due to receive 26 737 MAXs in 2024, according to the Aviation Week Network Fleet Discovery database, but the company gave a wide range of guidance of \$4.5-5.5 billion investment in new aircraft for the year.

"A big part of that fairly wide range is the uncertainty over the MAX," Plueger said. The company has focused its MAX orders on the -8 and -9, with 77 more aircraft yet to be delivered and 81 in the fleet.

Second, lessors have their own commitments to their customers and have to juggle many moving parts when an aircraft is delayed. "Tell us what you can actually do," ACG's Baker urged industry. "We need transparency. We need to know when this stuff is coming. We get schedule revisions repeatedly, and that makes it hard for us to

deliver to our customers. Don't just keep moving the goalposts."

Underneath the surface are ongoing tense negotiations among the OEMs and a vast array of customers. "We feel very clearly these are inexcusable delays," Plueger said. "We have made some arrangements with Boeing and some with Airbus. But I would just say that that issue continues and probably will continue for some time."

When delays are defined as inexcusable, customers are entitled to financial compensation from the manufacturers. They can also use the entitlement as leverage in negotiations for future orders.

Azorra's Baur contends that Embraer can benefit significantly from the earlier availability of production slots. "It definitely helps Embraer," he said. "And they are gaining traction with major airlines."

For aircraft traders like Jetcraft, the boom has unwanted consequences. "There are essentially no narrowbody aircraft traded on the market," Haddad said. That is because airlines are holding on to their fleets to the extent possible. "We have not been able to find a single narrowbody. We can be lucky enough if we find regional aircraft."

That is a space in which Jetcraft is highly active. The company recently bought 19 De Havilland Dash 8-400s from Horizon Air, 25 Bombardier/MHI RJ Aviation CRJ-200s from Delta Air Lines, and Embraer 145s and CRJ-1000s from Air France. "The regional segment is very active right now," Haddad said.

For the time being, no one in the industry anticipates a turn for the worse. Of course, there are issues to worry about: Ukraine, Israel, China, high interest rates and Europe's sluggish-at-best economic trends. However, any effects from factors that could be slowing down business cannot be felt yet.

One reason that CEOs believe the situation will not change is the length of lease rate extensions. Most airlines are looking at 3-4 years—not 12-18 months—to bridge capacity shortfalls created by manufacturer delivery delays. That will lock in current market rates for a longer period of time.

On the other hand, this would not be the commercial air transport industry if things were stable for long. "Stuff will happen," Hogan said. Just not yet. ☼



Both the U.S. Air Force and U.S. Navy will reduce planned F-35 buys under the fiscal 2025 budget.

CAPITOL CONSTRAINTS

- > PENTAGON ROLLS OUT SPENDING PLAN UNDER CONGRESSIONALLY MANDATED CAP
- > PROCUREMENT INCLUDES FEWER FIGHTERS THAN EXPECTED
- > MULTIPLE HYPERSONIC PROGRAMS TAKE CUTS

Brian Everstine and **Steve Trimble** Washington

Faced with mandatory cuts to its projected top-line budget, the Pentagon has sent Capitol Hill a budget plan riddled with slashes to procurement and delays to major research and development programs, with an expectation that lawmakers may provide more flexibility.

The Defense Department on March 11 unveiled a fiscal 2025 spending plan of \$849.8 billion, a drop from the projected \$895.2 billion due to the Fiscal Responsibility Act, a measure enacted amid the 2023 debt limit battle that limits discretionary spending if the government remains funded under a continuing resolution. The 2025 plan is a 1% increase over the fiscal 2024 request that was still awaiting appropriations as of late March, but it is a reduction in overall spending power because of the rate of inflation.

“We do not have positive, real growth in this budget, but again, that was intended by our elected officials who agreed on the top line last year,” Pentagon Under Secretary and Comptroller Mike McCord says.

Largely because of the spending cap, the U.S. Air Force plans to cut 250 aircraft and reduce its planned buys of Lockheed Martin F-35 Lightning IIs and Boeing F-15EX Eagle IIs. The service expects to shrink its overall fleet of the latter to 98, down from the original plan for 144. Fighter retirements expected in 2025 include 65 F-15C/Ds and 26 F-15Es, along with 32 older Lockheed Martin F-22s, 56 Fairchild Republic A-10s and 11 Lockheed Martin F-16C/Ds.

U.S. Air Force Secretary Frank Kendall says this plan represents what the service sees as “an acceptable level of risk” as it looks to future capabilities, though short-term spending also is taking a slight cut. Its fiscal 2025 request for the Next-Generation Air Dominance (NGAD) fighter platform is \$2.81 billion, up from \$1.9 billion in fiscal 2024’s request though slightly down from the \$2.97 billion expected under the prior year’s plan. The service now wants to spend \$16.23 billion over the next five years on NGAD.

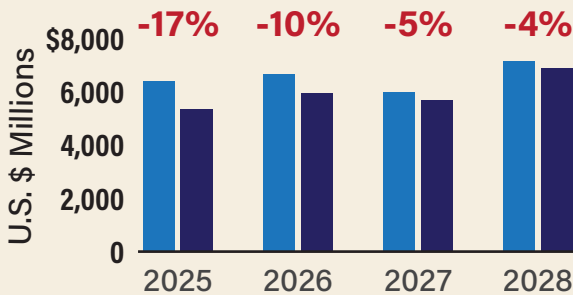
The Air Force’s big plans for the uncrewed Collaborative Combat Aircraft include a modest \$559 million for fiscal 2025, as the service expects to close the design and begin construction of the platform’s first increment and concept refinement for the next increment. A downselect to two is

Comparing 2024 and 2025 Future Years Defense Program Plans

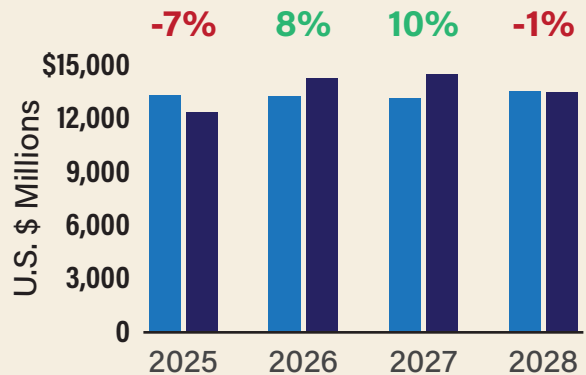
Key

■ 2024 FYDP ■ 2025 FYDP % Change

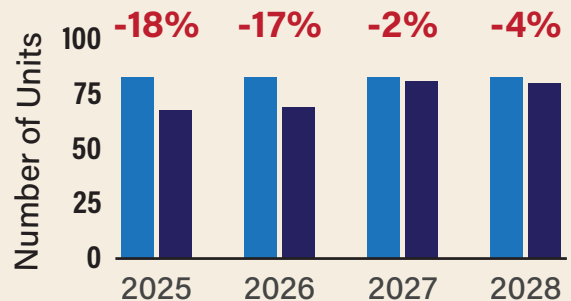
B-21 Procurement and Research and Development



F-35 Overall Spending



F-35A/B/C Aircraft Procurement by Unit



Source: U.S. Defense Department

planned for this summer, with Anduril, Boeing, General Atomics Aeronautical Systems Inc., Lockheed Martin and Northrop Grumman under contract for the first increment.

The Air Force is looking to begin procurement of the Boeing T-7A Red Hawk trainer in fiscal 2025, buying seven of the aircraft—half of what last year's spending plan called for. Additionally, budget documents show the T-7A's expected in-service date has been delayed to 2028. It was previously projected to be in service this year.

Air Force officials report good financial news for the Northrop Grumman B-21 Raider program, as lower-than-expected contract costs have translated to reduced spending. The request calls for \$1.96 billion in procurement for an undisclosed number of the bombers, up from \$1.62 billion in the fiscal 2024 request, along with \$708 million for advanced procurement. This is a considerable reduction from last year's projected total of \$3.09 billion for procurement.

"There were no material reductions in program quantities or scope," a service spokesperson says. "The procurement funding includes aircraft flyaway costs, support equipment, training, initial spares [and] engineering change orders. The B-21 program office continues to proactively manage the program baseline for cost, schedule and performance."

Like the Air Force, the U.S. Navy is projecting a smaller procurement total that it blames on the budget restrictions. The service plans to buy 13 F-35Bs and 13 F-35Cs in fiscal 2025, down from the expected 19 and 16, respectively.

"That creates a downward pressure where hard decisions

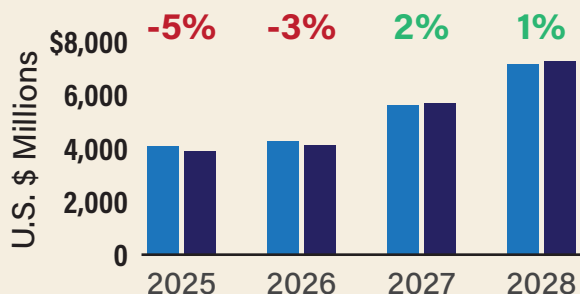
have to be made in the '25 budget to meet all the requirements of the Fiscal Responsibility Act," U.S. Navy Secretary Carlos Del Toro said March 7 at the McAleese Defense Programs Conference in Washington. He added that the Navy also is concerned about delays to Tech Refresh 3 and F-35 Block 4 upgrades. "Hopefully, industry will be able to overcome that challenge, and we'll be able to start buying that at higher rates in the future as well," he said.

Other Navy procurement plans include 27 Multi-Engine Training Systems, 19 Sikorsky CH-53K heavy-lift helicopters and three Boeing MQ-25 aerial refueling drones.

A Navy budget presentation also shows plans to move ahead on a new trainer, with procurement to begin in 2026 for a replacement to the McDonnell Douglas T-45. The service has conducted extensive market outreach for the program, now named the Undergraduate Jet Training System. An August request for information calls for a minimum of 145 aircraft with a full-rate production of 25 per year. Competitors for the program include Leonardo and Textron offering the M-346N, Lockheed Martin bidding the TF-50N and Boeing the T-7A.

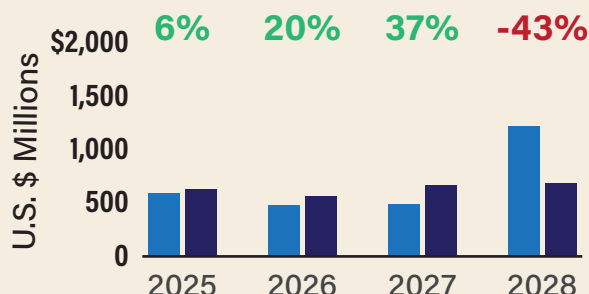
Even as the Navy cuts back on near-term procurement, it also is slashing research and development (R&D) for its future fighter. The fiscal 2025 request calls for \$458 million in R&D spending for the F/A-XX, a \$1 billion cut from the previous year's request. Navy officials say the service "remains committed" to the program, with long-term spending being rephased. However, long-term budget plans show spending

U.S. Air Force Next-Generation Air Dominance Research and Development*



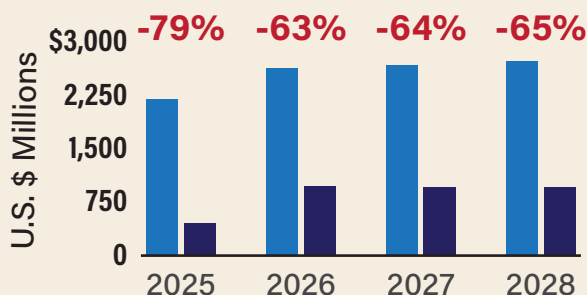
*Includes funding for Collaborative Combat Aircraft and Next-Generation Adaptive Propulsion.

U.S. Air Force Classified Missile Procurement*

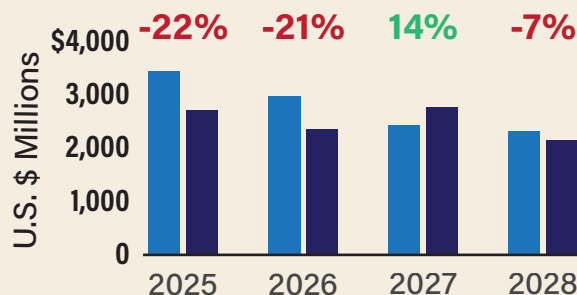


*Possibly includes Lockheed Martin AIM-260 Joint Advanced Tactical Missile

U.S. Navy Next-Generation Fighter



Hypersonic Weapons*



*LRHW, CPS and HACM.

peaking at \$970 million in fiscal 2026 for the program, a sizable cut compared with past plans and less than half of what the Air Force expects for its own future fighter.

The U.S. Army got ahead of budget season in February, creating headlines with the cancellation of the Future Attack Reconnaissance Aircraft (FARA) after already spending \$2 billion on the program. This shifted \$4.5 billion in spending across the next five years to other priorities, beginning with \$465 million in fiscal 2025.

Instead of continuing the FARA, the Army aims to buy new Boeing CH-47F Chinook Block IIs, more Sikorsky UH-60M Black Hawks and additional uncrewed aircraft systems. Overall, the plan allots \$3.16 billion to procurement for fiscal 2025. The service expects to buy six of the modified Chinooks per year, starting with \$700 million in fiscal 2025. For Black Hawks, it projects about \$800 million per year in fiscal 2027, 2028 and 2029, part of a new multiyear buy of 20-24 per year.

The 2025 request includes \$1.26 billion for advanced aviation development, especially the Bell V-280 Valor tiltrotor for the Future Long-Range Assault Aircraft program. This includes continuing builds of engineering and manufacturing development (EMD) types 1-6 and beginning manufacturing of EMD prototypes seven and eight, says Douglas Bush, Army assistant secretary for acquisition, logistics and technology. He adds that the service plans to make a Milestone B decision this year, finalizing the costs for the overall EMD phase.

The GE Aerospace T901 engine, developed as part of the Improved Turbine Engine Program, was key to FARA and is also pivotal to future UH-60 and Boeing AH-64 Apache upgrades. With FARA canceled, the Army is cutting back on the T901 by delaying the preliminary flight rating two more years.

While hypersonic weapons have emerged as a public priority across the Pentagon, individual programs are seeing delays and funding hits in the fiscal 2025 request.

The Army is projecting \$1.28 billion for the Long-Range Hypersonic Weapon, a 6% reduction from last year's spending plan. Within this total, R&D would increase 47% following a series of test failures, with procurement dropping by 26%. The Navy is not procuring any of the related Conventional Prompt Strike missiles in fiscal 2025, with officials saying the service is assessing the program to determine the "best course of action" and to rephrase missiles to future years.

Meanwhile, the Air Force appears again to zero out funding for the Lockheed Martin AGM-183 Air-Launched Rapid Response Weapon (ARRW), which was originally expected to be one of the first hypersonic systems fielded. The move comes two years after the service first shifted ARRW funding out of procurement and after one of the missiles was deployed to Guam for its final test, which took place March 17.

In a statement, the Air Force said ARRW will conclude its activities under the fiscal 2024 Middle Tier of Acquisition.

tion authorities. While ARRW has failed multiple tests, it recently has seen successes. The Pentagon's Director of Operational Test and Evaluation noted in an annual report released in early February that two all-up-round tests in March and August of 2023 demonstrated proper release and boost/ascent.

"The Air Force remains committed to fully analyzing and understanding all test data gathered while conducting the ARRW Rapid Prototyping test series," the service said in an email. "This data will inform subsequent development and fielding decisions with ARRW."

Funding now largely focuses on the RTX-Northrop Grumman Hypersonic Attack Cruise Missile. The budget includes \$517 million for development of this missile, with upcoming flight tests expected in concert with Australia under the Southern Cross Integrated Flight Research Experiment project agreement.

The still-young U.S. Space Force is taking its first budget reduction under the fiscal 2025 plan with a projected \$29.4 billion budget—about a \$600 million cut from its fiscal 2024 request. Within that total, the Space Force expects to spend \$18.7 billion on R&D, testing and engineering. Major efforts in the budget include \$4.7 billion for the proliferated multi-orbit missile warning architecture, encompassing both the Space Development Agency's proliferated low-Earth-orbit plan and Space Systems Command's medium-Earth-orbit designs.

Other efforts include \$413 million for the Evolved Stra-

tegic Satellite Communications program for secure nuclear command and control, a \$237 million new start for the Protected Technical Satellite Communications Global program to disaggregate Ka- and X-band capabilities on geostationary Earth orbit and \$111 million for space domain awareness systems including new network sensors.

Launches are a key driver in the Space Force's reduction, with 11 to be purchased in 2025 compared to the 15 planned. This is largely because of payloads not being ready in the time frame, says Maj. Gen. Michael Greiner, deputy assistant secretary for budget.

While the Space Force's budget is slightly down, Air Force Secretary Kendall says it does not tell the whole story. Much of what the Space Force does is in collaboration with other groups, such as the National Reconnaissance Office, with spending from what is known as the pass-through budget—Air Force money budgeted to go straight to other agencies.

Broadly speaking, Kendall remarks, the Space Force is not moving as fast as he would hope in putting new capabilities on orbit. Beyond the budget plan, he says he will use new authorities granted by Congress for new-start acquisitions ahead of appropriation for space programs next year while pushing other programs to move more quickly in the interim.

"Overall, I consider this to be an acceptable budget," Kendall says. "I can defend it. It does move forward on the things that we prioritize. Again, I'd like to be able to move faster, but we do have constraints." 🗳️

FAA Budget Proposal Takes Aim at Business Aviation

- AGENCY BUDGET WOULD CLIMB 14.6% IN POST-PANDEMIC REVAMP
- PROPOSED AIRPORT AND AIRWAY TRUST FUND TWEAK WOULD PUT MORE BURDEN ON PRIVATE JETS

Sean Broderick Washington

The Biden administration's proposed FAA fiscal 2025 budget seeks to ensure that aviation will provide enough tax revenue to fund the agency's chief regulator and that the tax burden will be distributed equally among users of the system. The ideas may sound simple, but winning consensus will not be easy.

Under the Transportation Department proposal unveiled March 11, bottom-line FAA funding would rise 14.6% compared with the past two years, led by a 22.2% increase in the facilities and equipment account. Agency funding would total \$21.8 billion, not counting another \$5 billion in special Bipartisan Infrastructure Law (BIL) grants.

The Transportation Department also detailed the administration's pro-

posed business aviation fuel tax increase to bolster the Airport and Airway Trust Fund (AATF). The change would raise the fuel tax for private jets to \$1.06 per gallon from 22 cents within five years, the department says.

The AATF provides most of the FAA's funding through excise taxes on tickets, frequent-flyer miles, fuel and mail. Revenues fell during the pandemic-related travel demand dip, however.

In fiscal 2020, the AATF funded 97% of the agency on the strength of 2019 activity, with the rest coming from the U.S. General Fund. In fiscal 2022, the AATF provided just 70% of FAA funding, not counting BIL grants and other emergency measures.

An FAA-ordered safety review of

the National Airspace System completed in late 2023 called for a revamp of AATF revenue sources to provide consistent funding and to reflect airspace usage more accurately. In the Biden administration's view, business aviation is not paying its fair share.

"Private jets are 7% of flights handled by the FAA but contribute just 0.6% of the taxes that make up [the AATF]," the Transportation Department says, calling the scenario "a corporate-jet-funding loophole."

Not surprisingly, business aviation stakeholders beg to differ.

"Of course, every American business should pay the taxes they owe," National Business Aviation Association President and CEO Ed Bolen says. "But President Biden has unfairly chosen to target those who use business aviation, even though the vast majority of flights are taken by U.S. companies to help them compete effectively in a global marketplace."

The FAA statement on the budget proposal does not mention the AATF changes.

"Our No. 1 priority is safety," FAA Administrator Michael Whitaker said. "This budget will provide the FAA

with the necessary resources to continue our essential safety work.”

Among the safety-specific line items: \$15.9 million and two full-time-equivalent positions to continue implementing aircraft certification reforms

stemming from the two Boeing 737-8 fatal accidents in 2018 and 2019 and related reviews. 🌐

NASA's 2025 Spending Plan Is Not What Was Imagined Last Year

- BUDGET FOR MARS SAMPLE RETURN TO BE DETERMINED
- CHANDRA X-RAY OBSERVATORY FACES STEEP FUNDING DIP

Irene Klotz Cape Canaveral

NASA is adjusting its spending outlook after budget caps nixed the Biden administration's requested \$2.3 billion hike for fiscal 2024 and sharply limited the White House's ask for next year.

Under the agreement hashed out by Congress appropriators and signed by President Joe Biden on March 9, NASA will receive \$24.9 billion for the year that began Oct. 1, 2023—\$509 million less than in fiscal 2023. The administration had asked for \$27.2 billion.

At 2% less than what NASA received for fiscal 2023, the 2024 budget marks the first year since 2013 that the agency's budget failed to grow.

For fiscal 2025, the White House is trimming its request to \$25.4 billion, the same amount NASA received in fiscal 2023. It is also about \$2.3 billion less than the projected \$27.7 billion fiscal 2025 request anticipated prior to passage of the Fiscal Responsibility Act, which capped nondefense discretionary spending for fiscal 2024 and 2025.

"We're not going to get out of this hole until you finish both fiscal years, '24 and '25," NASA Administrator Bill Nelson told reporters on March 11.

While today's budget environment is sobering, Nelson, a former longtime senator from Florida, said NASA faced a far more dire situation a decade ago. "This is mild by comparison," he remarked.

NASA's budget should begin to grow again in fiscal 2026, but in the short term, hard choices loom.

The agency's efforts to expand human space exploration beyond low Earth orbit (LEO) under the Artemis initiative should remain mostly on track, although budget documents released March 11 show the third crewed

mission on the surface of the Moon, Artemis V, will be delayed a year to 2030. That is to be the first mission using Blue Origin's Human Landing System (HLS). Artemis III, slated for late 2026, and Artemis IV, expected in 2028, are to use the HLS provided by SpaceX.

Overall, NASA's exploration programs—including the Space Launch System, Orion spacecraft, HLS programs, new spacesuit development and other elements of the Artemis initiative—would receive \$7.6 billion. That is about the same as what NASA

priced and scheduled. Whatever NASA decides to do with the program, overall spending for planetary science is not expected to change, so any additional funds would have to come from other programs, NASA Associate Administrator for Science Nicola Fox and Planetary Science Division Director Lori Glaze said during budget rollout town halls.

An early alarm sounded for NASA's 25-year-old Chandra X-ray Observatory: Budget documents show a drop in spending for telescope operations—to \$41 million in 2025 and \$5 million in 2029 from \$68 million in 2023. "The Chandra spacecraft has been degrading over its mission lifetime," agency budget documents state. "The reduction to Chandra will start orderly mission drawdown to minimal operations."

Funding for the Hubble and James Webb observatories and preparations for the upcoming Nancy Grace Roman Space Telescope infrared observatory are stable.

NASA Directorate Budget Comparison
(U.S. \$ Billions)

Directorate	FISCAL YEAR			
	2023 Enacted	2024 Request	2024 Appropriation	2025 Request
EXPLORATION	\$7.5	\$8.0	\$7.7	\$7.6
SCIENCE	7.8	8.3	7.3	7.6
SPACE OPERATIONS	4.3	4.5	4.2	4.4
AERONAUTICS	0.935	0.996	0.935	0.966
SAFETY, SECURITY AND MISSION SERVICES	3.0	3.4	3.0	3.0

Source: NASA

plans to spend this year and some \$500 million below previous projections.

Planetary science programs face a bigger squeeze. Rather than the anticipated request of \$8.4 billion for science overall, the White House is asking for \$7.6 billion in fiscal 2025. Of that, \$2.7 billion would be allocated to planetary science, which received \$3.2 billion in fiscal 2023 and \$2.7 billion this fiscal year.

Even before the latest budget rollout, NASA was revamping its flagship Mars Sample Return program, which an independent advisory panel last year determined to be unrealistically

The 2025 spending plan proposes that NASA cancel the Geospace Dynamics Constellation heliophysics science mission and revamp a series of Earth System Observatory projects.

Beyond that, NASA's Commercial LEO Destinations (CLD) program faces cuts. The program supports development of privately owned space stations to take over NASA's LEO research program after the International Space Station's planned deorbit in the 2030s. The CLD, which received \$228 million in fiscal 2024, had been expected to receive \$229.6 million in 2025, but the budget ask for 2025 is \$169.6 million. 🌐

The New GE Aerospace Intends To Fly Lean and Focus on R&D

> LEADERS PLAN TO FLEX FLIGHT DECK LEAN OPERATING MODEL

> PURE-PLAY COMPANY EXPECTS BOLT-ON ACQUISITIONS

Michael Bruno New York

On April 2, General Electric will dissolve, and a new pure-play aerospace and defense giant will emerge: GE Aerospace. But as much as the latter will differ from its multi-industry predecessor, two things not only will remain the same but will likely grow in importance to the company and its supply chain: lean operations and steady progress.

“We want everyone to have a continuous improvement mindset—we never rest,” says General Electric (GE) Chairman and CEO Larry Culp, Jr., who will hold the same positions at GE Aerospace. At its birth, the company is unveiling its Flight Deck lean operating model, and Culp and other GE leaders are increasingly looking to bring proprietary versions of lean and kaizen practices to GE Aerospace contractors.

“Flight Deck is the framing of the next step of our lean transformation,” Culp says. “Unfortunately, as we look to meet today’s challenges and tomor-

row’s, it’s not all about what happens inside of our four walls. Our supply chain has a critical role to play.

“Over 80% of our delivery challenges today are somewhere rooted in our supply chain,” he continues. “It might be a supplier to us; it might be a supplier to them. We’re taking Flight Deck to Gemba, to those points of impact, to make sure we can identify constraints, get to root causes and solve them.”

Culp—speaking to financial analysts and reporters at a professionally produced investor briefing in downtown Manhattan on March 7—attributed Flight Deck’s application to a 25% year-over-year improvement in CFM International Leap engine deliveries in 2023. The business operating practices had been soft-launched not just at GE Aerospace’s centers, including Terre Haute, Indiana, but also to unidentified Leap suppliers.

“A lot of that really is a result of taking lean into the supply base to help

them help us,” Culp says. “More to do, but I like the momentum that we’ve got in this regard.”

The board of directors for the existing GE—comprising aerospace and energy businesses and a smattering of other corporate-level functions—decided on Feb. 29 that GE Vernova will begin trading as its own public company on April 2. Shareholders of record on March 19 will receive one share of GE Vernova for every four shares of GE owned. Following the spinoff’s completion, GE will operate as GE Aerospace. GE shareholders will retain their shares of GE common stock with the company.

The first spinoff of GE—once a multi-industry conglomerate and formerly one of the most popular holdings in retail stockholders’ portfolios—came in January 2023 with cleavage of GE HealthCare. The company’s breakup has been years in the making after it expanded into too many disparate sectors and built up too much debt while pursuing aggressive cost-cutting under controversial CEO Jack Welch (*AW&ST* Nov. 22-Dec. 5, 2021, p. 48).

With almost all that behind them, leaders of GE—once known for everything from light bulbs and washing machines to banking and jet engines—now look forward to running a pure-play aerospace and defense company.

Still, GE Aerospace’s launch comes

More Startup Space Special-Purpose Acquisition Companies Fizzle

> ASTRA SPACE IS GOING PRIVATE THROUGH A BUYOUT BY ITS CO-FOUNDERS AND TOP EXECUTIVES

> LOCKHEED MARTIN OFFERS TO ACQUIRE TERRAN ORBITAL

Michael Bruno Washington

While the first quarter of 2024 is not yet over, the year already is destined to be the last for many once-high-flying space startups. From Astra Space to Terran Orbital and others, many of the companies that shot to prominence in 2019-21 after reverse mergers with special-purpose acquisition companies, which allowed them to become publicly traded investments, now are going private or going away.

Astra Space will go private by ac-

cepting a recently lowered buyout bid from its co-founders and top executives, who say the rocket and engine upstart was facing imminent liquidation. CEO Chris Kemp and Chief Technology Officer Adam London, along with their investment backers, will take the Alameda, California, company private. The deal is expected to close in the second quarter, a March 7 announcement states.

In late February, Kemp and London, who own controlling stakes in

Astra, cut their bid to pay just 50 cents per outstanding share, down from the \$1.50 they offered in November. They cited ongoing cash burn, including paying consultants, and said it would be better to give shareholders something rather than nothing via Chapter 7 bankruptcy.

The co-founders have indicated an intent to continue the business, but no details have been announced.

The take-private deal marks a nearly complete reversal from the \$2.6 billion valuation the startup sported when it became a publicly traded company after a reverse merger with a special-purpose acquisition company (SPAC) in February 2021. Astra, which once aimed to launch payloads to low Earth orbit almost every day by 2025, at one point saw itself competing with SpaceX and Rocket Lab. But rocket-launching efforts stopped in mid-2022 after numerous mission failures.

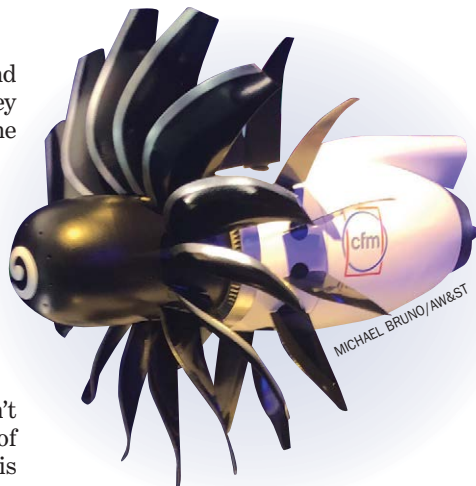
Meanwhile, Lockheed Martin is of-

at a tumultuous time in aerospace and defense manufacturing: Boeing and key supplier Spirit AeroSystems are in the spotlight for manufacturing mistakes in their lifeblood 737 MAX program. The situation has become so dire that the two companies are discussing recombining (*AW&ST* March 11-24, p. 14). Despite such a merger's ability to shape industry, Culp says he has no intention of following suit as a strategy.

"I'm not suggesting that we wouldn't look at opportunities to bring part of our supply chain in-house, but that is a theme—whether because of the Boeing-Spirit [AeroSystems] rumor or some of the things that have happened at the behest of private equity—to me, that's not strategy," Culp told Aviation Week on the sidelines of the March 7 investor briefings.

"That's just reacting to some investment bankers putting forward the most recent popular idea," he continued. "I've never been a fan of allocating capital on the basis of that."

Culp told financial analysts during the formal investor presentation that strategic, operational and financial considerations would drive mergers and acquisitions. He added to reporters afterward that there was no explicit favoritism between the company's commercial aerospace and defense businesses.



GE Aerospace is committing to 6-8% in R&D spending for such projects as the Revolutionary Innovation for Sustainable Engines open-fan program.

"I don't think you're going to see us trying to shape a commercial-defense mix at any one point in time," he said.

Other elements of the capital allocation strategy include a long-term standard of spending 6-8% of annual sales on research and development projects. He advised analysts there would be no "R&D dividend"—a reference to the peace dividend, or cutback in U.S. defense spending at the end of the Cold War. While current projects

may run their course, there will always be something else, Culp stressed.

"If you look over time, that's where we have been, and that's as good of an indicator as possible," he said. "What I was trying to do in response to that question is just knock down the idea that if we can launch a new program, there's some sort of peace dividend [or] program dividend."

Culp and GE Aerospace leaders also provided other facets of their capital allocation strategy. They expect to provide shareholder returns via 70-75% of available funds after R&D and capital expenditures, including a \$15 billion buyback plan. Culp acknowledged to reporters that the 70-75% range "might arguably be on the low end" for aerospace and defense.

Of course, the capital allocation strategy depends on how long Culp intends to remain chief executive. Asked about his intentions by one analyst, Culp provided a roundabout response that suggested he was not departing soon. He noted that he has been unable to focus on just one profit-and-loss business since 1994 and that he was looking forward to having fun.

Culp joked: "I think some of my colleagues at Aerospace were excited about that prospect—others, maybe a bit anxious." 🐞

fering to buy small-satellite startup Terran Orbital for what would amount to a roughly \$606 million enterprise value. Although Lockheed already owns more than a quarter of the startup, the move would secure Lockheed's new-space supplier while putting an end to a dramatic couple of years for Terran.

In a U.S. regulatory filing on March 1, Lockheed announced it had made a nonbinding offer to buy Florida-based Terran, starting with paying \$1 in cash for each share of outstanding Terran common stock. Like Astra and other space SPACs, the company traded at about \$10 per share when it went public.

Other space SPACs similarly have been grounded in recent months. Space tug startup Momentus admitted in January it may have received a fatal blow after losing the U.S. Space Development Agency's (SDA) recent competition for 18 so-called Tranche 2 satellites, recent U.S. regulatory filings state.

On Jan. 12, Momentus said in a Securities and Exchange Commission filing that it had laid off 20% of its staff toward the end of December.

Roughly a dozen space-related startups became publicly traded during the SPAC frenzy that started with Virgin Galactic's SPAC dealmaking in October 2019. That space tourism company in late 2023 announced a strategic pause in business operations as it races to get its Delta-class suborbital vehicles into service by 2026 before running out of cash.

Other companies also have downshifted. Velo3D, a maker of additive manufacturing machinery for SpaceX and other aerospace and defense customers, ousted its founding chief executive in December and has been considering so-called strategic alternatives.

The latest space SPAC headlines follow Virgin Orbit's demise, which started a year before. But not all space

SPACs are flailing. Rocket Lab, which is competing with SpaceX in everything from rocket launches to satellites, bought some of Virgin Orbit's assets and recently became an SDA prime contractor after winning a potential \$515 million award for Tranche 2.

Rocket Lab Chief Financial Officer Adam Spice, speaking on March 19 in California at the annual Roth Capital Partners investor conference, noted how hard space launch is for any company, let alone space SPACs.

"Satellites are difficult, applications from space are difficult, but launch is by far the hardest thing to execute on," Spice said. "It's hard, not just the mechanics and physics of it, but just the cost of capital. There was a period of time over the last 3-5 years where there was a significant amount of capital flowing into startup companies, and I think those days are past. Now the people who have those capabilities have them." 🐞



Leonardo considers its AW09 light helicopter, purchased from Switzerland's Kopter Group in 2020, as one of the drivers of growth in its helicopter business.

Leonardo Lays Out a Formula for Restructuring and Growth

- THE COMPANY HAS CREATED A NEW SPACE BUSINESS UNIT
- DUE DILIGENCE IS UNDERWAY ON A DOZEN POTENTIAL GROWTH TARGETS

Tony Osborne Rome

Leonardo is seeking growth through new alliances, digital restructuring and greater focus on the cyber and space domains as it adapts to the changing global security situation.

Just as Russia's invasion of Ukraine has proven that dual-use digital technologies—including mobile phones, commercial drones and low-cost satellite communications—can be as transformative on the battlefield as modern weaponry, the company sees its own digitalization as the key to its transformation plan.

Leonardo CEO Roberto Cingolani—a former scientist and government minister—told investors on March 12 that the company has made great strides in the process. It has adopted supercomputing to support development programs and built artificial intelligence algorithms, cloud computing networks and electronic systems “as the glue” at the heart of all its products, he noted.

“Bullets and bytes are the new approach,” he said. “Leonardo has

everything in its portfolio—the point is to create your orchestra to put them together.”

In fact, the efforts have given the company a competitive advantage, he said, particularly through the creation of lucrative digital services.

The European defense group, which counts Italy, Poland and the UK as its domestic markets—with a golden share owned by the Italian government—laid out its four-year industrial plan for investors on March 12. Through this plan, it hopes to grow not only orders, revenues and profits but also its product line through mergers and acquisitions.

While Leonardo's managers are processing about a dozen due diligences on small and midsize enterprise targets in emerging technologies and markets, Cingolani told investors, the company needs to rationalize, too. He wants to save €1.8 billion (\$1.9 billion) over the next four years, driving changes in procurement by retendering contracts across the supply chain; reducing company travel, real estate

and the corporate center; eliminating noncore businesses; and shrinking its electronics portfolio around 20%.

Cingolani argued that closer cooperation and coordination are needed in Europe, a market fragmented by the number of countries and industries vying to send their products into the market. As examples of cooperation, he pointed to Leonardo's partnerships on the Global Combat Air Program (GCAP) among Italy, Japan and the UK; on ATR with Airbus; with missile producer MBDA and electronic warfare specialist ELT Group; as well as its share in Germany's Hensoldt.

“No single European country can make it on its own . . . and we fragment our effort when we are not coordinated,” Cingolani stated, adding that security should be addressed as a “continental program, not a domestic or national one.”

Internal fragmentation has prompted a change in how Leonardo participates in the growing space market, too. Having previously presented itself through joint ventures and shareholdings, the company now has established a space business unit.

“Leonardo can do everything in space,” Cingolani said. “We are in launchers, we are in [satellite communications], we are in satellite services—but the point is there was no clear identity.”

The new unit consolidates the Telespazio joint venture with France's Thales and extracts several product lines from Leonardo's electronics

business, which made products such as sensors for spacecraft. Its key focuses will be ground services; satellite development, production and services; and space exploration.

Cingolani reported no interest in pursuing launch capabilities nor satellite communications apart from meeting some Italian domestic needs. There is, however, interest in the development of a so-called space cloud, an in-orbit network able to process data in orbit rather than on Earth.

Such a capability could be “fundamental to improve our capability in satellites,” he said.

Meanwhile, Leonardo plans to maintain and grow its aircraft and helicopters business. Cingolani said he expects continued growth from sales of the Eurofighter Typhoon combat aircraft and development of future capabilities for the platform. However, the company anticipates a transition in the 2030s toward work on the GCAP, as well as next-genera-

tion uncrewed aircraft systems and collaborative platforms, or adjuncts to crewed combat aircraft.

Leonardo’s long-suffering aerostructures business finally will break even in 2025, Cingolani insisted, noting that the company is diversifying the aerostructures business with work for supersonic airliner developer Boom and for advanced air mobility projects.

“Everybody is very committed to the plan,” he asserted. ☞

Tied by Tiltrotor

— Tony Osborne Anaheim, California, and Rome —

WITH THEIR SHARED EXPERIENCE ON TILTROTORS, BELL and Leonardo Helicopters say they are the perfect pair to provide the technology for Europe’s future military rotorcraft needs.

The two rotorcraft manufacturers teamed up in February at the Helicopter Association International’s Heli-Expo through a memorandum of understanding to offer a tiltrotor platform in response to NATO’s call for industry concepts for its Next-Generation Rotorcraft Capability (NGRC).

Leonardo is taking the lead on the proposal, with Bell in support of the NGRC Study 5 activity—part of NATO’s ongoing efforts to deliver a new medium-size rotorcraft for allies starting around 2040.

As part of that effort, NATO’s Support and Procurement Agency plans to place three contracts with industry to deliver up to six rotorcraft concepts that could meet the current NGRC specifications.

Airbus had hoped Leonardo would partner with it to provide an all-European offer, just as the two have teamed on the NHIndustries NH90 program. But it was not to be.

The relationship between Bell and Leonardo extends back to the 1970s. As Agusta, the Italian company produced several Bell-developed helicopters under license for both the domestic and European market. The two also collaborated on development of the AB139 and the BA609 commercial tiltrotor. Bell ultimately sold its share in those two programs. But the AB139—rebranded the AW139—has become one of the most successful

medium helicopters ever sold, while what is now the AW609 is in the final stages of development and nudging toward certification. Meanwhile, Bell has successfully bid its V-280 Valor tiltrotor for the U.S. Army’s Future Long-Range Assault Aircraft, against Sikorsky’s coaxial X2 technology.

“There is a request from the military market to overcome the embedded limitations of the helicopter, and we believe the tiltrotor technology is the answer,” Leonardo Helicopters Managing Director Gian Piero Cutillo told Aviation Week on the sidelines of Heli-Expo. “So let us explore this together.”

Officials at Leonardo insist the new Bell-Leonardo arrangement is not a repeat of earlier relations but rather one that will evaluate the market. They remain tightlipped on what could follow.

Leonardo CEO Roberto Cingolani was similarly upbeat about the arrangement in March as the company presented its industrial plan. “If the two things match, we will do something big,” he told financial analysts.

Even if their relationship is unsuccessful, Leonardo is sure to secure military orders for the AW609—especially from Italy. And it remains partnered with Airbus on the continuing European Next-Generation Rotorcraft Technology initiative funded by the European Defense Fund, which could feed into the NGRC or branch off into a separate development program.

Rival Sikorsky has said it plans to bid on the NGRC studies with an aircraft based on its X2 technology. ☞



JAY MILLER/BELL

Bell and Leonardo are the arguable leaders in tiltrotor technology, but it remains to be seen if their NGRC proposals can pave the way for the V-280 to enter the European market.

F-15s IN FLUX



> U.S. AIR FORCE
DOWNSIZES F-15 FLEET

> MOST STRIKE EAGLES
TO BEGIN RETIREMENT

> REMAINING F-15Es TO
RECEIVE SURVIVABILITY
UPGRADES

Brian Everstine Aboard an F-15E over Southern Idaho

After briefly going supersonic above snow-capped mountains, the Boeing F-15E Strike Eagle pilot, call sign “Grimm,” pulls the throttle to make the twin Pratt & Whitney F100-PW-229 engines slow for a dive.

The range operator, known as Cowboy Control, radioed the pilot to spiral low to the ground in the expansive Mountain Home Range Complex. This F-15E is “red air” for the day’s sortie, acting as a target for other Strike Eagles in the 391st Fighter Sqdn. that are using the aircraft’s powerful APG-82 active, electronically scanned array radars to hunt for enemies as low as 300 ft. above ground.

The Bold Tigers of the 391st showcasing their skills in the late February flight represent broader changes across the U.S. Air Force’s F-15 fleet. The unit is facing retirement of some of its aircraft and upgrades to the rest, all while shifting away from the permissive air-ground role that gave the aircraft its Mudhen nickname and earned it notoriety in the Middle East. Increasingly, with modern upgrades, F-15Es and aircrews are reinventing themselves and training more toward air-to-air combat, as shown in this “blue air” versus “red air” battle. Additionally, the fleet is shifting the strike role to new long-range weapons, such as the

AGM-158 Joint Air-to-Surface Stand-off Missile. These capabilities, service officials say, will be critical in potential combat in the Asia-Pacific region.

Col. Michael Alfaro, the commander of the 366th Fighter Wing who has more than 2,200 hr. in the Strike Eagle, says his unit and the upgrades the aircraft are receiving make the aircraft uniquely suited to help fifth-generation fighters and bombers in a long-range fight.

“We have a lot more that we can carry,” he tells Aviation Week. “Especially with some of these upgrades that we’ll be getting, we can be survivable enough to aggregate with fifth-gen [fighters]. Pulse in the window of permissibility that we can hopefully create and then bring a lot of mass with standoff weapons, [that’s] what I think the niche is for the Strike Eagle.”

The Strike Eagle fleet is in the beginning of a large-scale retirement; 26 are targeted to be removed from operation in fiscal 2025 as part of a plan for an overall reduction to only 99 aircraft from 218. Meanwhile, the entire F-15C/D fleet will be retired over the next four

F-15Es at Mountain Home AFB, Idaho, are changing tactics as the service focuses on the Indo-Pacific region.

years, and the service is bringing on new-build F-15EXs, though that fleet will be reduced far below the original target.

Within the Strike Eagle fleet, the particular aircraft that gave Aviation Week a ride, tail No. 90-235, is one of the lucky ones. The Air Force plans to retain a fleet of Strike Eagles with the F100-PW-229 motors, retiring the older aircraft powered by the lower-thrust F100-PW-220s. These aircraft also are set to receive the new, highly capable Boeing and BAE Systems Eagle Passive Active Warning Survivability System (EPAWSS). The 366th Fighter Wing at Mountain Home AFB, Idaho, was set to send its first aircraft to receive the upgrade in March, and the Air Force plans to upgrade only the F100-PW-229-powered F-15Es.

Additionally, the fleet also is in the process of receiving the BAE Systems and Datalink Solutions Multifunctional Information Distribution System—Fighter Data Link Low-Volume Terminal to improve the aircraft’s situational awareness by providing at-a-glance display of targets, threats and friendly forces.

That is the good news for the Strike Eagles. The bad news is that the priority—directed to the units by higher

headquarters—is modernization over current operations, so the wings themselves must take near-term risk.

“The big problem we have right now is aircraft availability,” Alfaro says. “It was a conscious decision as we’ve gone through all of our conversations. Maybe a first principle is we cannot delay modernization of the aircraft, even if it buys more risk in the short term.”

Since most aircraft are more than 30 years old, that has manifested in parts shortfalls in a tight logistics supply chain, aircrews say. Aircraft are flying with some quirks—individual systems are broken or behave differently—in a process that can look like “death by 1,000 paper cuts,” Alfaro says.

For example, pilots will step in to fly on a particular day and be warned of such things as: “The left display doesn’t work,” “Your radar only works in medium pulse-repetition frequency” or “Your heads-up-display isn’t going to turn on,” he says.

These deficiencies can be hard on young pilots who are looking to build habit patterns while new to an aircraft, Alfaro says.

At any given time, one or two aircraft might be cannibalized for certain parts. As jets go away for Epawss installations, the fleet will face a short-term reduction in addition to maintenance needs.

The wing is managing its flight operations to prioritize training and upgrades for younger pilots, so instructors are flying the most to go through this training. Alfaro says he tries to fly every Monday.

Given the coming retirements—all aircraft powered by F100-PW-220 engines are expected to be gone by 2028—the Air Force is working through force structure plans. RAF Lakenheath, England, is sending its F100-PW-229-powered F-15Es to both Mountain Home and Seymour Johnson AFB, North Carolina. Seymour Johnson will retire one squadron, retaining one operational unit and two formal training units. Mountain Home will keep its 391st Fighter Sqdn. and 389th Fighter Sqdn., though the units will be overcrewed as the F100-PW-220-powered aircraft are retired.

This is all dependent on the Air Force’s plan being approved. Some aircrews anticipate that Congress might step in because of the extent of the retirements.

While the Strike Eagle fleet has some uncertainty, the fate of the F-15C/Ds is set. The service is in the midst of retiring the aging Eagles, which face large mission capability problems mostly centered around structural issues. Sixty-five of these aircraft are targeted for retirement in the Air Force’s fiscal 2025 budget request, and the entire fleet is expected to be gone by 2027.

This has created some gaps across the service. Kadena AB in Japan, for example, has retired the Eagles that had long been based there. F-15Es from the 391st deployed there in 2023 to fill the spot—though it was a unique situation as the base and U.S. Forces-Japan were not used to the Strike

capabilities at “an acceptable level of risk.” Based on the Fiscal Responsibility Act, which limits the Defense Department’s overall budget, the Air Force has been forced to make “some adjustments in procurement in order to fund some additional modernization research and development,” Kendall said.

The plan will likely spark concern on Capitol Hill, where lawmakers are worried about National Guard units in their states. Loh has long been vocal about wanting additional EXs in his fleet to ensure there are enough aircraft for the homeland defense role.

“It is both a homeland defense platform as well as a power projection platform,” Loh says. “The combat capability is . . . much greater than an F-15.”

Specifically, Loh highlighted the F-15EX’s open mission systems architecture as well as a separate computer—distinct from the operational flight program computer—with high-speed fiber connections to more quickly integrate weapons and sensors.

“That is a game changer when we think about modern-day warfare,” he says. “It has the ability to go long ranges, longer ranges than even the F-15C, and so those long ranges allow us to deliver air superiority in a combat-capable

configuration over distances that we would see in the future.”

Rob Novotny, Boeing’s F-15EX program manager, said on Feb. 20 that the first combat aircraft for the Air Force are in production at the company’s St. Louis facility, adding that six test aircraft already have been delivered. Boeing is building 1.5 airframes per month and increasing to two per month by the end of 2025. As of now, the aircraft are being built in a two-seat configuration and cannot be flown in the single-seat design—similar to the Strike Eagle’s model with the weapons systems officer in the rear, though that role will need to evolve.

“We need to clear our minds of the old weapon system operator mindset, and we need to think somebody that’s facilitating a long-range kill chain, somebody that’s working over-the-horizon communication, somebody who is working manned-unmanned teaming,” Novotny says. “That’s what I think that cockpit will be used in the future. That’s the feedback we’re getting from all our customers.”



F-15Es made a rare appearance at Kadena AB in Japan during the summer of 2023.

Eagle’s capability in that location. More recently, Air National Guard F-15C/Ds have taken the role.

Lt. Gen. Michael Loh, Air National Guard director, has said the fleet is so damaged due to age that one aircraft becomes inoperable every six weeks.

Looking forward, the plan had been for new-build F-15EXs to take over for the aging F-15C/Ds. The first EX unit will be in Portland, Oregon, with the Air National Guard, and an active unit at Kadena and the California Air National Guard in Fresno will soon follow. However, much of this force structure is unknown because of shifting Air Force plans for the aircraft.

When the service first announced it would buy the F-15EX in 2021, it said it planned a fleet of 144. That number has dwindled, and the service announced in March, through its fiscal 2025 budget request, that the total fleet will include only 98 of the fighters.

Air Force Secretary Frank Kendall, in a briefing with reporters ahead of the budget rollout on March 11, said the service is looking to protect the fleet’s

How an F-15E Wing Is Evolving Its Tactics

Brian Everstine Mountain Home AFB, Idaho

TWO McDONNELL DOUGLAS F-15Es LINED UP TO LAND here, one after the other, for what looked like a normal two-ship landing.

As a small crowd watched apprehensively, however, the Strike Eagles came in about 600 ft. northwest of the base's expansive runway. With sunshades on the pilot's left and rough terrain on the right, the fighters touched down on the much shorter taxiway.

The test, which the 366th Fighter Wing dubbed Operation Garrison Forward, was devised to practice operating in a conflict when the main runway is destroyed. After weeks of cutting red tape and getting approvals, almost everyone involved, including those in the cockpits, had the same reaction: That is it?

"In a highly contested environment, we fully expect that the adversary is going to bomb all our runways," 366th Wing Cmdr. Col. Michael Alfaro says of the exercise. "We landed an F-15 on a taxiway on purpose, basically just as a confidence maneuver."

It is not a remotely new idea. Fighters have been landing on alternative surfaces like highways for decades. But it was a first for the F-15E and the wing, which plans to repeat the landing on a nearby country road in rural Idaho—and it is a message to potential adversaries.

"The difference between the Soviet Union and what we now face in China is, we've proven time and time again that we can land [Fairchild Republic] A-10s pretty much anywhere, that we can land [McDonnell Douglas] C-17s pretty much anywhere," says Col. David Stamps, commander of the 366th Operations Group. "But China's not really concerned about those airframes as a threat to their mainland."

"But when you have something like a dual-seat Strike Eagle that is [nuclear-capable], with weapons capable of penetrating their borders, and specifically hitting targets of interest at our choosing, that's what we're trying to increase their awareness of," he explains.

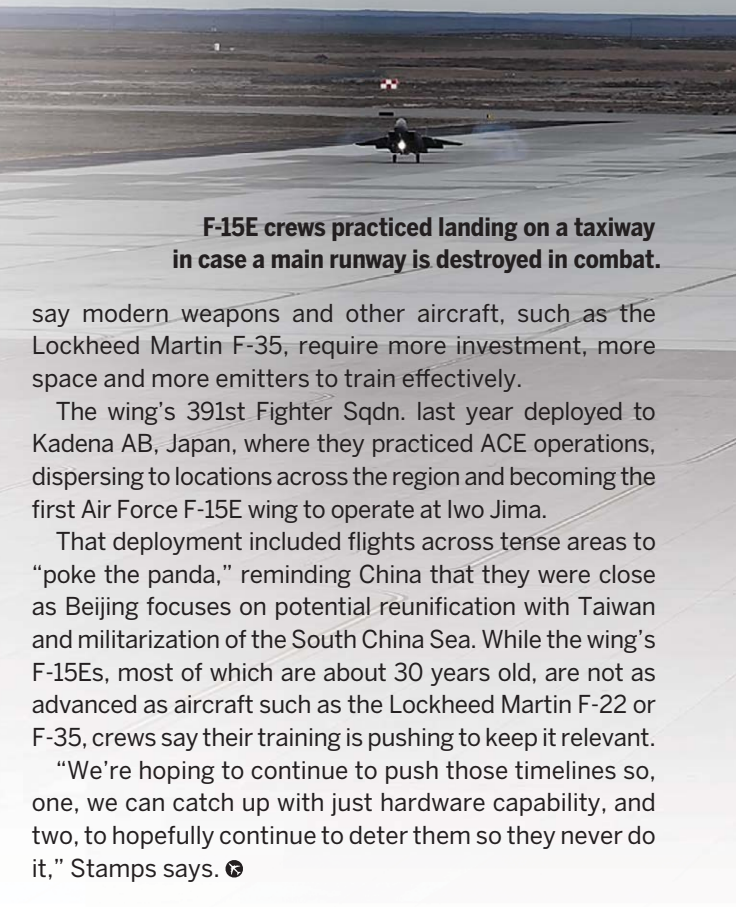
The 366th Fighter Wing and the broader U.S. Air Force F-15E community are in a state of evolution. The aircraft was a workhorse for decades in the Middle East, bombing targets in a permissive environment. Today, the Air Force is shifting to face a different world, with increased threats at longer distances.

The service is addressing this with new tactics such as Agile Combat Employment (ACE), in which aircraft and personnel scatter unpredictably to small, austere locations. In addition, the F-15E carries new weapons such as the Lockheed Martin AGM-158 joint air-to-surface stand-off missile.

Changing tactics and weapons is a bit of a tradition for the wing's "Gunfighters," who earned their nickname—and a Presidential Unit Citation—in the Vietnam War, when aircrews decided their McDonnell Douglas F-4Cs needed guns. Maintainers took it upon themselves to add a 20mm Gatling gun pod, which almost immediately resulted in their Phantoms downing MiGs.

Mountain Home is special because of its airspace. The wing owns the Mountain Home Range Complex, with the Idaho Air National Guard's 266th Range Sqdn. operating about 55 threat emitters in vast, varied terrain that can extend to other ranges in Utah and Oregon, giving pilots room to practice. They can go supersonic above 10,000 ft. and dive as low as 100 ft. while avoiding radars and other threats. Alfaro says this is a "skill set you absolutely have to train to, and you can't do that at every base."

The 266th Range Sqdn. can throw out multiple types of jamming—GPS, radar, communications, data link—along with mobile surface-to-air missiles in airspace the wing can control. This level of training is hard to find elsewhere, even at major ranges in Alaska and Nevada. Pilots



F-15E crews practiced landing on a taxiway in case a main runway is destroyed in combat.

say modern weapons and other aircraft, such as the Lockheed Martin F-35, require more investment, more space and more emitters to train effectively.

The wing's 391st Fighter Sqdn. last year deployed to Kadena AB, Japan, where they practiced ACE operations, dispersing to locations across the region and becoming the first Air Force F-15E wing to operate at Iwo Jima.

That deployment included flights across tense areas to "poke the panda," reminding China that they were close as Beijing focuses on potential reunification with Taiwan and militarization of the South China Sea. While the wing's F-15Es, most of which are about 30 years old, are not as advanced as aircraft such as the Lockheed Martin F-22 or F-35, crews say their training is pushing to keep it relevant.

"We're hoping to continue to push those timelines so, one, we can catch up with just hardware capability, and two, to hopefully continue to deter them so they never do it," Stamps says. 🇺🇸

MBDA Under Pressure To Rebuild Missile Production Capacity

- > AIR DEFENSE NEEDS DROVE 70% OF MBDA'S 2023 EXPORTS
- > JOINT VENTURE TO PRODUCE PATRIOT MISSILES IN GERMANY

Tony Osborne Paris

Since December, warships from UK, French and more recently Italian navies have been firing Aster surface-to-air missiles at Houthi drones targeting merchant shipping in the Red Sea.

The firings represent the first combat use of the Aster missile, the European equivalent of the Standard family of surface-to-air weapons used by the U.S. Navy. The missile's success is driving demand for the weapons.

There is just one small issue: A new Aster missile has taken 42 months from the placing of an order to delivery. This is the result of an outdated production process in which missile components crisscross the Alps between France and Italy several times during each missile's assembly.

"Fundamentally, Aster was developed during the period of the peace dividend," MBDA CEO Eric Beranger told journalists at a company press conference March 13. The manufacturer is a partner in the Eurosam joint venture that builds the Aster, along with France's Thales. "When it was created, performance was looked at, workshares were looked at, along with the way the supplier and governments would cooperate, but time was not important," Beranger said.

The war in Ukraine changed all of that "suddenly and brutally," he noted. Governments' demands for rapid missile stock refills have prompted a wholesale review of the production processes associated with the European manufacturer's missiles portfolio.

The challenges around the Aster's production reflect those facing European defense manufacturers more broadly as governments ask them to rebuild production capacity to a near-war footing.

"We are looking at all our products, starting with the air defense systems, because we have sensed that this is where the priority is in terms of need," Beranger explained. "We have pretty clear targets that we have set ourselves, and we are discussing that

with our customers." He added that there is "huge pressure" to speed up production and to be "battle-ready when asked."

The Aster is a focus of those efforts, Beranger said. The company aims to shorten production time to less than 18 months by 2026—down from the 42 months recorded before the war in Ukraine. Production rates for the type also are planned to increase by 50%, he added.



BEN SHREED/UK ROYAL NAVY

The Aster missile, which the Royal Navy calls the Sea Viper, is the primary weapon of the service's Type 45 air defense destroyers. Several missiles have been fired against Houthi drones in the Red Sea since December 2023.

Beyond that, MBDA is tripling production of the UK-developed Common Anti-Air Modular Missile (Camm), a weapon adapted from the Asraam for land- and sea-based air defense.

Rates for the Akeron MP and Brimstone anti-tank missiles, the Exocet anti-ship missile and the Mica air-to-air missile are also to rise, while monthly production of the Mistral man-portable surface-to-air missile is set to quadruple.

MBDA is backing these efforts with an increase in headcount. Last year, the manufacturer employed an additional 2,500 people across the five member nations—France, Germany, Italy, Spain and the UK—and

envisages a similar increase this year.

Over the next four years, MBDA plans to spend at least €2.4 billion (\$2.6 billion) expanding its production facilities (*AW&ST* Oct. 2-15, 2023, p. 31). Beranger said this is being backed by a buildup in raw material stocks including titanium and electronic components for several thousand missiles. Where the company senses risk in its supply chain, Beranger said, it will build stocks where appropriate.

Demand for ground-based air defenses were a major driver of MBDA's revenues during 2023, representing 70% of its exports. Orders by Poland for Camm and Camm-ER (Extended Range) missiles to meet its sizable Pilica+ and Wisla programs were among the largest export contracts ever signed by the manufacturer. Sweden also ordered Camms for its navy's

Visby-class corvettes, and Italy ordered Camm-ERs to support its Medium Advanced Air Defense System for use by its army and air force.

Other notable air defense contracts for 2023 included the five-nation deal signed at the Paris Air Show to acquire Mistrals jointly, as well as MBDA's Germany-based joint venture with RTX, winning the contract to produce around 1,000 Patriot guidance enhanced missiles in Germany for European operators of the system.

Beranger said the air defense sales made for an "extraordinary year" in which the company received €9.9 billion in orders—10% up from 2022—and increased its backlog to €28 billion. ☛

MADE IN THE UAE

- > UNITED ARAB EMIRATES AIMS TO CONQUER THE DEFENSE EXPORT MARKET
- > FOCUS IS ON AUTONOMY, ELECTRONIC WARFARE AND PRECISION WEAPONS
- > EXPORT FINANCING EMERGES AS NEW OPTION



EDGE GROUP PHOTOS

Steve Trimble Abu Dhabi

An unmarked door opens into a cavernous warehouse at the end of a guarded compound on an isolated fringe of the Arabian Desert in the United Arab Emirates.

Inside, David Campillo, an international business development manager, stands amid the full portfolio of export-ready uncrewed aircraft systems (UAS) offered by his company, Abu Dhabi Autonomous Systems Investments (ADASI), one of about two dozen entities affiliated with UAE defense conglomerate Edge Group.

A common theme emerges in this exhibition of ADASI's fully developed platforms, including the Garmoocha rotorcraft, the fixed-wing Reach-S medium-altitude long-endurance aircraft, the short-range Shadow 25 and long-range Shadow 50 loitering muni-

tions, and the small-munition-carrying QX Series of quadcopter drones. Most of the key technologies—payloads, propulsion, airframes and autonomy—come from ADASI or sister companies within Edge.

"We try to control the supply chain," Campillo says.

Foreign customers want suppliers that deliver on schedule. The UAE government, the industrial group's top customer, needs homegrown alternatives to sometimes restricted foreign technologies. Edge is trying to meet both needs as quickly as possible while considerably raising its

The Reach-S is packed with native technologies made by Edge's diverse range of defense businesses.

profile on the international market. "So it's important to own as much as you can of the process," Campillo adds. "But it's difficult."

The challenge has driven a decade-long wave of domestic consolidation, foreign acquisitions and strategic partnerships by the UAE.

The first wave of consolidation began in 2014 with the creation of the Emirates Defense Industries Co. (EDIC). Five years later, the UAE combined about 20 entities previously owned by EDIC, Tawazun Holdings, Emirates Advanced Investments Group and other joint ventures

to form Edge Group. The January addition of International Golden Group, an international arms broker, might complete the country's internal defense consolidation.

Edge's two dozen businesses now boast a turnkey suite of platforms, payloads, propulsion systems and autonomy software. The UAS designed or acquired by ADASI can be built with airframes from aerostructures supplier EPI and carry payloads made by sister companies Al Tariq or Halcon. The latter locally developed guidance systems, fusing and explosives supplied by Lahab, another sister company. Similar internal capabilities are available for Edge's armored vehicle suppliers NIMR Automotive and Al Jasoor, as well as naval affiliate Abu Dhabi Ship Building (ADSB) and small arms maker Caracal.

The lone independent defense company is Calidus, the maker of the Bader 250 light attack fighter and a portfolio of armored vehicles. Unlike the other local acquisitions within Edge, Calidus remains privately owned. And Edge has no plans to expand its portfolio beyond entities with some level of state ownership.

"Everything that used to be partially owned by the government or fully owned by the government is now part of Edge," says newly appointed CEO Hamad Al Marar, who succeeded Mansour AlMulla in January. "I'm not really concerned around the potential of actually acquiring more organizations. The main purpose [now] is to try to streamline resources."

The 10-year acquisition spurt, which includes several foreign companies in countries ranging from Brazil to Poland, has elevated Edge to rank among the top 25 defense businesses in the world, Al Marar notes. The ranking itself helps confer legitimacy to potential export customers wary of entrusting critical security needs to smaller companies.

"I believe this actually motivated or has paved the way for our collaborations in Latin America and Africa and East Asia," Al Marar says.

In 2022, Angola acquired for \$1 billion three new BR71 Mk II corvettes supplied by a joint venture between Edge's ADSB and French shipbuilder Constructions Mecaniques de Normandie.

The order marked a breakthrough in Edge's export-focused strategy, instantly raising the share of foreign

sales in the company's annual revenue to about 33%. But the one-year result remains an outlier on Edge's privately held balance sheets; the steady-state share of export deals annually accounts for 20-25% of all revenue, Al Marar says.

But the export share should dramatically increase soon.

"We're aiming to get to 40% [of annual sales from export customers]," he notes. "I think we're on the right trajectory to do that. However, I think it will [start] as \$1 billion every year with an incremental, healthy increase as we go forward."

Al Marar's export-focused strategy is partly driven by financial necessity. The UAE Armed Forces spend about \$3 billion annually on procurement from foreign suppliers, according to the U.S. International Trade Administration. That leaves about \$3.5-4 billion every year for spending on Edge Group products and services by the domestic military and other government agencies. To increase profits

China and Israel, relatively new entrants, such as Turkey and South Korea, also are fighting to gain market share with a diverse list of products, including new fighters, helicopters, missiles and UAS.

Although Edge produces a range of platforms in each domain, the company's growth strategy shifts the focus elsewhere.

"We're not going to turn around and start building a competitor to the [Lockheed Martin] F-35 now, obviously," says Harry Dawson, Edge's director of international business development. "Why would we? So our focus is on autonomy, smart weaponry and electronic warfare [EW]. That's where we feel that we can add the greatest value."

Edge is targeting markets that need capabilities in those three areas but prefer to avoid the restrictions imposed by both the U.S. International Traffic in Arms Regulations (ITAR) regime and a security relationship with the Chinese government.

"The benefit that we can bring the



Al Tariq's Precision-Guided Munition supports one of the Edge Group's three major focus areas, which also include electronic warfare and autonomy.

enough to be able to invest in future capabilities needed for the Emiratis' security requirements, the growth must come from the foreign market.

Edge faces no shortage of competition for defense products and services outside the UAE. In addition to traditional leaders in the U.S., Europe,

value is in high-end, very complex, advanced technological solutions that are used for subsystems or enhancing systems within those three fields of EW, autonomy and smart weaponry," Dawson said says. "We can provide to our customers relatively affordable prices, and we can do it without

ITAR. And that is a unique offering.”

Al Marar contends that the core market for Edge is nonaligned countries that, like the UAE, want to maintain normal relations with the U.S. and China.

“Buying from the UAE, you do not upset the East, and you do not upset the West,” Al Marar says. “Most of these countries do not want to be in this political [competition]. That has helped us a lot.”

Edge’s export campaign also received a boost from a recent policy change by the UAE government: The \$1 billion sale of corvettes to Angola in 2022 included its first export credit financing package. The addition elevates the UAE to an exclusive club of countries that help finance international arms deals signed with national industries.

“The vast majority of large-ticket defense sales in the world are financed one way or another,” David Massey, CEO of Edge’s ADSB, says. “And historically, the UAE gifted things to friendly nations or made investments, but it didn’t use government-to-government financing for defense sales as an instrument of foreign policy. Now it does.”

The financing options involve a wide range of UAE government support beyond the arms deals in question. A single package can include help with other areas of a customer’s economy.

“The financing that is offered to support some of our export sales is usually part of a package of transactions, which may have no defense components at all,” Massey explains. “You know that the UAE is a major investor in infrastructure and oil and gas and other things across Africa and Asia, and even in South America.”

Dawson notes that export credit financing packages are sensitive and not a guaranteed option for every customer, so he could not provide details about how they are structured. However, he provided a general description of how they are used by the UAE government in defense transactions.

“What it enables us to do is to support the solid defense needs of nations that might not have that capital at that time in order to spend it on much-needed equipment and capabilities,” he explains. “And we have the technology and the capabilities to meet that, and then we have the financing mechanism as well.”

V-22s Cleared for Takeoff, But Root Cause of Crash Remains Unidentified

➤ FULL RETURN TO FLIGHT COULD TAKE MONTHS

➤ BUDGET REQUEST INCLUDES FUNDING FOR CLUTCH UPGRADES

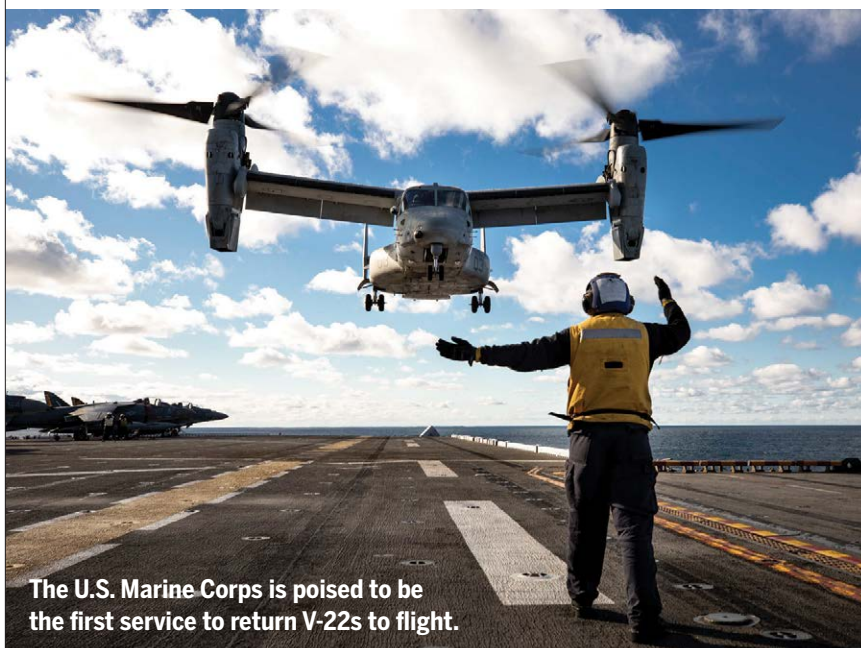
Brian Everstine Washington

Following an extended grounding and a patchwork of mitigations and maintenance after another fatal crash with no known root cause, the Pentagon has cleared the Bell Boeing V-22 Osprey tiltrotor fleet to return to full operations.

Naval Air Systems Command (Navair) announced March 8 it was issuing a flight clearance for the tiltro-

Navair will not identify the component or detail the mitigations beyond increased maintenance. Taylor says the material failure identified in the November crash was “unprecedented” in the Osprey’s more than 750,000 flight hours.

“I can’t talk about what the exact component is, but I will tell you, we have a high confidence that we under-



The U.S. Marine Corps is poised to be the first service to return V-22s to flight.

tor fleet after it had been grounded for more than 90 days following the November 2023 crash of a U.S. Air Force MV-22 that killed eight airmen. Navair says lifting the grounding leaves it up to the individual services that fly the Osprey to determine how they will return to operations—a process expected to take months.

Navair says it knows which component failed in the crash but still does not understand why. Col. Brian Taylor, the V-22 joint program manager, says Navair used simulation and modeling to “work up the fault tree” to determine what mitigations could be put in place to protect against a recurrence.

stand what component failed and how it failed,” Taylor told reporters ahead of the announcement. “I think what we are still working on is the why, and so that is still in the hands of the investigation.”

The rollout resembles how the office outlined a plan in early 2023 to replace problematic parts of the tiltrotor’s clutch without an established root cause for the hard clutch engagement (HCE) that caused a June 2022 MV-22 crash that killed five Marines.

Following Navair’s latest statement, each service outlined broad plans to return to flight.

The U.S. Marine Corps has the largest fleet of Ospreys and has been

U.S. MARINE CORPS

the most affected by the grounding. However, Marine Corps Brig. Gen. Richard Joyce, assistance deputy commandant for aviation, says there has not been pressure to return to flight amid the investigation.

The Marines have 348 V-22s delivered, 240 of which are operating on any given day among 17 squadrons. The service plans to focus on returning deployed forces to flight first, followed by those next to deploy and then those to be involved in key exercises and other high priorities.

To start, there are to be maintenance checks, instructor pilot refresher training and flights designed to achieve basic currency. A second phase will focus on these instructors providing refresher training to more junior pilots, and the third phase will focus on mission-specific training. While the first phase will take about 30 days, the three phases will vary in length and stretch into late spring, the service says.

The U.S. Navy plans to execute a similar incremental approach to return its CMV-22s to flight, says Vice Adm. Daniel Cheever, commander of Naval Air Forces. With its Ospreys grounded, the Navy has continued flying Grumman C-2A Greyhounds for carrier onboard delivery missions. Despite the groundings, Cheever says there are no plans to change the impending C-2 retirement.

Air Force Special Operations Command also aims to begin an incremental approach while it finishes investigating the November 2023 crash, starting with ground and simulator training to integrate new planned flight controls, safety briefings, reviewing maintenance records and refining of each squadron's training plans to integrate new safety protocols.

The second phase will be a multi-month program for aircrew and maintainers to regain basic currency before expanding to full-mission currency. Meanwhile, ground crews are to be trained on new maintenance plans needed to return to flight.

The U.S. Navy plans to begin replacing problematic components of the V-22 tiltrotor's clutch beginning in 2026, as it says it is narrowing down to a root cause for HCE that has long been elusive. The service suspects an out-of-phase engagement in the gearbox.

Since at least 2010, the Osprey fleet has been plagued by HCE in the air-

craft's prop rotor gearbox (PRGB), which has caused multiple accidents—most notably the June 2022 MV-22 crash. It has centered on the input quill assembly (IQA), which can shear off and damage the clutch. Since early 2023, the services operating the V-22 have been replacing the IQA every 800 hr.

In its fiscal 2025 budget request, the Navy details a new plan to upgrade the input quill in the V-22's PRGB to eliminate resident issues with the IQA and to purge the fleet of thin-densed chrome.

The thin-densed chrome plating in the V-22's gearbox has been a known issue for almost two decades, wearing out during use and chipping into the Osprey's oil system. The issue appeared in early testing, though it was not reported to be a safety issue. Ongoing problems with chipping have continued, with multiple incidents reported in recent years.

An improved PRGB would change sprag engagement characteristics by making it less prone to slipping and thus less prone to HCEs, the Navy says in budget justification documents. The funding is for a two-part effort: the first for the development and procurement of prototypes and qualification testing of an improved design. The second part is to acquire kits and space to implement the improved input quill and clutch for the entire fleet.

Funding begins in fiscal 2026, with \$48 million planned for 45 kits. The full program includes \$138 million for 328 kits.

Navair has three efforts focused on the HCE issue. The first is an IQA lifecycle assessment, collecting component condition data of clutch assemblies across the fleet as they are retrofitted. This data defines wear characteristics of the IQA to further mitigate and analyze wear mode and validate the 800-hr. limit.

Next is the overall IQA redesign, which is in finalization. A candidate prototype is to begin qualification testing early this year. Last is the dynamic disengagement testing, which will confirm the existence of the out-of-phase engagement theory and determine if the redesign corrects the problem and proves the theory. Since the implementation of the IQA redesign, there have not been any HCEs, Navair says. 🗳

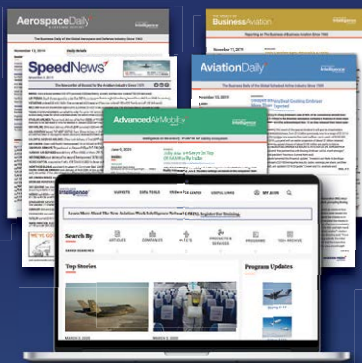
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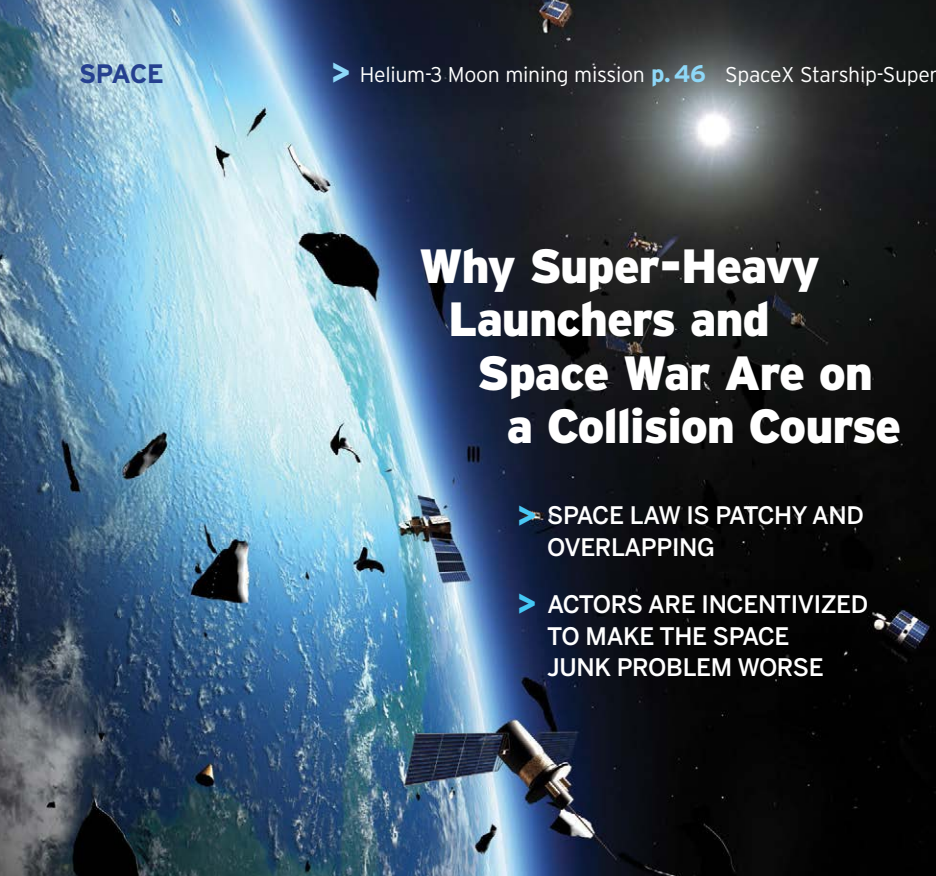


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Why Super-Heavy Launchers and Space War Are on a Collision Course

> SPACE LAW IS PATCHY AND OVERLAPPING

> ACTORS ARE INCENTIVIZED TO MAKE THE SPACE JUNK PROBLEM WORSE

ALAMY STOCK PHOTO

Garrett Reim Seattle

Super-heavy launch vehicles, such as SpaceX's Starship and Blue Origin's New Glenn, promise to bring down the cost of reaching orbit to new lows. In the process, tens of thousands of satellites are expected to be launched in the coming decade.

Even with the number of spacecraft in orbit expected to explode, space is becoming a warfighting domain. Satellites are at a growing risk of being attacked, breaking apart and crashing into one another, risking a cascading event known as the Kessler syndrome as Earth's orbits become more crowded and polluted.

These two events appear to be on a collision course. Regulations, international treaties and best practices for stopping the creation of space junk are patchy and overlapping at best. Even what nations agree upon in principle can, in practice, be easily interpreted differently by multiple parties, policy analysts say.

As tensions rise among Russia, China and the U.S., the world desperately needs rules of the road and treaties to prevent collisions and to restrict conflict in space before the region is ruined for all of humanity.

"Insufficient focus and a lack of imagination to appreciate how devastating a future conflict involving space will be is a significant risk to all," tes-

tified Gen. Stephen Whiting, commander of U.S. Space Command, before the Senate Armed Services Committee on Feb. 29. His testimony came two weeks after the White House disclosed that the U.S. intelligence community had determined Russia will attempt to field a "troubling" new space-based anti-satellite weapon.

Several news organizations reported that Russia wants to place a nuclear weapon into orbit, which, if detonated, could create a massive electromagnetic pulse (EMP), frying the electronics of swathes of satellites circling Earth.

Commercial satellites in low Earth orbit (LEO), such as SpaceX's roughly 5,500 Starlink broadband satellites, are especially vulnerable to an EMP attack. Indeed, when the U.S. conducted Starfish Prime in 1962, the high-altitude nuclear test over the Hawaiian Islands, it not only damaged satellites near the explosion but also created an artificial radiation belt that damaged faraway satellites and spacecraft for months afterward. Subsequent high-altitude nuclear tests by the Soviet Union—as well as the Cuban missile crisis—helped bring about the 1963 Partial Test Ban Treaty.

Despite that and other treaties governing peaceful uses for space, Washington is growing concerned again about war in orbit. A broad announce-

ment from the Air Force Research Laboratory in December said that one of its goals was to "develop novel technologies to protect LEO satellites from the effects of high-altitude nuclear explosions."

Amid these concerns, the space launch industry is racing ahead. SpaceX plans to hold at least nine launch attempts of its Starship-Super Heavy this year as part of its flight-test program. SpaceX hopes eventually to support more than 100 tons of payload to LEO per launch.

That would transform the economics of reaching space, potentially lowering the cost of travel to LEO to \$100/kg, a fraction of the already historically low \$6,000/kg the company

Satellite crowding and military conflict could worsen the clutter in Earth orbit.

advertises for its Falcon 9. Blue Origin's New Glenn super-heavy launch vehicle, with two initial launch attempts anticipated for this year, is also expected to lower launch costs through economies of scale.

SpaceX has already shown what lower launch costs make possible. The company's workhorse, the partially reusable Falcon 9 medium launch vehicle, has carried nearly 6,000 Starlink satellites to space, a few hundred of which were later deorbited due to malfunctions, solar storm damage and other problems. Amazon's Project Kuiper, China Satellite Network and others are planning to launch mega-constellations of thousands of satellites in the coming years as well.

Since more satellites orbit Earth than ever before, debate persists on how best to avoid collisions, deorbit spacecraft and reduce the risks of war.

"Space is a vacuum, but space law and diplomacy is not a vacuum," says Robin Dickey, a policy analyst with the Center for Space Policy and Strategy at the Aerospace Corp. "The problem is that there are gaps and overlaps, and a lot of room for interpretation."

In the U.S., the Defense Department inserts orbital debris mitigation requirements into its contracts with space companies, the Federal Communications Commission imposes deorbiting rules upon satellite operators seeking radio spectrum licenses, and the FAA regulates the safe disposal of rocket upper stages. Advanced spacefaring nations and enti-

ties, such as France, Japan, the UK and the European Space Agency, have similar contractual agreements, regulations and laws.

Several multilateral treaties and agreements also govern the safe use of space. Best known is the 1967 Outer Space Treaty, signed by the U.S., Russia, China and 111 other countries. The treaty bans nuclear weapons in space, limits the use of the Moon and other celestial bodies to peaceful purposes, prohibits claims of sovereignty in space, and holds countries liable for damage caused by their space objects, among other obligations.

But for every rule, there seems to be an exception; for example, many governments, including the U.S., interpret the law of armed conflict—treaties and agreements governing war—as applying to and permitting war in space under certain circumstances.

“The law of armed conflict is a big body of law,” Dickey says. “It’s complex, and it can be very difficult to interpret to the unique physical and political environment that is space.”

What is more, dozens of countries, including nuclear and space powers China and France, have not signed the Partial Nuclear Test Ban Treaty. Russia also now appears willing to flout its commitment to the treaty.

While orbital weapons of mass destruction are banned by the Outer Space Treaty, direct-ascent, anti-satellite weapons are not. In 2007, China conducted an anti-satellite missile test, destroying one of its own Fengyun weather satellites in LEO. The test still holds the record as the most polluting event in human space history, Dickey notes.

“There were the 3,000 pieces of debris that we can track [from the anti-satellite test],” says Marlon Sorge, a technical fellow at the Space Innovation Directorate at the Aerospace Corp. “There’s something on the order of a few hundred thousand pieces of debris that were created [that we can’t track], that if they hit the body of a satellite, the satellite is dead. There’s an enormous invisible cost to these events as well.”

According to NASA, more than 23,000 pieces of space debris larger than a softball orbit Earth. There are approximately 500,000 pieces of debris at least 1 cm (0.4 in.) in diameter and an estimated 100 million pieces measuring at least 1 mm.

The U.S. Space Surveillance Network, a worldwide group of ground- and space-based sensors created to track all human-made objects in Earth’s orbit, can track objects as small as 5 cm in LEO, but new methods are needed to spot smaller debris.

In response to direct-ascent, anti-satellite tests by China and Russia—including a 2021 test by Moscow that has forced SpaceX’s Starlink satellites and the International Space Station to make evasive maneuvers—the U.S. has led a pledge campaign not to conduct such tests. A growing list of U.S. allies, including France, Germany, Japan, South Korea and the UK, have signed on.



The Starship and other super-heavy launchers could loft thousands of new satellites into orbit.

Already small pieces of debris—often of unknown origin—appear to be kicking off the dreaded Kessler syndrome, a point at which there is enough debris in orbit that collisions between objects happen at a rate faster than the atmosphere can burn them up. In September, Swiss space debris removal startup ClearSpace reported that a fast-moving piece of junk, possibly only millimeters in size, hit a leftover payload adapter floating in Earth’s orbit—one it had planned to remove.

The time frame for flying debris making space unusable is difficult to predict—perhaps many decades or even hundreds of years away. But it could accelerate with more objects in space and more destruction of those objects.

Ironically, as orbital slots are taken and debris fields grow, space actors are likely to be incentivized to make the problem worse by rushing to grab what bits of usable space remain, says Nodir Adilov, economics professor at Purdue University and co-author of a research paper called “An Economic ‘Kessler Syndrome’: A Dynamic Model of Earth Orbit Debris.”

“You’re starting to feed into the problem,” he explains. “You’re going to accelerate it.”

What emerges is a classic political-economic “tragedy of the commons,” where common space is abused or overused to the benefit of individual actors, Adilov says.

Think of it like the overfishing problems of the world’s oceans, where individual fishermen have incentives to catch as much as possible before others do. What is more, much as vast oceans make it difficult to catch poachers, the remoteness of space could make it easier for bad actors to violate rules and treaties. The result could be a sort of tragedy of the cosmos.

Getting traction on global commons issues such as climate change-causing pollution is very difficult, adds Brendan Cunningham, an economics professor at Eastern Connecticut State University and co-author of the economic Kessler syndrome research paper.

“It’s very hard to actually get your hands around the magnitude of the problem,” he says. “The sort of dual-use nature of [space] technology means that there’s very little trust among the major parties.”

Sometimes it is difficult to know where to start the conversation. Reasonable people can come to different conclusions about what is dangerous and what is not, Dickey notes.

“Someone else’s models, fed by different information, using different modes of analysis, may come up with a completely different result of what’s risky or not,” she says. “Whether that’s done in good faith or not, there’s still a lot of wiggle room to justify your position.” ☛

Former Blue Origin President Leads Helium-3 Moon Mining Mission

- ISOTOPE HAS POTENTIAL COOLANT APPLICATIONS FOR SUPERCONDUCTORS
- STARTUP AIMS TO SELL ELEMENT TO QUANTUM COMPUTER AND NUCLEAR FUSION DEVELOPERS

Garrett Reim Seattle

Harrison Schmitt is the only living member of NASA's last crewed mission to the Moon: Apollo 17 in 1972. A geologist, Schmitt has not stopped talking for the past 50 years about what he and his fellow Apollo astronauts discovered in the lunar regolith: helium-3.

Schmitt, now 88, has teamed up with Blue Origin's former President Rob Meyerson and former Chief Architect Gary Lai to co-found a company to harvest the isotope from the lunar surface and bring it back to Earth. Their startup, Interlune, aims to collect small bottles of the rare gas and sell it to emerging technology industries that prize the stuff, including developers of quantum computers and nuclear fusion reactors.

"Helium-3 is the only element in the universe that's expensive enough to warrant going to the Moon and bringing it back to Earth," says Meyerson, who is the company's CEO.

The element is difficult to produce on Earth and typically comes from the radioactive decay of tritium in nuclear reactors. On the Moon, the gas is scattered across the surface, brought from the Sun on solar winds.

Helium-3 has been accumulating on the lunar surface for billions of years but only recently has become in vogue on Earth, where developers of quantum supercomputers prize it for its ability to be chilled to near absolute zero and act as a coolant for superconductors, Meyerson says. The medical imaging sector, another potential customer for Interlune, uses the isotope's close cousin, helium-4, to cool superconducting magnets in MRI machines.

Meyerson declines to estimate how much the element could sell for on Earth but says it would be enough to reinvest into additional space infrastructure businesses. "I do believe that in the long run, in the 10-20-year time frame, there will be an in-space economy where people are buying water, rocket propellant and construction materials in space," he adds.

Interlune, based in Seattle and founded in 2020, emerged from stealth to reveal its plans on March 13. The company also announced that it had raised \$18 million in seed capital from investors. In addition to Schmitt, Meyerson and Lai, Interlune's co-founders include former RocketLab executive Indra Hornsby and former Maxar Technologies product manager James Antifaev.

The company aims for its helium-3 harvester equipment to hitch a ride to and from the Moon on spacecraft developed as part of NASA's Artemis and Commercial Lunar Payload Services (CLPS) development programs. Reentry through the Earth's atmosphere would likely rely on one of several reentry vehicles being developed by private companies.

"The core intellectual property that we've developed is a means to separate out a gas mixture, which includes helium-3, from the lunar regolith in a way that requires about 10 times less power," Meyerson explains. The company has a patent pending on the technology designs and has tested it both in a laboratory and in simulated lunar gravity onboard a parabolic aircraft.

Meyerson declines to explain Interlune's technology but says it is not a solar concentrator or thermal-based

approach, describing it as "mechanical in nature." Since less power is required, the equipment is smaller, lighter and cheaper to transport to and from the Moon, he adds.

Interlune says helium-3 is expensive enough to justify mining on the Moon.

Interlune's harvester design includes an excavator, gas extractor and separator onboard. The machine would harvest in the sunlight of the lunar day (about 14 Earth days) and then sleep through the lunar night (about 14 Earth days). The robotic system would be partially autonomous and ground-controlled, with a five-year commercial operating lifespan.

In October, the company received a Small Business Innovation Research Phase 1 Contract from the National Science Foundation to develop a mechanical device to sort Moon dirt by particle size. Interlune's device is designed to use rotating paddles to provide centrifugal motion to sieve the particles through a screen.

The startup plans to conduct a prospecting mission onboard a CLPS-class lunar lander in 2026 and a pilot mission for its harvester in 2028. Initial commercial operations would begin in 2030. For commercial operations, the harvester would require larger lunar landers. The equipment could reach the Moon via one transport mission on the SpaceX Human Landing System, or two or three missions on Blue Origin's Blue Moon lander, Meyerson says.

Because processing would be done on the Moon, very little helium-3 would be transported back to Earth. "It's a single-digit number of kilograms," Meyerson explains.

The Moon is speckled with helium-3, but certain regions are thought to have more deposits. Schmitt, executive chairman of Interlune, trained fellow Apollo astronauts in field geology and has studied lunar regolith samples and remote-sensing data gathered from NASA's 2009 Lunar Reconnaissance Orbiter mission.

"There's really few people, if anyone, who are more knowledgeable about the lunar resources and helium-3 in particular," Meyerson says.

The precise location of Interlune's prospecting mission is a closely guarded company secret, he adds. "That site is very, very large, and it's going to support many, many years—decades—of harvesting." ☾

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Starship Moves Toward Operational Service With Flight Test 3

> SPACEX NAILS HOT-STAGING SEPARATION FOR A SECOND TIME

> SHIP ROLL PROMPTED CANCELLATION OF ENGINE RESTART TEST

SpaceX demonstrated its Starlink communications system during the March 14 Starship-Super Heavy integrated flight test.

complete that part of the phase, but ... we'll figure out what happened on both stages and get back to flight hopefully in the beginning part of May."

The 396-ft.-tall Starship-Super Heavy rocket lifted off from SpaceX's Boca Chica Beach, Texas, spaceport at 9:25 a.m. EDT March 14, less than a day after receiving clearance for IFT-3 from the FAA. All 33 of the Super Heavy's methane-fueled Raptor engines fired, repeating a test objective first demonstrated during the IFT-2 on Nov. 18.

After a full-duration burn, 30 Super Heavy engines shut down as planned, leaving three firing as the Starship upper stage lit its six Raptors to fly off the booster successfully, repeating a hot-staging separation also first accomplished during IFT-2.

The Super Heavy first stage separated 2 min. 49 sec. after launch, completed a flip maneuver and restarted its 13 inner engines for a boostback burn, setting the stage for a soft splashdown in the Gulf of Mexico.

During the Super Heavy's flight in November, the booster was destroyed during the boostback burn when an engine exploded after losing pressure in its oxidizer turbopump due to filter blockage in the liquid oxygen supply. That set up a cascade of engine shutdowns, and the rocket was destroyed about 3.5 min. after liftoff some 60 mi. above the Gulf of Mexico.

On IFT-3, the Super Heavy—designated Booster 10—flew for nearly 7 min. and relit some of its engines for a planned landing burn, setting up a soft splashdown. That was not successful, and Booster 10 was destroyed about 1,516 ft. above the ocean.

SpaceX made even more progress with the Starship upper stage during IFT-3. On its previous flight, the Starship spacecraft failed prior to reaching its intended suborbital trajectory. During IFT-2, SpaceX had loaded extra liquid oxygen on the vehicle to simulate payload mass and was venting the propellant when a leak occurred, sparking explosions and fires. The vehicle broke apart about 7 min. after liftoff at an altitude of approximately 93 mi. "Ironically, if it had [had] a payload, it would have reached orbit," SpaceX CEO and Chief Technology Officer Elon Musk told employees on Jan. 12.

For IFT-3, SpaceX targeted a steeper trajectory to buy time for a

Irene Klotz Washington

For the record, SpaceX's third Starship-Super Heavy integrated flight test ended like its predecessors, with the FAA opening a mishap investigation after both vehicles were destroyed prior to the end of their planned missions.

But integrated flight test-3 (IFT-3), which took place March 14, was fundamentally different than last year's IFT-1 and IFT-2 because the Starship spacecraft not only reached its in-

tended trajectory, but also completed most of the test milestones, paving the way for future operational missions.

"It was an incredibly successful flight," SpaceX President and Chief Operating Officer Gwynne Shotwell said March 19 during a panel discussion at the Satellite 2024 conference. "We hit exactly where we wanted to go.

"Boost phase was beautiful, and we got the relight of the booster engines to come back," she added. "We didn't

SPACEX

trio of engineering objectives and to set up a water landing without the need for a reentry burn. “We wanted to make sure we could passively come back on a trajectory we could count on if we didn’t relight the second stage engine a second time to reenter,” Shotwell said.

The Starship’s 64-min. mission was to end with a splashdown in the Indian Ocean—rather than off the coast of Hawaii, as targeted on IFT-2.

For this flight, Starship’s six Raptor engines completed a full-duration ascent burn, allowing SpaceX to begin a series of additional test objectives. Those included opening and closing a slot-like payload bay door near the top of the ship to prepare for future Starlink satellite deployments. (SpaceX refers to the door as the “Pez door,” after the Pez candy dispenser.)

During the door test, SpaceX began another demonstration to transfer cryogenic liquid oxygen from one tank inside the Starship to another. NASA sponsored the technology demonstration under a \$53 million Tipping Point program contract. SpaceX is developing a Starship variant that will need to be fueled in orbit prior to transfer-

ring NASA astronauts to and from lunar orbit and the surface of the Moon. The first crewed lunar landing under NASA’s Artemis program is planned for late 2026.

“Cryogenic fluid technologies are critical for human missions to the Moon and Mars and our future exploration goals,” NASA wrote on X, formerly Twitter, after the flight. “During the Starship test flight, we worked with SpaceX to demonstrate a liquid oxygen propellant transfer. Teams are reviewing flight data to learn how it went.”

After the propellant transfer, SpaceX had hoped to complete a third flight-test objective and relight a Starship Raptor engine, simulating a deorbit burn. The test, which would have taken place about 41 min. into the flight, was called off “due to vehicle roll rates during coast,” SpaceX later explained. For this flight, the in-space engine firing was not needed for the Starship, known as Ship 28, to reenter the atmosphere.

The IFT-3 mission also provided SpaceX with the opportunity to test and showcase its Starlink communications network, a global broadband constellation in low Earth orbit that includes more than 5,000 operational satellites.

Using Starlink and NASA’s Tracking and Data Relay Satellite system, SpaceX broadcast live views of Starship in space and, stunningly, during entry into the atmosphere, which began about 46 min. after launch.

A camera mounted on a flap on the ship’s exterior relayed high-definition video through a Starlink terminal aboard the Starship as it traveled some 16,800 mph and was enveloped in plasma. “This is the fastest and furthest that Starship has ever flown, so this is the first time we’re getting to collect this data and understand how its 18,000 hexagonal heat shield tiles are working together to protect the belly of Starship as it reenters the Earth’s atmosphere,” said mission commentator Kate Tice, SpaceX’s senior manager for quality systems engineering.

The telemetry signals from the Starship ended about 3 min. later when the Starship was at an altitude of about 40 mi. and presumed destroyed, bringing IFT-3 to a close some 15 min. early.

SpaceX aims to return to flight in early May for the first of possibly five more Starship-Super Heavy flights this year. 🚀



SpaceX’s third Starship-Super Heavy flight test lifted off from Boca Chica Beach, Texas, on March 14. The planned 64-min. mission ended about 15 min. early when the Starship was lost during reentry.

TREVOR WAHLMANN

Space-Based VHF Promises New Airspace Efficiencies

> ITU SPECTRUM ALLOCATION ENERGIZES DEVELOPMENT

> EUROPEAN ANSPs ADVANCE CONCEPT SPACE SEGMENT

Bill Carey Washington

A new allocation of radio spectrum by the International Telecommunications Union has triggered a quest by air traffic management organizations to provide satellite-based VHF communications in oceanic and remote airspace.

At the December World Radiocommunication Conference in Dubai, the International Telecommunications

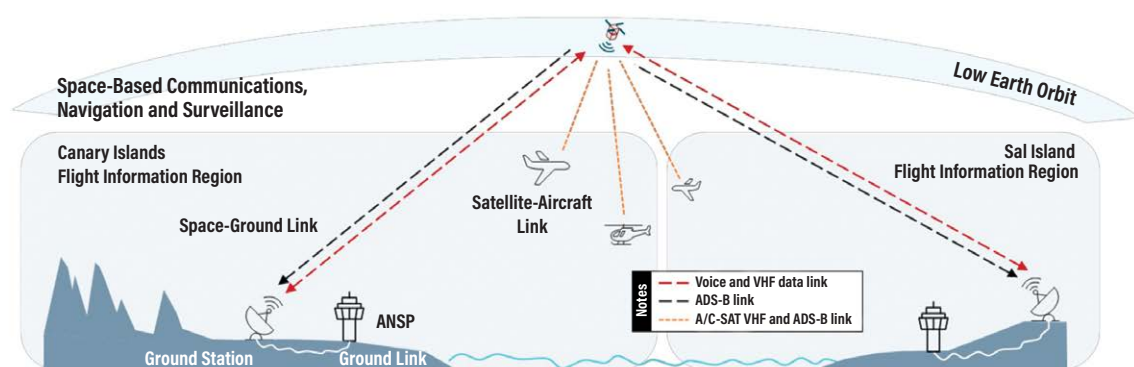
high-frequency (HF) radio. Satellites would function as “VHF towers positioned in the sky,” offering more coverage and comparable service to terrestrial VHF communications.

Importantly, airlines would not have to change the onboard equipment they use to connect to the ground-based VHF radio infrastructure, proponents of the concept say,

ture company, Startical, to build a satellite constellation dedicated to aircraft surveillance and communication services. Startical leads a European Commission-funded project called Echoes (Extended Communications in VHF Over Enhanced Satellite segment) to demonstrate the feasibility of space-based VHF by conducting use cases in the South Atlantic Ocean involving two LEO satellites. Other participants include Nav Portugal and German aerospace center DLR.

In March, U.S.-based joint venture Aireon announced it was developing the Space-Based VHF Coalition with partners Iridium, Nav Canada, the UK's NATS, AirNav Ireland, Italy's Enav and Denmark's Naviar. In April 2019, Aireon activated space-based

VHF Link Would Expand ANSP Capabilities



Source: Sesar JU

The space-based VHF concept is being tested in the South Atlantic Ocean.

Union (ITU) granted a slice of spectrum in the VHF band at 117.975-137 MHz for the delivery of aeronautical mobile-satellite (route) services. With a new VHF communications link connecting aircraft and satellites, air navigation service providers (ANSP) see an opportunity to improve the safety, efficiency and environmental sustainability of long-range flight operations, particularly in areas with limited connectivity.

Space-based VHF voice and data communications, in combination with satellite-based surveillance, offer ANSPs the potential to reduce aircraft separations further over oceanic and remote areas where pilots and controllers now rely on conventional satellite communications (satcom) or

leaving a future transmitter solution to the space component. Skykraft, an Australian company that is developing a constellation of low-Earth-orbit (LEO) satellites for air traffic management (ATM) services, announced in July 2023 that it had staged the world's first trial of space-based VHF voice communications in collaboration with Airservices Australia.

Other ANSPs are advancing space-based VHF communications for their respective users. “This concept holds exceptional significance for flight operations in regions with limited connectivity, especially across oceanic and remote areas,” says Enrique Maurer Somolinos, director general of Spanish state-owned ANSP Enaire, in a column on the Civil Air Navigation Services Organization website.

Enaire and ATM technology provider Indra have created a joint ven-

surveillance of the North Atlantic Ocean, the world's busiest oceanic airspace, using automatic dependent surveillance-broadcast (ADS-B) receiver payloads hosted on the Iridium Next LEO satellite constellation.

Space-based ADS-B payloads receive ADS-B position messages every few seconds from transponder-equipped aircraft flying below, then stream the data to Aireon's ground network. From there, it is processed and distributed to ANSPs that subscribe to the Aireon service. The application of near-real-time surveillance in the North Atlantic has allowed controllers to close longitudinal separations between aircraft flying within the track system to 14 nm from 40 nm.

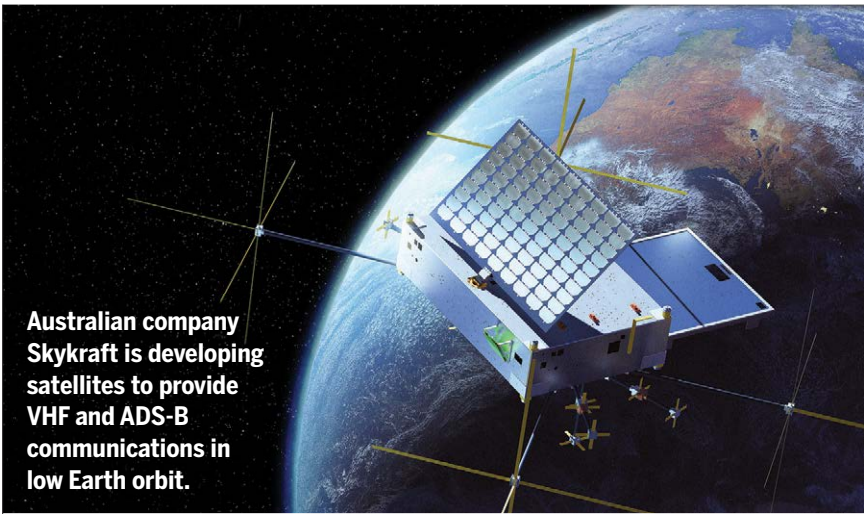
In addition to required navigation and surveillance capabilities, aircraft operating in remote areas outside the range of VHF ground-based commu-

nications must be equipped with a long-range communications system combining satcom and HF radio or dual HF radios.

Closing aircraft separations even further to fine-tune the efficiency of the airspace system has been limited by satcom performance, Aireon CEO Don Thoma says. He believes the same technical rigor that produced space-based ADS-B surveillance must be applied to the development of space-based VHF communications.

"Several companies have promoted this capability," Thoma notes. "From an Aireon perspective, we've been doing [space-based ADS-B] for five years, and it took us seven years before that to build and deploy the system. We felt, with our partners in this coalition, that we're probably best suited to tackle these tough issues. That's why we pulled this coalition together and why our investors and our customers were happy to support it."

A frequency spectrum management panel of the International Civil Aviation Organization is deliberating space-based VHF and expects to produce draft standards and recommended practices by June 2025. Fol-



Australian company Skykraft is developing satellites to provide VHF and ADS-B communications in low Earth orbit.

lowing ITU approval of the spectrum allocation, the Aireon coalition is moving to the next phase of its project to develop a concept of operations, a business case and technical requirements for the concept.

Thoma acknowledges that space-based VHF requires "an additional space asset." While the capability would be interoperable with ADS-B in a third-generation refresh of the Iridium Next constellation, Aireon could

bring VHF communications to bear sooner on a complementary LEO satellite system or by acquiring capacity on another constellation, he suggests.

"Nothing that we would do would require a modification to the aircraft avionics," Thoma assures. "That was a golden rule of Aireon for ADS-B, and it has to be the golden rule for space-based VHF," he says, because the cost to airlines would break the business case. 🌐

Airlines in Europe Wanted More From Single Sky Deal

➤ EUROPEAN PARLIAMENT AND COUNCIL REACH AGREEMENT

➤ CARRIERS SAY DRAFT TEXT DOES NOT GO FAR ENOUGH

Helen Massy-Beresford Paris

In the early hours of March 6, European negotiators finally achieved what was starting to seem impossible: a long-awaited agreement on Single European Sky reforms. Yet airlines that have long criticized the delays reacted with disappointment.

Reforms to the European Commission's Single European Sky (SES) rules are intended to optimize flight routings, reduce delays and cut fuel emissions. The changes had been planned for many years, but individual member states' reluctance to give up the sovereignty of their airspace was blocking progress.

The European Parliament and the

European Council, under the presidency of Belgium since Jan. 1, reached a provisional deal on March 6.

Reforming Europe's airspace is seen as an important step in reducing the aviation sector's environmental impact. Airlines have repeatedly voiced frustration that inefficient routings lead to higher costs and greater emissions, and they cited a 10% potential emissions reduction if SES reforms were put in place.

Although the text of the agreement still requires approval by EU member-state representatives and the European Parliament's Transport and Tourism Committee, followed by the

parliament and council as a whole, the parliament said "the agreement represents a significant achievement in EU aviation policy."

"Today's deal signifies a shift toward efficiency and sustainability in air traffic management [ATM]," said Marian-Jean Marinescu (European People's Party, Romania), one of the rapporteurs who led the talks. "The current nationalistic airspace architecture hampers progress, leading to longer flights, increased emissions and unnecessary costs. It's high time to finally prioritize efficiency over nationalism to pave the way for safer, more cost-effective and environmentally friendly air travels in Europe."

Airlines are keen to benefit from the fuel and cost savings that better routings would provide. Carriers are also frustrated by the environmental scrutiny they face, whereas the SES reforms, seen as a straightforward way to reduce emissions, have long remained just out of reach. They voiced disappointment in the draft agreement.

"We have been consistent in calling

for an SES that delivers for airlines, passengers and the planet,” industry group Airlines for Europe (A4E) said on March 6. “On first look, it seems this agreement is still some way off. This will not be the end of A4E’s efforts to achieve a seamless, digital and truly Single European Sky that will reduce delays, improve efficiency and reduce carbon emissions.”

The European Regions Airline Association (ERA) said that, based on its initial assessment, the text did not go far enough. “ERA has continuously recognized the need for an ambitious and seamless Single European Sky, one that delivers for our airlines, our

proposal following Brexit, and trilogue negotiations led to new draft rules.

The European Parliament said the latest draft introduces performance plans for air navigation service providers (ANSP) to improve network management of EU airspace, with binding targets and incentives to make flights more efficient and environmentally friendly. The plan proposes the establishment of an independent advisory Performance Review Board (PRB) to help the commission and member states make decisions on implementation.

The draft proposal contains provisions to make ANSP and network man-

The group called for a PRB with an enlarged scope but said the negotiation compromise offered one with limited scope that does little to change the status quo.

A4E also said the role of national supervisory authorities ideally would be empowered to make decisions without external influence and would operate in a regulatory framework that ensures harmonized implementation. The compromise put forward, however, maintains the authorities’ current limited role while increasing complexity.

Members of the parliament called for more competition in the ANSP market during the negotiations, the parliament said, adding that the new bill includes the possibility for providers to procure other air navigation services, such as communication, meteorological or aeronautical information services, under market conditions.

On the topic of network management, A4E had hoped for more clarity and collaboration to ensure airlines can implement efficient flight plans and identify causes for inefficiencies while making sure airlines are accountable only for conditions under their control. Instead, the agreement maintains the current situation but removes flexibility, A4E said, and “favors ‘shortest routes’ over efficient trajectories, increasing

airline fuel use and emissions.”

A4E said the compromise fell short on the environment as well. The airline group wanted the SES to focus on increasing ATM system efficiency to ensure that the benefits of technology improvements could materialize and support airlines and the broader industry in reaching environmental goals.

Instead, A4E said, the compromise creates extra complexity and inconsistencies, does not encourage states and ANSPs to collaborate or enhance capacity and reduce delays, and it tries to enforce airline decarbonization using a regulation designed for ANSPs.

While reaching any agreement at all is an achievement after many years of deadlock, there are still numerous hurdles to overcome before the draft becomes a reality. 🌐

European SES reforms to make airspace more efficient are overdue.



PETER LANE/ALAMY STOCK PHOTO

passengers and the environment,” ERA Director General Montserrat Barriga said. “We are therefore disappointed that the final agreement appears to fall short of meeting these requirements. At first glance, several concessions appear to have been made that unfortunately reduce the likelihood of the substantial improvements that we have pushed for in terms of airspace capacity, operational efficiency and sustainability. It’s clear that further efforts will be required to address today’s aviation challenges effectively.”

The commission had proposed revising the SES rules in 2013, but negotiations moved slowly; member states’ unwillingness to give up airspace sovereignty was often cited as the reason. In 2020, the commission upgraded the

agement contribute to climate neutrality. Under the new rules, the commission will adopt EU performance targets on capacity, cost efficiency, climate and environmental factors for ANSPs, and performance will be reviewed at least every three years.

The commission will also conduct a study to help define how charges levied on airspace users for air navigation services could encourage them to be more environmentally friendly—for example, by using the most fuel-efficient routing or alternative clean propulsion technologies.

In an analysis document published just before the March 6 announcement, A4E expressed its views of aspects of the draft negotiators were discussing—and highlighted many areas it said were lacking.

NASA Lauds ASIA-AQ Mission DC-8's Ability To Assess Air Quality

> MISSION STRIVES TO CROSS-REFERENCE SATELLITE AND GROUND STATION DATA

> THE DC-8'S REPLACEMENT WILL HAVE SPACE CONSTRAINTS

Chen Chuanren U-Tapao Royal Thai Navy Airfield, Thailand



NEARLY 55 YEARS since its first flight, NASA's McDonnell Douglas DC-8-72 is on the last legs of its flying service in a two-month tour to Asia to measure air quality in four key countries and territories.

Under the banner of the Airborne and Satellite Investigation of Asian Air Quality (ASIA-AQ) mission, the DC-8—paired with a NASA Langley Research Center Gulfstream GIII—started the mission in the Philippines the first week of February, followed by visits to South Korea and Taiwan. A planned stop in Malaysia was canceled, and the aircraft returned to South Korea before arriving in Thailand for the final stop.

Barry Lefer, NASA program scientist for air quality research, says the mission's goal is to improve understanding of local air quality through multiperspective observations and modeling. While satellites such as South Korea's Geostationary Environment Monitoring Spectrometer provide an hourly overview of the air quality for roughly 20 countries from space, these two aircraft provide detailed chemical compositions of the air itself.

Flying at 28,000 ft. in a "lawn mower pattern," the GIII is fitted with a multi-wavelength lidar and spectrometer that measures nitrogen oxide, formaldehyde and aerosol concentration below the aircraft. Meanwhile, the DC-8 flies below 15,000 ft. to designated areas of interest and airfields, taking air samples at various altitudes.

Twenty-six sensors stick out of the aircraft in special window plugs (see photo). These instruments, operated by a mix of American, South Korean and German research institutes, include a cavity-enhanced spectrometer, bulk aerosol filter, meteorological measurement system and chemical ionization mass spectrometer. The respective instruments and consoles are placed as close to the probe as pos-

sible, given that air particle data would be lost as the particles travel over a longer piping and could adhere to the piping walls.

Craig Little, a DC-8 airborne research pilot, says the aircraft is deployed with a flyaway kit that includes spares and tires to support the rare

airports, he notes, as the widebody aircraft would not be able to make 180-deg. turns on a small runway.

James Crawford, a research scientist at Langley, adds that the 777 is expected to be ready in 2025, but the current plan is to have only 12 windows, which he says will not be sufficient for his portfolio in atmospheric research.

When asked about air transport's contribution to pollution, Crawford says airports and airways are a more diluted source of pollution than forms of ground transportation.

"We have been conducting low approaches on airports located in major cities, such as Seoul, Gimpo, [South Korea, and] Manila, [Philippines,] during ASIA-AQ," Crawford says.



An array of instruments on the DC-8 help it determine specifics about air quality characteristics.

aircraft type. He says crews had to swap out the No. 3 CFM International CFM56-2-C1 engine in South Korea, receiving the replacement from Edwards AFB, California, in three days via a Korean Air freighter.

"The DC-8 can fit in a lot of instruments due to the way the fuselage is designed," Little says. "A new Boeing aircraft will not be that easy." He adds that the engineering team at Langley is starting to "face issues" fitting instruments into the new Boeing 777-200ER.

"It is a capable team handling this, but it wouldn't be as simple as the DC-8," Little says. The 777 will not be able to conduct missions from small

"The variation in what we sample from the DC-8 has been too large to be explained by the signature of the airport itself, which should be a much more stable signature. This suggests that these low approaches are an effective way to sample how conditions are changing from day to day and with time of day for the surrounding city.

"We hope to change the perception of what the source of pollutions are," Crawford adds. "We think that air traffic is not the lowest-hanging fruit. In terms of cleaner air, changing the way we fly is harder than [changing] the way we drive and live. The energy transition on the ground is easier than on an aircraft." 🌱

Investment Logjam Threatens Nascent eSAF Sector, Insiders Warn

➤ FEEDSTOCKS ARE ABUNDANT BUT DIFFICULT TO ACQUIRE

➤ SETTING UP PLANTS REQUIRES HIGHER INFRASTRUCTURE COSTS THAN NORM FOR INVESTORS

Angus Batey London

The global aerospace sector's 2050 net-zero promises hang in the balance unless it makes quick progress to unlock funding and begin building a large number of power-to-liquid sustainable aviation fuel plants. That appears to be the consensus among insiders involved in the emerging sector who blame costs, price and investment pressures for holding up meaningful advancements.

Andrew Symes, co-founder and CEO of Oxford-based eSAF catalyst developer OXCCU, referring to the production pathway responsible for the majority of available SAF. "Ethanol-to-jet could get you so far, and then [PTL] is the future."

PTL feedstocks may be abundant, but that does not mean acquiring them will be easy. Some PTL developers intend to source carbon from large

"With PTL, you're basically converting electrical potential energy into stored chemical potential energy, so you need huge amounts of power," Lumsden said. "The UK goes through 15 billion liters [3.4 billion gal.] of jet fuel every year, and if we were to produce that through a 100% PTL pathway, you would need [a grid capacity of] 60 gigawatts of electricity. The UK electricity grid [can presently generate] about 45 gigawatts."

If the resulting eSAF is to be as sustainable as possible, this electricity must come from renewable sources. Even a sizable increase in wind and solar power plants would be insufficient, given the unpredictability of the UK's weather. Lumsden believes that modular nuclear systems colocated at eSAF plants might prove to be the best solution.

The good news is that the demand for eSAF is immense and likely to be long-lasting. Although the end product offers an almost guaranteed market, investment is proving difficult to procure. This is true for all SAF, but it appears particularly to affect PTL.

"The main difference between efuels and the other SAF is that you basically need to do something more," Air France-KLM New Energies Director Elise Roc said at the panel. "You are going to do the work of Mother Nature that for the other SAF is done through the biomass. So you need more infrastructure, and because you need more infrastructure, [you need] more capital."

The cost of constructing a plant—and, perhaps, its own dedicated electricity-generating capability—is orders of magnitude greater than early-stage investors are accustomed to considering, and investors in large-scale infrastructure projects do not generally put money into first-of-a-kind projects developed by startups. The sector must look elsewhere for funding.

Airlines and aircraft manufacturers need SAF, and lots of it in short order, yet they are unlikely to be able to step in to back full-scale eSAF production projects. Air France-KLM has invested in several SAF providers but acknowledges there is only so much an airline group can do.

"We are present," Roc said. "We don't have strong balance sheets, so we're trying to do what we can."

Dassault Aviation Chairman and CEO Eric Trappier echoed her com-



OXCCU's prototype reactor will soon occupy this foundation pad, built adjacent to London Oxford Airport's fuel farm.

"We've got 26 years to 2050, which isn't very long, and everything is going far too slowly if we're to meet the expectations of ICAO [International Civil Aviation Organization] and IATA [International Air Transport Association], and everyone that's looking to [sustainable aviation fuel (SAF)] to solve the decarbonization problem," Alasdair Lumsden, co-founder of power-to-liquid sustainable aviation fuel (eSAF) startup Carbon Neutral Fuels, said during a Feb. 27 panel discussion at the inaugural SAF Investor conference in London.

SAF is vital to every aircraft operator's carbon reduction efforts, but supply is limited, and prices remain considerably higher than for Jet A. Other SAF requires feedstocks that are not available in sufficient quantities to replace global Jet A consumption; power-to-liquid (PTL) relies on water, carbon (perhaps captured from the air) and electricity to manufacture.

"I think there now is a wide acceptance that HEFA [hydroprocessed esters and fatty acids] is limited," noted

industrial emitters, perhaps siting their plants adjacent; others plan to use direct air capture. But this is not the only challenge.

"Water, fundamentally, has to be part of the conversation," said Alex Chikhani, founder and CEO of British eSAF startup CirculAIRity. "One of the pathways we're looking at is atmospheric water generation, which is essentially dehumidification of the atmosphere. We're doing that basically because aircraft [emit] CO₂, which is very clearly talked about, and water vapor, which is almost never talked about. Water vapor has a much bigger environmental impact from flight than CO₂, and it makes CO₂ six times more potent in the atmosphere. Therefore, it makes the best sense to use water vapor from the outset. We also know that water itself has many other uses in life, and we don't want to just pass the problem elsewhere."

Once water and plenty of usable carbon are secured, eSAF manufacturers still need a reliable—yet unprecedentedly vast—supply of electricity.

ments in Paris on March 6. He told Aviation Week he sees eSAF—not hydrogen—as “the solution for the long term,” but he expects his company to invest only in ensuring its aircraft will be compatible with the fuel.

“It’s not our business,” he said. “It’s more a chemical than a mechanical or an electronic business.”

One way forward could be for a PTL developer to show a lender that they have a long-term agreement with an airline to buy all, or a substantial portion, of their projected output. Fuel offtake agreements usually are made over a considerably shorter timescale than it would take to see a PTL plant turn a profit; compressing the investment timescale would markedly increase project costs.

“[Airlines] think seven years is very, very long,” Nanna Baldvinsdottir, co-founder and CEO of Icelandic green hydrogen and eSAF startup Idunn H2, said at the Feb. 27 panel. “I can’t do anything with a seven-year contract—I need a 20-year contract or a guarantee. If I’m doing this project in a seven-year timeline, it’s going to be exorbitantly expensive.”

While eSAF pricing is likely to remain high, the causes behind that high price are at least predictable.

“We appreciate that we’re not likely to be competitive with fossil kerosene, perhaps ever, but at least not in the short to medium term,” said Andy McNeill, business development manager for British startup Arcadia eFuels.

“I know that all the other production pathways are less expensive, but our [cost] is known,” Baldvinsdottir added. “Once we start at Year 1, there is really no mystery to what the price is going to be at Year 20 because the power is contracted long-term, the water is contracted long-term, the carbon is contracted long-term.”

Nevertheless, funding for PTL eSAF is lagging other low-carbon aviation initiatives. Money has become available for aviation decarbonization projects, but investments tend to go to platforms rather than plants.

“Although all the technologies [for PTL eSAF production] preexist, the integration doesn’t necessarily exist today,” Lumsden said. “All the plants are first-of-a-kind. It’s very exciting to invest in [electric vertical-takeoff-and-landing vehicles] and new widgets and new technologies, but there’s huge value in integration, and we need to

see investors valuing that integration.”

Another factor that hampers development is concern over the comparative price of eSAF, not just against Jet A but also compared with SAF produced from other pathways. There is a temptation to see the price differential as something that will fall once investment is secured and capacity increases, but this might not be realistic.

“I do worry a little bit that we try to talk down the cost of producing efuels,” McNeill said. “I think that we do it with the best of intentions. We don’t want to be a burden on the supply chain. But particularly for first-few-of-a-kind projects, there is an inevitability. This is quite an expensive production pathway, but it is critical and essential that we start this journey, because we all believe that we’re going to need efuels—not just in aviation, but for shipping and for heavy-haulage road transportation. It’s going to be a little bit more expensive than any of us like.”

Attempting the near impossible will not just rely on robust planning, innovative technology and forceful leader-

operating. Because for the same feedstocks, the same molecules you produce, value will be different under an EU rule as compared to a [Carbon Offsetting and Reduction Scheme for International Aviation] rule versus a U.S. rule.

“The [EU] mandate is great,” he added. “It’s firm and long-term, so that’s super helpful. IRA is a bit more pragmatic and short term, and therefore also helpful to actually propel some projects. What we do need is to have that validation of a first-of-its-kind commercial project, and that requires government money, government support—because it is a high risk, and it’s not at [technology readiness level] 9 yet.”

“In the United States, the IRA is very helpful,” said Keith Lawless, SAF+ International Group’s senior aviation expert. “It’s not enough, but it’s a good start. And there’s a lot of questions with the upcoming [U.S. presidential] election: Is [the IRA] going to be diluted? If you’re going to an investor, these are questions they have, and you can’t answer them, so it’s difficult.”



MICHAEL CHEETHAM/SAF INVESTOR

An efuel panel discussion at the SAF Investor conference on Feb. 27 featured (from left) Andrew Symes, Saurabh Kapoor, Alex Chikhani, Andy McNeill, Nanna Baldvinsdottir and Ausilio Bauen, moderator, of the ERM Group.

ship within the PTL sector; it will also require significant government intervention. Regulations such as the U.S.’ Inflation Reduction Act (IRA) and the European Union’s SAF mandate—which recognizes PTL SAF as a special case by specifying a subsidiary level of minimum eSAF uptake—are helpful but likely insufficient on their own.

“Clearly, you don’t start with projects where you don’t have the right policy support or the right credibility environment—that’s given for any project, not just eSAF,” said Saurabh Kapoor, co-founder and CEO of Swiss startup Metafuels. “Beyond that, one has to look in what submarket am I

Ultimately, states might need to underwrite their own SAF production capabilities, whether through a method such as the UK’s in-development SAF revenue certainty mechanism or a more direct route. Treating SAF production as a traditional for-profit investment might not be a helpful or accurate way to think about it.

“The SAF sector globally is not here to make money,” Chikhani said. “The SAF sector has been put into place because of the planet’s need. We are fundamentally here to address climate change. Yes, I do respect there is a need for that commercial money to be made—but there ought not to be.”



Guy Norris Colorado Springs

With the first powered flight of its Talon test vehicle under its belt, hypersonic aircraft developer Stratolaunch says an early data review of the March 9 milestone mission indicates follow-on reusable vehicles will be capable of demonstrating flight faster than Mach 6 by the end of next year.

Carrying three test payloads, the Talon TA-1 was dropped from Stratolaunch's Roc carrier aircraft at around 9:40 a.m. Pacific Time. The Roc was flying close to 22,400 ft. and 167 kt. in Vandenberg SFB's Western Range off California's central coast. Approximately 11 sec. after release, TA-1's 5,000-lb.-thrust Ursa Major-built Hadley rocket engine ignited, accelerating it to more than four times its release altitude.

The Talon is designed to fly at hypersonic speed for several minutes. While precise performance details are being withheld for competitive reasons, Stratolaunch says TA-1 achieved around 200 sec. of powered flight and accelerated to a high supersonic speed. Because of thermal ef-

fects, hypersonic speed is typically defined as Mach 5 or above, while high supersonic usually denotes more than Mach 3. TA-1 appears to have exceeded Mach 4 on this run.

After its release, TA-1 was tracked briefly by an Aero L-39 photo chase airplane that had flown from Merced, California, to rendezvous with the Roc and the company's other chase aircraft, a Cessna Citation II. Flight data indicates the Talon then coasted for up to 5 min. after rocket burnout before splashing down off the coast.

"Now that we've done this risk-reduction flight, we are accelerating that learning curve and giving the Department of Defense what they've desperately asked for, which is a high-cadence hypersonic test capability,"

After a clean release, the Talon TA-1 dropped away from the Roc.

Stratolaunch CEO and President Zachary Krevor says. "This flight demonstrates that it doesn't always have to be government-led. It can be a partnership with industry, which is a win for everyone."

A second powered mission with the Talon TA-2 scheduled for the second half of the year will target the first autonomous landing at Vandenberg as well as flight speeds beyond Mach 5.

"So far, we are finding out from the data that we have more capability than we initially estimated," Krevor says. "We're happy overall with the accuracy of our predictions, but also we came at it appropriately with a slightly conservative position. It's now clear that we are going to be able to push our vehicle to the upper ends of the capability that we've advertised—and faster than we initially thought."

Stratolaunch originally sought to build up gradually to Mach 6 performance within two years of first flight.

"We'll be able to accelerate that and demonstrate top-end Mach 6-type

- 
- > STRATOLAUNCH TALON FLIGHT DATA BOOSTS HOPES FOR EARLIER MACH 6 CAPABILITY
 - > LANDING GEAR “SLED” TO VERIFY AUTOMATED RUNWAY PERFORMANCE
 - > ROC CARRIER AIRCRAFT SET FOR HIGHER-ALTITUDE EVALUATION TESTS



capability by the end of 2025,” Krevor says. “We still have further data review to do to understand the environments that we flew through. We predict a course based on the top-end capability using forecasts of what those vibration and heating environments are going to be like, and so on.

“That’s pretty detailed engineering work, so that takes time to understand and then correlate to your models,” he notes. “But the initial performance assessments have allowed me to be very excited about accelerating our top-end capability.”

The company’s confidence stems from close correlation between flight data and predicted performance, as well as improved propellant management techniques and other thermal energy balancing upgrades instituted after a captive-carry flight in December. Data showed minor modifications “were working better than predicted and would enable us to have more propellant on board than we initially forecast,” Krevor notes.

The changes ensured “that we’re not putting in too much heat into the liquid oxygen [LOx] tank before we fly because that causes the boil off, but at the same time, some of our components don’t want to operate quite as low as cryogenic temperatures,” he says. “We are making sure that the bays around the LOx tank have that thermal balance.” Other components that perform better in

warmer environments similarly have been relocated.

Additional performance improvement options range from increasing the altitude at which the Talon is released to equipping the Roc with oxidizer top-off systems and boosting the thrust of the Hadley rocket motor.

Regarding the latter option, Krevor says: “As with any subcontractor, we’re always going to ask for more performance, push the envelope and, of course, do it for \$1. Ursa Major has been a great partner, and we’ve worked together on a couple of options that they have at their fingertips to potentially upgrade the Hadley performance. But I don’t want to give the wrong impression—we are very happy with its performance. That being said, could they push a little bit more in terms of Hadley capability? We think the answer is ‘yes.’”

Flight tests to evaluate higher release altitudes are planned for the coming months, following a maintenance check for the Roc.

“Design altitude for Roc is typical airline altitude, even a little bit higher, so we’re exploring what is the right capability for us,” Krevor explains. However, he stresses that the original performance targets already are within reach. “Our goal is not to maximize performance, but to deliver value to the customer,” he says. “Based on the TA-1 results, we don’t need Roc to go to the top in terms of maximum

performance to enable Talon to maximize its performance.”

Meanwhile, work on TA-2 is well advanced. The vehicle has been towed outside the company’s Mojave Air and Space Port facility for initial “weight-on-wheels” testing.

“We’re incorporating some of the early lessons learned from TA-1 into the vehicle,” Krevor says, referring to the propellant management improvements. “Folks should expect to see TA-2 back outside for an integrated test period sometime this summer.”

Another vehicle occasionally on display outside the hangar is a Talon mockup dubbed the “landing gear test rig,” developed to verify automated runway landing, braking and rollout performance, including centerline tracking.

“It has full flight-like landing gear and full flight software and is being tested on the runway to ensure we have the brake and maneuvering performance after we land,” Krevor says.

Designed with TA-2’s mass properties and inertia, the ungainly vehicle allows Stratolaunch to continue flight development work on the TA-2 flight article while confirming flight software, braking and maneuvering performance on the landing system.

“It allows us to accelerate this capability,” Krevor explains. “She doesn’t look very pretty, but you’ll see a landing gear sled maneuvering around on the runways of Mojave.” ☼



The next vehicle, TA-2, is close to completion and undergoing ground tests before its planned Mach 5 and autonomous landing mission later this year.

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Luminary Aims To Use the Cloud To Transform Engineering Analysis

➤ MASSIVELY PARALLEL PROCESSING ACCELERATES CFD

➤ SOFTWARE SERVICE AUTOMATES ANALYSIS STEPS

Graham Warwick Washington

While the aerospace industry has been under pressure to accelerate product development, a U.S. startup has emerged from stealth, promising to slash the time required for engineering design and analysis by providing cloud-based access to massive computing power as a software service.

cal engineering hasn't kept pace despite increasing pressure to deliver advanced products faster and more efficiently," Lango says.

By providing access to massively parallel Nvidia GPU clusters in the cloud, Luminary says, its platform can run high-fidelity simulations 100 times faster than legacy software on com-



With \$115 million in funding, San Mateo, California-based Luminary Cloud already has several aerospace and defense customers, including Joby Aviation and Piper Aircraft, for its computer-aided engineering software-as-a-service (SaaS) platform.

Luminary is leveraging the raw speed of graphics processing units (GPU) and cloud-based computing as well as automating many steps in engineering analysis, from initial cleanup of the geometry from computer-aided design (CAD) to interactive visualization of the resulting flow simulations from computational fluid dynamics (CFD).

High-performance computing systems expert Jason Lango and Stanford University Aerospace Design Laboratory founder and Director Juan Alonso created the startup in 2019 with fundraising led by private equity company Sutter Hill Ventures.

"While software engineering has become more agile, thanks to advances in cloud technologies, physi-

puting infrastructure owned by the companies designing new products.

"We are able to take complete aircraft configurations and run them in complex simulations in a matter of minutes, saving a significant amount of time," Joby Chief Aerodynamicist Gregor Mikic says. "Luminary provides us with an entire set of tools that take us from geometry to result."

For CFD analyses, "we have brought simulation times for 100-150 million cells to under 2-3 min.," Alonso says. "If you go to a transient simulation that would have taken 36 hr., we can do those in about 27 min. That's the power of GPU computing."

This increase in speed enables what Luminary terms real-time engineering, allowing the engineer to interact with the simulation. "We're a company that has done everything from scratch in the cloud with GPUs," Alonso says. "And that's what's required to give you this interactive experience, which we have not had until now.

"We have the fastest flow solvers—compressible for aerospace and incompressible for aerospace and other applications," he says.

The mostly manual traditional workflow begins with cleaning up the CAD geometry to remove such features as rivets and gaps not needed for analysis. The next step is to generate the CFD mesh, a grid of points that divides the flow around the aircraft into millions of cells within which the software can solve the equations that govern fluid behavior.

Traditional meshing, which determines the accuracy of the simulation, requires experts and can take hours or days. It is a process that usually must be repeated several times to reach an acceptable result.

Luminary uses automated CFD meshing. "We hired the best people in the world in mesh generation, mesh adaptation and error estimation, so we could say customers should never see

Automated mesh generation and adaptation allow Luminary to guarantee simulation accuracy.

a mesh, they care about the geometry," Alonso says, "and the mesh is a means to an end. We are going to guarantee the accuracy of a calculation by adapting the mesh based on how much error we estimate there is."

Customers provide Luminary with error bars defining how accurate they need a simulation to be. "You say, 'I'm in the early stages of my process; I want lift and drag of that airplane to within $\pm 5\%$.' We don't need a very fine mesh for that. So we give you the calculation with a mesh that gives you that accuracy," he explains. "Then you say, 'We're ready to build a final prototype and go fly. We want to do some checks to $\pm 0.1\%$.' We give you the mesh that guarantees the numerical accuracy to be 0.1%."

Luminary has adopted a consumption-only business model. Customers do not buy a software license or pay per user. "You pay for what you use," Alonso says. "It's SaaS. You get accounts, and they're all free. If you use it, you pay us. If you don't use it, you don't pay us."

"And you can scale your demand during the year—that's a business element that is quite important," he adds, noting that most of the aerospace industry uses legacy software running on in-house computing infrastructure that is challenging and expensive to scale. 🌐

FAA's Revised eVTOL Certification Rules Move Closer to Europe's

- FAA "INCREASED PERFORMANCE" MORE SIMILAR TO EASA RULES
- INDUSTRY SAYS CHANGES EASE TYPE CERTIFICATION TRANSFER

Graham Warwick Washington

In releasing a revised type certification basis for Joby Aviation's electric vertical-takeoff-and-landing aircraft, the FAA has introduced changes that help narrow the gap between the U.S. and European approaches to regulating this new class of air vehicle.

In response to public comments on the proposed G-1 certification basis published in November 2022—the first for an electric vertical-takeoff-and-landing (eVTOL) aircraft—the FAA has incorporated the concept of “essential” and “increased” performance categories with different safety levels.

The change is in response to several commenters, including the European Union Aviation Safety Agency (EASA), calling on the FAA to adopt EASA's Special Condition for VTOL (SC-VTOL). This regulation sets a higher safety level, equivalent to commercial aircraft, for passenger-carrying eVTOLs.

“The FAA disagrees and has instead adopted ‘essential’ and ‘increased’ performance approvals,” the final rule states. “Although the FAA's ‘essential’ and ‘increased’ performance approvals are similar to EASA's ‘Category Basic’ and ‘Category Enhanced’ approvals, differences remain.”

Representing industry, the General Aviation Manufacturers Association (GAMA) welcomed the changes. While falling short of fully harmonizing the U.S. and EU rules, the FAA's changes will make transferring type certification between the regulatory regimes easier.

“Transferability is not harmonization because we know there are certain areas that might maintain some appropriate differences based . . . in particular on the structure of European operating rules versus U.S. rules,” says Walt Desrosier, GAMA vice president of engineering and maintenance.

“But we want to get close enough to have transferability, where the differences can be recognized between the authorities . . . and allow for the products to be validated, exported and operated in their respective countries,” he adds. “And we think, to a large degree,

the FAA did that in this final rule.”

The “increased performance” approval requires the aircraft to be able to continue to the planned destination or alternate after a critical change of thrust, defined as the most adverse effect on performance or handling qualities resulting from failures of the flight control or propulsive system.

For increased performance approval, the aircraft must be capable of climbing to a safe altitude after such a failure and maintaining level flight to



JOBY AVIATION

Joby says the FAA's revisions to the JAS4-1's certification basis did not necessitate design changes.

the planned destination or an alternate landing site without requiring exceptional pilot skill, strength or alertness.

The “essential performance” approval means the eVTOL is capable of continued controlled flight and landing but not required to have the capability to land at the planned or an alternate landing site as is required for increased performance, the FAA says.

Under both essential and increased performance, the aircraft must be capable of a controlled emergency landing following any condition where it can no longer provide the commanded power or thrust required for continued safe flight and landing, the FAA adds.

“Both the FAA's and EASA's performance levels include the aircraft's ability to conduct a controlled emergency landing after a condition when the aircraft can no longer provide the commanded power or thrust required

for [continued safe flight and landing],” the regulator says.

Under the revised G-1, Joby's tilt-prop JAS4-1 must meet either the essential or increased performance requirements, the FAA says. Additionally, the eVTOL may be approved for both essential and increased performance with appropriate and different operating limitations, the regulator adds.

“We are grateful to have had visibility into the proposed G-1 certification basis changes for some time and today's publication confirms our expectation that no design changes are required to our aircraft,” Joby says. “The essential/increased performance framework is similar to the Cat. A/B framework which exists for Part 27 helicopters. Joby intends to certify flight-crew procedures and aircraft performance data for both categories.

“However, the categories under which the aircraft will be required to operate for different types of operations, and specific operating locations, will be subject to operational rules laid down by FAA Flight Standards,” Joby says. “Those operational rules are not yet known. In general, however, Joby's intent has always been to assure a flyaway capability following a critical change of thrust, which is the intent of increased performance.”

Joby in 2020 became the first eVTOL developer to receive a G-1 from the FAA and has now completed the first three stages of the type certification process: certification basis, means of compliance and certification plans. The startup is in the fourth of the five stages—testing and analysis.

“We continue to be fully focused on the fourth stage of the process and can confirm that the additional documentation requirements flowing from the G-1 amendments do not impact our ability to continue delivering on the for-credit testing work required in this stage,” Joby says. “We continue to target the start of commercial passenger operations in 2025.” 📢

Check 6 *Aviation Week editors and SMG Consulting's Sergio Cecutta discuss China's potential AAM lead: [AviationWeek.com/Check6](https://www.aviationweek.com/Check6)*

TECH TAKE

By **Graham Warwick**

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

UK Team To Develop LH₂ Fuel System

A UK consortium has received funding to develop a liquid-hydrogen fuel system and supply chain to support multiple classes of zero-emission aircraft in the 2030s.



The HyFIVE consortium will develop a modular, scalable LH₂ fuel system.

The HyFIVE consortium comprises Marshall, GKN Aerospace, Parker Meggitt, Manchester University, University of Bath and Cardiff University.

The project will receive an initial £37 million (\$47 million) in funding, with £20 million from the UK government via the Aerospace Technology Institute (ATI) and £17 million from industry.

HyFIVE will develop and test a modular, scalable cryogenic hydrogen fuel system architecture compatible with either hydrogen-electric powertrains or hydrogen-combustion propulsion. The collaboration will cover five key areas: storage, conveyance, indication, fueling and venting.

“The HyFIVE program is primed to solve the significant technical, safety, certification and industrialization challenges associated with the application of [liquid hydrogen] in aviation,” ATI Chief Technology Officer Jacqueline Carter says.

By 2027, the consortium plans to have conducted a ground demonstration of an integrated liquid-hydrogen fuel system, achieving technology readiness level 6 and becoming ready for transition into product development for aircraft entering service in the mid-2030s.

The program also aims to have de-

veloped a customer-ready supply chain and industrial strategy by then, as well as a range of flight demonstration and exploitation paths with prospective customers.

As part of the consortium, fuel system supplier Marshall will provide expertise in complex system design, integration and certification. GKN will contribute know-how in advanced materials and cryogenic system optimization. Parker Meggitt will provide sensing, thermal management and fluid conveyance experience.

GKN is leading the UK government-supported H2Gear program to ground-test a scalable hydrogen-electric fuel cell propulsion system in 2025. It intends to bring together the complete scalable fuel system and propulsion system in a single flight testbed environment before the end of the decade.

Lunar Test for 3D-Printing Materials

Additive manufacturing specialist Stratasys plans to test two types of 3D-printed material on an upcoming lunar lander mission.

The material samples are to be carried to the Moon’s surface onboard a Firefly Aerospace Blue Ghost lunar lander this year as part of NASA’s Commercial Lunar Payload Services 19D mission. There, they will be tested to see how they hold up in the harsh lunar environment. Northrop Grumman has sponsored the project.

One experiment will examine how Stratasys’ Antero 800NA FDM filament, which is filled with tungsten, shields against gamma and X-ray radiation. The polyetherketoneketone-based thermoplastic has “excellent mechanical properties, chemical resistance and low outgassing characteristics” and could be used for lunar landers, Stratasys says. “Ground testing suggests [the] potential for 50% radiation dose reduction.”

The other experiment will test the Antero 840CN03 FDM filament, which has electrostatic discharge properties to protect electronics and was previously integrated into NASA’s Orion spacecraft as part of the Artemis I mission in 2022. The test also includes a photopolymer material with electrostatic discharge properties made by Henkel for use with Stratasys’ Origin



An FDM Antero 840CN03 radiation experiment housing contains radiation-shielding test samples.

One 3D printers. The material is tolerant of high-heat environments, Stratasys explains.

“This experiment will subject coupon samples of the 3D-printed materials to moon dust, low pressure that can lead to outgassing and the rapid temperature swings that result from virtually no atmosphere on the moon,” the company says.

Stratasys notes that 3D printing is well suited to space applications as the machines can make lighter, customized parts in low volumes—and for less money than conventional methods.

—Garrett Reim in Seattle

Composite LH₂ Tank’s Breakthrough Performance

Gloyer-Taylor Laboratories has demonstrated a composite liquid-hydrogen tank that significantly exceeds the hydrogen mass fraction needed to achieve equal flight range with kerosene fuel.

Tennessee-based Gloyer-Taylor Laboratories (GTL) is proceeding with fabrication of flight prototypes, having completed validation testing of a small subscale composite vacuum-jacketed dewar tank with liquid hydrogen (LH₂).

When fully isolated, the double-wall dewar tank held hard vacuum for about 50 min., more than 100 times the requirement, GTL says. This allowed the tank to hold the LH₂ at -430F for more than 21 hr. while remaining leak-tight with minimum hydrogen permeation, the company adds.

During the test, the subscale dewar tank experienced only 2.8 watts of heat load. Based on this, GTL expects flight tanks will see only 1% LH₂ boil-off per day.

Validation testing also demonstrated

the tank's capability for rapid chill-down, "paving the way for aircraft to be refueled in minutes versus waiting hours for a metal tank and transfer lines to cool," GTL says. When filled with LH₂, the inner composite tank fell from room temperature to 20K (-424F) in less than 20 sec. and the composite tubes achieved full LH₂ flow in less than 1 sec., the company adds.

GLOVER-TAYLOR LABORATORIES



GTL's dewar tank has a composite inner tank surrounded by a vacuum-insulated outer shell.

Holding 19 kg (42 lb.) of LH₂, the flight-type tank prototype is 53 in. long, has a diameter of 28 in. and weighs 15 kg—including the inner tank, outer vacuum shell, multilayer vacuum insulation, internal tubing and sensors. This gives the composite dewar tank a gravimetric index, or hydrogen fraction, of more than 55%, which GTL says is 10 times better than current hydrogen tanks.

When stretched to carry 50 kg of LH₂, the hydrogen fraction increases to more than 62%, with larger versions able to exceed 70%, the company reports. This tank performance "significantly exceeds the 35% hydrogen fraction goal needed for hydrogen to achieve parity with kerosene," GTL says.

Contrail Avoidance Is Affordable

While avoiding the formation of condensation trails is an emerging priority for aviation in reducing its climate impact, cost remains a concern for operators. A research paper is putting numbers on the issue, showing contrail prevention is affordable.

For a massive 73% reduction in contrail energy forcing, the extra cost is close to a calculated 0.1%, the researchers say. Energy forcing quantifies the total radiative energy trapped by a condensation trail (contrail) over its lifetime within the atmosphere.

The paper was written by lead author

Alejandra Martin Frias, a specialist with flight-planning service provider Flightkeys, and Marc Shapiro, contrails team director at Breakthrough Energy, an initiative launched by Bill Gates.

Compared to cutting CO₂ emissions, curbing the formation of contrails strikes many as a low-hanging fruit. In fact, contrails could account for the majority of aviation-related greenhouse effects, and slightly modifying a flight-path may be enough to avoid a region where atmospheric conditions make formation of contrails likely.

The study combines Flightkeys' algorithm with a prototype contrail forecast model. "The results show that navigational contrail avoidance will require minimal additional cost (0.08%) and fuel (0.11%) investments to achieve notable reductions in contrail climate forcing (-73%)," the authors write.

"This simulation provides evidence that contrail mitigation entails very low operational risks, even regarding fuel," they add.

Operators and air traffic controllers can help by initiating contrail mitigation testing as soon as possible, the authors state. Such trials have taken place at limited scale so far, notably with Eurocontrol, the organization responsible for air traffic management in Europe.

The researchers analyzed 84,839 American Airlines domestic and international flights—including transatlantic operations—conducted during two seasons. The first covered the period from June 3-18, 2023, and the other took place from Jan. 3-18, 2024. Cost estimates accounted for fuel as well as time-dependent factors such as maintenance and overflight charges.



The cost of flightpath changes to avoid creating contrails is less than 0.1%, a study says.

Of the 11,260 flights identified as generating net-warming contrails, only 709 could not be rerouted due to airspace constraint issues. The rest were rerouted successfully, yielding the major reduction in energy forcing. Fuel- and time-related costs increased margin-

ally, while flight time decreased on average. Deviations are typically flight level changes, and the tendency is to adjust to a lower altitude.

The authors also discuss two mitigation strategies. The first option targets so-called big hits—the 2-10% of flights responsible for 80% of total contrail energy forcing. The second option focuses on cost-based avoidance. With some algorithm refinement, airlines could choose which flights to optimize based on the specific cost of rerouting.

—Thierry Dubois in Lyon

Electric Aircraft Approved for Training

The FAA has granted the Pipistrel Velis Electro an exemption to light-sport aircraft airworthiness rules, allowing U.S. flight schools to operate the two-seat electric aircraft for flight training. Slovenia-based Pipistrel is part of Textron's eAviation segment.



FRANK GALLIA/PIPISTREL

The Velis Electro is the first and so far only commercially available type-certified electric aircraft.

"With this exemption, the cost barrier to pursuing flight training can be substantially reduced," Textron eAviation President and CEO Kriya Shortt says. The Velis Electro, which has a flight endurance of 50 min., received type certification from the European Union Aviation Safety Agency in 2020 under light-sport aircraft certification specification rules allowing daytime use under visual flight rules.

Pipistrel designed the Velis Electro for flight training—in particular pattern training involving multiple takeoffs and landings at an airfield. The company delivered 16 aircraft in 2023; in early March, the 100th Velis Electro was delivered to Green Aerolease, a French sustainable aircraft rental provider, and will be operated in Germany by Green Aviation Hub. ☼

—Molly McMillin in Wichita

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Raising the Bar

By Matteo Peraldo

Speculation is heating up about a new single-aisle program, raising the urgency for a new aerospace supply chain business model.

The current setup, in which big players rely on an intricate network and multiple tiers of small and medium-size enterprises (SME), has proved resilient in recent crises. It is reaching its limit, however. As supply chain requirements for a new program come into focus, it will become clear just how high the bar must be raised.

Safety and quality remain paramount, as evidenced by recent issues with Boeing's 737 MAX and Pratt & Whitney's geared turbofan engine. The FAA audit of Boeing underscores how bad news lifts regulatory scrutiny to unprecedented levels.

New aircraft, especially with disruptive technologies, will undergo extraordinary regulatory scrutiny. OEMs know the financial and reputational costs of supplier quality lapses. A 2021 crisis created by noncompliant Boeing 787 parts produced by a tiny Italian computer numerical control machining shop proves there can be no weak links.

For new aircraft, ramp-up will be much more accelerated. The last time Airbus or Boeing introduced an all-new single-aisle aircraft was 1988; reaching 100 annual deliveries took four years. Since airlines are weighing sustainability concerns and are reluctant to operate two generations simultaneously, OEMs and their supply chains might need to start production at rates exceeding 50 per month right out of the gate. This pace will require a strong balance sheet across the supply chain; substantial investments would be necessary long before the first delivery. After years of cost reductions and recent crises, very few small suppliers have the financial strength for new program investment.

While the jury is still out on fuselage and engine technologies, advancements in thermoplastic composites and additive manufacturing suggest future aircraft likely will feature many fewer parts and less metal, reducing opportunities for smaller-scale manufacturers. For instance, additive manufacturing helped GE reduce the number of parts in a fuel nozzle from 20 to one.

On-time delivery is non-negotiable. The industry has tolerated subpar performance for too long. For the next generation of aircraft, expressions such as "missing parts" and "traveled work" must be eradicated. Enhanced visibility is imperative. During the pandemic, OEMs realized the harsh reality of limited knowledge about suppliers below Tier 1. They dug deep into the supply chain to identify and support distressed companies. As attention shifted to bottlenecks within the tiers post-pandemic, OEMs began monitoring Tier 3 suppliers' raw material orders and scrutinizing cast-

ing providers' yields. Although digital tools improve visibility, reducing the supply chain's breadth remains crucial.

The digital ecosystem also will transform, requiring suppliers to step up from product lifecycle management tools to the digital factory. Transitioning from paper drawings and legacy systems will require substantial investment and upskilling. More sensitive data will require improved

cybersecurity, an area in which many suppliers are underinvested. Companies reported a 45% year-over-year rise in ransomware attacks in the first half of 2023.

Commercial aerospace struggles to compete for talent. Today's engineering candidates often prefer working at tech giants, and engineers interested in aerospace often view startups in space or advanced air mobility as more exciting. Competitive salaries, stability and career opportunities help OEMs and larger players, but the challenge for small suppliers is undeniably daunting.

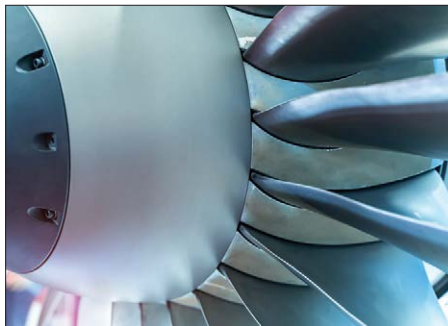
In the future, Tier 1 companies below double-digit billion-dollar revenue will risk becoming obsolete. Even in the subtiers, strong investments in industrial capacity, technology, digital and talent will demand a strong balance sheet. A leaner supply chain could emerge where even the smaller suppliers will operate in the billion-dollar range, reshaping the current fragmented landscape, especially in aerostructures and cabins. Consolidation appears inevitable—how fast remains the question.

In a more proactive scenario, a surge in merger and acquisition activities in the next few years is catalyzed by private equity. New "mega Tier 1s" could emerge with robust balance sheets, poised to invest as risk-sharing partners in next-generation programs. This presents a potential win-win: Sellers can realize high valuations based on share of current-generation programs; buyers benefit from scale and positioning on the next-gen aircraft.

Alternatively, in a reactive scenario, consolidation will proceed slowly until it becomes clear which companies (likely an elite few) will dominate the new single-aisle market. Valuations will diverge for winners and losers. Companies not on the new platforms will rely solely on the aftermarket. Even here, additive manufacturing will eventually eat at least a portion of their lunch.

The writing on the wall is clear. With the potential exception of a handful of top-performing and highly innovative players, commercial aerospace is no longer an industry for small suppliers. ☞

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