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AVIATION WEEK

& SPACE TECHNOLOGY

Putin's Great Plane Robbery



China's Heavyweight
Fighter Fleet

Why the B-21 +
Wingman = 2 Bombers

Space-Based Optical
Communications Light Up

RICH MEDIA
EXCLUSIVE



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ON THE COVER

The aviation industry is at the heart of Western sanctions imposed on Russia for its invasion of Ukraine. Terminated leases and certificates and export bans aim to put Russian commercial aviation on hold, but Russian President Vladimir Putin is hitting back with unprecedented measures. Our reports and analysis begin on page 24. Photo by Leonid Faerberg.

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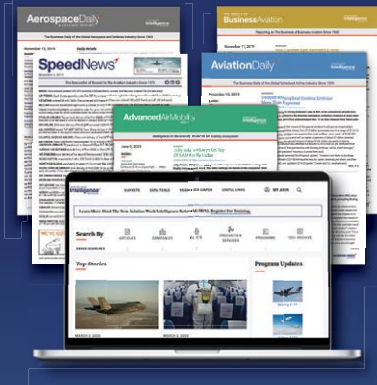
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TED CARLSON/SIKORSKY

IRONY IN PAINT

The person who was fortunate enough to wield the “EXPERIMENTAL” stencil and paint gun on a very prominent location on the cockpit doors of the Sikorsky/DARPA H-60 Optionally Piloted Vehicle pictured on your recent cover (*Feb. 21-March 6*) likely appreciated the somewhat whimsical irony of informing a nonexistent human pilot of the certification status of an aircraft that has eliminated the need for said human pilot’s existence.

Congratulations to Igor Cherepinsky and his team. It’s likely that the original Igor would be very pleased but not surprised.

Len Meyer, Harwinton, Connecticut

PIC IS PIC

Kudos to William Garvey for his column about the events, actual and legal, surrounding the termination of Capt. Justinic (*“Costly Countermand,” Feb. 7-20, p. 14*).

I age-retired from regional airline flying in 2018 with almost 40 years of commercial experience. The court’s decision against and punishment of the defendant supports the correct concept that the pilot in command (PIC) is just that, negating pressures or threats to operate in questionable or unsafe circumstances from employer-owners.

I was more protected from this under Part 121 operations and helped by union membership, but I understand the palpable pressures under Part 91, where the PIC is often and practically a one-person operation.

I applaud Capt. Justinic’s reasonable decisions and am happy he has been vindicated. On more than one occasion I was asked to operate in either questionable weather or aircraft conditions but managed to enhance safety by just saying “no.”

Capt. (ret.) Bart Groeneveld, Park Hills, Kentucky

THE END OF TRANSCENDENCE?

It breaks my heart to write this; I have spent my entire life believing that the exploration of space should transcend international politics. For over 20 years now, the International Space Station has been a shining beacon, literally flying over our heads showing us what human beings from all continents, creeds, religions and cultures can achieve if they work together for a common aim. But there comes a time when it is impossible to divorce these projects from the actions of the governments that support them.

As a recognition of Russia’s outrageous, illegal and barbaric invasion of Ukraine, the other members of the ISS consortium should inform Russia that they are no longer prepared to share that facility with Russia and that their cosmonauts should leave at the earliest opportunity. Should Russia refuse to leave the ISS, the other participant countries should make clear that they intend to withdraw their support from the project and that their astronauts will leave the ISS as soon as possible.

This is of course tragic for the individuals involved both in orbit and on the ground, who have played no part in this confrontation, but this is a time for clear, unequivocal gestures to make it clear to Russia that the action it has taken in Ukraine is totally unacceptable to civilized countries.

Alan Marlow, Great Horwood, England

PORK BARREL DINOSAUR?

In his “Feedback” letter, Thomas Frieling expressed the wish for a long operational life for the Space Launch System (SLS) rocket (*“Expendability Revisited,” Feb. 7-20, p. 5*). Unfortunately, the SLS is obsolete before it has even flown.

The Falcon 9 routinely reuses the majority of its hardware. The Starship should reuse all hardware. Several other competitors have fully reusable and partially reusable spacecraft in development.

The SLS looks like a pork barrel dinosaur. Maybe we can find a spot for it down by the docks alongside the Spruce Goose.

Dale Gibby, Columbus, Indiana

Editor’s note: The government SLS/Orion program was never intended to be a technology driver. It was established to expand human presence beyond low Earth orbit, repurposing as much hardware as possible from the space shuttle program.

CORRECTIONS

An item in “First Take” in the *March 7-20* issue should have stated that MDA of Canada awarded Rocket Lab a contract for spacecraft buses.

“Starship, Plan B” (*Feb. 21-March 6, p. 32*) should have stated that the SpaceX Starship’s lift capacity is 100-150 tons to low Earth orbit.



JULIET TREHM/AMCAST

BEHIND THE SCENES

Chef **Wolfgang Puck** said hello to **Allison Gold** (left), Aviation Week senior show manager, and **Lydia Janow**, senior vice president for events, at the dinner at his restaurant for Aviation Week’s SpeedNews Commercial Aviation Suppliers Conference. The conference and a sister event, the Raw Materials & Manufacturers Supply Chain Conference, drew nearly 300 attendees to Beverly Hills, California, in early March.

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

WHO'S WHERE

Shawn Black has been named *GKN Aerospace* president of defense. Black, a former U.S. Marine Corps captain, has held senior-level positions at Leonardo DRS, Cobham and Cobham's Advanced Electronic Solutions, where he was chief operating officer and later CEO.



Raytheon Technologies has named **Chris Calio** chief operating officer, promoting the former Pratt & Whitney president into a role overseeing all four divisions of the recently merged entity. **Shane Eddy** succeeds him as division president; he was senior vice president and chief operations officer at Pratt.



Catherine Koerner has been promoted to deputy associate administrator for NASA's Exploration Systems Development Mission Directorate. Succeeding her as Orion Program manager is **Howard Hu**, who will oversee Orion's first uncrewed flight test around the Moon.



Hu has been with NASA more than 30 years in a number of technical and leadership positions.

Douglas Bush has been confirmed as *U.S. Army* assistant secretary for acquisition, technology and logistics. He had served with the House Armed Services Committee and is also a wargame designer.

Uncrewed aircraft system developer *Advanced Aircraft Co.* has appointed **Paul Allen** as CEO and **Aaron Frank** as chief operating officer. Allen was program manager of Boeing subsidiary Insitu, Iris Automation Inc. and was AgEagle vice president of business development, working with U.S. defense customers and allies. Frank was CEO of Skycart, corporate development director and head of drone and unmanned aerial systems solutions at Local Motors and director at GE Capital.

The Space Frontier Foundation has chosen **Ann Kapusta**, a space operations veteran, as its new executive director. Kapusta is co-founder and managing director of ThinkSpace Consulting.

Maureen Waterston has joined *Leidos* as chief human resources officer. She was in the same role at Pratt & Whitney and held human resources leadership positions at United Technologies Corp. divisions and Otis Elevator.



Jaunt Air Mobility has hired **Yves Comeau** as vice president of finance. He has held a number of leadership roles in 31 years with Bombardier Aerospace, including setting up new manufacturing and assembly plants in different countries.



Jim Davidson has been promoted to CEO from president and chief strategy officer at *Accelya*.

He succeeds John Johnston, who will stay on as special advisor to the board. Davidson was CEO of Farelogix prior to its acquisition by Accelya, and before that was president and CEO of NTE



and president and CEO of Amadeus Global Travel.

Daniel Germain has been promoted to business unit director of displays and sensors at *CMC*

Electronics. He was senior product manager of the unit and has been with CMC since 1989. He succeeds Andrew Kriulik, who has retired.

GomSpace, a cubesat and smallsat services supplier, has appointed **Thomas Pfister** chief commercial officer, based in Toulouse. Pfister was Asia-Pacific commercial satellites sales director for Airbus Defence and Space.



Scott Lawson has been named general manager of aftermarket business jet components and systems supplier for *Henderson Jet Services*. He previously held leadership and management

positions at Airborne Express and Evans Composites, among other companies.

Tecnam has promoted **Volodymyr Rizzitano** to customer service manager from aircraft delivery manager. Rizzitano will provide problem-solving support to customers and to Tecnam



Service Centers worldwide.

U.S. Air Force Gen. (ret.) **Ellen Pawlikowski** has been elected to the *Velo3D* board. She brings decades of experience in

aviation, aerospace and defense. *Velo3D* is decreasing its board to nine members from 12.

Orbital Assembly Corp. has named **William Tauskey** and **Drew Wahl** to its board. Wahl is a co-founder and managing director of IG Partners (IGP), a management consulting firm. Tauskey, who has been with IGP since 2009, also has been managing partner at ConXtus consulting since 2015.

Astroscale Holdings has appointed **Jan Woerner**, former European Space Agency director general, and **Yuko Noguchi**, a lawyer specializing in technology law and intellectual property, to its board.

The National Cybersecurity Center has appointed **Dawn Meyerriecks** to its board. Meyerriecks, who is a Mitre senior fellow, led the CIA Directorate of Science and Technology, overseeing the organization's first restructuring in its 57-year history.

HONORS & ELECTIONS

Northrop Grumman employee **Veldesta Evans** received the *2022 Black Engineer of the Year Community Service Award* at the recent 36th annual Black Engineer of the Year (BEYA) Global Competitiveness Conference. Fifteen Northrop Grumman employees also were recognized as *BEYA Modern Day Technology Leaders*. They are: **Shawnette Adams, Eric Auzenne, Brigitte Blair, Andrea Burgess, Joi Carter, Cynthia Cloud, Alante Dancy, Jeffrey Gray, Raul Ibarra, Ashley Johnson, Faraji Leary, Fabio Nelson, Kayode Sanni, Krystle Stringfellow** and **Reginald White**. ☺

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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FIRST TAKE

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NASA

SPACE

The 18 segments of the James Webb Space Telescope's primary mirror are fully aligned and working as a single 21-ft-dia. mirror as designed, NASA announced on March 16.

NASA's first Space Launch System rocket rolled out to the launchpad at Kennedy Space Center on March 17 for a fueling test in advance of a planned launch this spring.



NASA

The European Space Agency has suspended cooperation with Russia's Roscosmos on the ExoMars 2022 rover and launched a fast-track study of options to implement the mission.

Russia is to stop supplying RD-181 engines, used on Northrop Grumman's Antares rocket, to the U.S. in retaliation for sanctions imposed in response to its invasion of Ukraine.

ROTORCRAFT

Swiss engineering company Marenco, whose SH09 helicopter was acquired by Leonardo as the AW09, is seeking investors for an eight-passenger hybrid-electric concept dubbed the M12/M22 (page 56).

Sikorsky is no longer accepting orders for the S-76D, effectively shutting down the 45-year-old medium helicopter program.

A Texas-based company has rescued Enstrom Helicopter from bankruptcy and plans to reopen the factory in Michigan in late April.

DEFENSE

In a turnaround, Germany plans to purchase 35 Lockheed Martin F-35As to partially replace its fleet of Panavia Tornados and take over the nuclear-deterrence mission (page 19).

Pakistan has inducted its first six of 25 Chengdu J-10C multirole fighters, delivered to Kamra air base on March 4 in the first export sale of the Chinese fighter.

Having threatened sanctions over its purchase of Sukhoi Su-35s, the U.S. has agreed to supply Egypt with Boeing F-15EXs, the chief of U.S. Central Command told lawmakers on March 15.

The first Northrop Grumman B-21 has entered ground testing, and production has started on the sixth example of the next-generation bomber, the U.S. Air Force says (page 14).

The first of three Northrop Grumman RQ-4 Block 30(I) Global Hawks for the Japan Air Self-Defense Force arrived at Misawa air base on March 12.

The U.S. government has determined that North Korea conducted initial test launches of a new intercontinental ballistic missile on Feb. 26 and March 4.

The U.S. Air Force's AFWerx innovation unit has awarded a \$9 million contract to Blue Force Technologies to build four uncrewed jet aircraft called Bandits for adversary training.

U.S. hypersonic aircraft startup Hermeus has closed a \$100 million fundraising round, providing the funding to fly its first Quarterhorse test vehicle in 2023.

Saudi Arabian defense company Intra is developing an indigenous, twin-engine, high-altitude, long-endurance unmanned aircraft called the Samoom (page 43).

COMMERCIAL

Boeing is no longer purchasing titanium from Russia, a move that will speed up the company's push to diversify its supply of the raw material (pages 30-31).

VIEW FROM WASHINGTON

U.S. Ups the Ante

The U.S. is dramatically ramping up military assistance to Ukraine after its president made an emotional appeal to Congress. Taking the total in recent weeks to \$1.35 billion, the new package includes uncrewed aircraft for the first time.

The Biden administration has specifically identified weapon systems that will be sent to Ukraine, including Stinger anti-aircraft and Javelin anti-armor missiles and 100 tactical uncrewed aircraft—likely AeroVironment Switchblade loitering munitions.

"It would certainly be safe to assume one of the purposes of these unmanned aerial systems would be to deliver a punch," a senior U.S. defense official said.

U.S. Defense Secretary Lloyd Austin, meanwhile, was meeting NATO member nations that could provide Ukraine with familiar Russian-made air defense systems, such as S-300s and S-400s. The White House said the U.S. has identified and is helping nations that could provide such systems to Kyiv.

This would require a backfill with other air defense systems, such as U.S.-made Patriot missiles, if a nation were to hand over its surface-to-air missile systems.

"The focus right now on is on talking to countries that have systems that we know Ukrainians need and can use, and we're doing that actively," the official said. "For some countries it is harder to give those kinds of systems away, because of how dependent they are on them or how many they might have."

Russian airlines, under a new law permitting them to reregister foreign aircraft as their own property, are moving Western-made aircraft from foreign jurisdictions to the Russian registry (page 27).

Embraer has launched passenger-to-freighter conversions for the E190 and E195 to meet growing e-commerce demand. Entry into service is planned for 2024.

Alaska Airlines and regional subsidiary Horizon Air have established a flight academy in the Pacific Northwest in an effort to address a shortage of pilots.

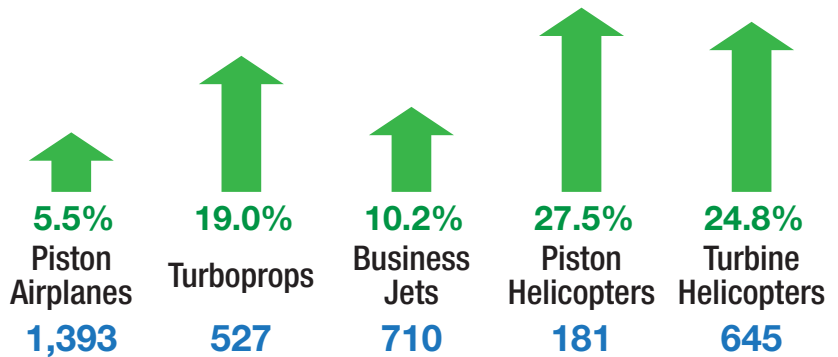
TECHNOLOGY

Zero-emission propulsion startup Universal Hydrogen is to locate manufacturing of modular hydrogen capsules and regional aircraft powertrain retrofit kits in Albuquerque, New Mexico.

Spirit AeroSystems is to design and manufacture the wing for Airbus' City-Airbus NextGen electric vertical-take-off-and-landing (eVTOL) air taxi.

Fractional operator NetJets has signed an agreement with Lilium that covers a possible order for 150 eVTOL aircraft, potentially operating Lilium's Florida network and training by FlightSafety International.

STRONG SHOWING
General Aviation Deliveries in 2021



Sources: General Aviation Manufacturers Association

The general aviation industry made a strong rebound in 2021 from COVID-19-related setbacks, with aircraft shipments converging on totals seen before the onset of the pandemic, says the General Aviation Manufacturers Association. Business aircraft order backlogs also grew on demand from private buyers, with most manufacturers sold out into 2024.

Former Airbus Space and Defense CEO Dirk Hoke will take over in September as CEO of eVTOL developer Volocopter, which has secured an initial tranche of \$170 million in Series E financing.

BAE Systems is collaborating with Slovenian light aircraft manufacturer Pipistrel to examine potential military training applications for electric aircraft.

Textron is to acquire Slovenian electric

aircraft pioneer Pipistrel, which will become part of a new Textron eAviation unit focused on sustainable aircraft.

OBITUARY

Eugene Parker, the heliophysicist who in 1958 developed the theory of the existence of the solar wind, died March 15 in Chicago. He was 94. He gave his name to NASA's Parker Solar Probe and was present in 2018 when it was launched to fly through the Sun's atmosphere. ☾

80 YEARS AGO IN AVIATION WEEK

Americans faced a grim-looking future in March 1942, three months after Japan's attack on Pearl Harbor brought the U.S. into World War II. Japanese forces had just captured Singapore from



the British, and Nazi Germany, which controlled most of Europe, was at the gates to Moscow. "We could lose this war," proclaimed a sobering editorial in this magazine written by Editor Leslie E. Neville. "With German submarines to the east of us and Japanese submarines to the west, and the prospect of certain forms of aerial action against our coasts a very real one, many of us remain

unmoved," he warned. "How long is it going to take for us to learn that there is no such thing as impregnability?" Neville lamented that Allied nations such as France, the UK and the U.S. should have allocated more defense spending to aircraft production. "It has taken too many people too long to learn the simple truth that it is easier to shoot down than to shoot up," he wrote. "Unless Congress stops using aviation for a political football, unless management stops worrying about stockholders and workers stop striking, we are not going to win this war."

Subscribers can read Neville's editorial and every issue of Aviation Week back to 1916 at: archive.aviationweek.com



UP FRONT

BYRON CALLAN

**IT IS TOO SOON TO ANSWER**

definitively the question as to whether the war in Ukraine will result in a mini up-cycle, with incremental defense demand

peaking in 2023-25 and then returning to a relatively staid budget outlook, or if it will mark the start of another longer cycle in which defense spending will grow annually as fast or faster than GDP for the balance of the 2020s.

Defense stocks have been signaling a significant change. Some in Europe and the U.S. were outperforming broader market indices before Russia invaded Ukraine on Feb. 24 and then soared after the conflict erupted. The moves are attributable to higher defense spending announced but not defined by some European countries and prospects for higher U.S. defense spending as well. The sector also has benefited from investors looking for safer places to put their money amid the turmoil and uncertainty caused by the war and sanctions.

Markets are asserting that 2023-25 financial expectations before the war for most U.S. and European defense contractors will be higher than consensus estimates currently show. According to data on consensus sell-side analysts' sales and earnings-per-share estimates collected by Bloomberg, there have been no significant upward revisions—yet. Analysts can and should make their own projections, but the changes wrought by the war in Ukraine will not be reflected in the U.S. fiscal 2023 defense budget that will be sent to Congress soon, and European defense budget changes also may not be detailed for months. It could take weeks or months for consensus estimates to move higher.

But an open question is whether defense spending in the U.S. and Europe will be stepped up in 2022-24 and then flatten, or if it can grow annually as fast as or faster than GDP over the balance of this decade. That question is most likely going to be answered by what happens to Russia's President Vladimir Putin and to Russia's capacity to generate and sustain its military power.

If its broad goals are achieved in Ukraine and Russia can declare a "victory," the sanctions and export controls unveiled since Feb. 24 are very unlikely to be reversed, particularly if Putin remains in power. Nor will the unity shown by NATO and the U.S. and the preliminary plans for higher defense spending be rolled back.

However, Russia's economy will face major adjustments in 2022 and beyond. It will have to replace

equipment lost in Ukraine, incorporate lessons learned from the war and, if it occupies parts of Ukraine, likely fight a harsh and nasty insurgency there. Its defense enterprises will have to find new sources of machine tools and micro-electronics, and Russian defense exports to traditional clients such as Algeria, Egypt, India and Vietnam could be curtailed.

Presuming that Putin remains Russia's leader or is succeeded by someone with similar views, key to post-war adjustments will be how the Russo-Chinese strategic relationship evolves. Effectively cut off from Europe

and the U.S., Russia will likely become more economically integrated with China, and their strategic/military cooperation will deepen beyond occasional joint military exercises. China should have an interest in supporting Russia, in part to keep U.S. military power tied down in Europe and not arrayed against it in the western Pacific. Expanding these relations will take time, as will development of technologies that are good enough to be a threat to U.S. and allied forces. This scenario—Putin remaining in power and Russia's strategic relationship

with China growing stronger—could be the most bullish for defense in the 2020s.

There are possible downside scenarios for Russia and defense as well. Russia could fail in Ukraine, and Putin could be replaced by leadership that wants to return to financial and economic integration with democracies in the U.S., Europe and Asia. That shift could remove Russia as a significant military threat and open new opportunities for nuclear arms control.

Another scenario is that Putin falls after a failed effort in Ukraine, and an internal security struggle results in Russia. That scenario could still be broadly supportive of U.S. and allied security concerns. Russia would remain a nuclear power, but its ability to equip and field advanced conventional military forces could be significantly degraded. Its support for regimes in Central Asia and the Middle East would diminish, which could have knock-on effects on regional stability and threat assessments. That scenario also might compel China to look more toward Eurasia as a source of instability, which could weigh on its aspirations in the Pacific. ☞

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Contributing columnist Byron Callan is a director at Capital Alpha Partners.

Signs of a Supercycle?

How the war in Ukraine and its outcome could affect **military markets**





GOING CONCERNS

MICHAEL BRUNO

TOMORROW.IO WILL HAVE TO WAIT for another day. The former ClimaCell weather services company rebranded and unveiled a plan a year ago to launch and operate a 32-satellite constellation as the cornerstone of a strategic shift to space-based services. Then in December, the Boston-based company said it would become publicly traded via a reverse merger with a special-purpose acquisition company (SPAC).

But just one financial quarter later, that scheme has been terminated. On March 7, Tomorrow.io CEO Shimon Elkabetz announced on LinkedIn that his company and the SPAC, Pine Technology Acquisition, had called off their deal. “In the recent months during our SPAC process . . . it became apparent through both our strategic initiatives and overall market conditions that the best choice for the company and its expansive growth is to remain private for now,” he wrote.

The dead deal hurts in more ways than one. For starters, Tomorrow.io must pay a breakup fee of \$1.5 million. At least Elkabetz had the courage to announce the deal’s demise publicly. Although merger and acquisition deals fall apart regularly—note that Lockheed Martin recently walked away from Aerojet Rocketdyne—it still must have been hard to give up on a year-long monetization plan and to become the face of one of the latest negative trends in aerospace and defense.

Tomorrow.io was supposed to raise roughly \$420 million in gross proceeds—before SPAC shareholder redemptions or deal costs—including \$75 million in direct investments from JetBlue Technology Ventures and others. It will likely go on to raise more private funds as needed. The six-year-old startup is already realizing revenue and has a track record of landing venture capital: The company received at least \$77 million in new venture capital at the start of its makeover. Customers have included Delta Air Lines, Uber and National Grid. A future public offering remains a possibility.

The more interesting question is what will happen to Pine and all the other SPACs that have been eyeing aerospace and defense assets. It has not been a good year so far in the SPAC universe. Space-investing newsletter Payload noted that a SPAC has been called off every 6.6 days on average so far this year.

A PitchBook analysis released in December con-

cludes that at least 25% of all blank-check holding companies that debuted public shares in 2020 will not execute a deal prior to the traditional two-year deadline for doing so. This is the year when the bevy of SPACs that formed in 2020 faces a deal-or-no-deal moment.

When the PitchBook report came out, 84 traded SPACs had yet to capture a real business. One of them is New Vista Acquisition, led by former Boeing CEO Dennis Muilenburg and other aviation luminaries. New Vista formed in December 2020 and began trading as a public entity on April 16, 2021. Ostensibly, it has until the same date in 2023 to close an acquisition or return its money to investors.

But sector-specific conditions have combined with a wider souring sentiment on SPACs, making it harder to go public via a SPAC-related deal, as Tomorrow.io has shown. For starters, according to insiders, the number of viable candidates in aerospace can be misleading. The difference between a startup tinkering with a new design for an aircraft, rocket, spacecraft or related service and the plausibility or timeline of fielding a U.S.-certified, field-supported, revenue-producing version at

scale can be vast. Just look at 108-year-old Boeing, which is struggling with 737 MAX and 787 production years after the aircraft entered service.

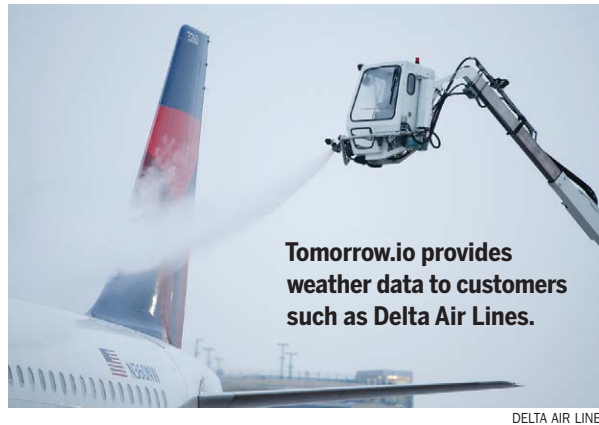
In this sense, the noise-to-signal mismatch in aerospace seems to be a microcosm of the disappointment writ large (*AW&ST* Jan. 10-23, p. 26). “We posit that the boom of SPAC issuance outpaced the true market opportunity for the SPAC vehicle,” says Cameron Stanfill, senior analyst and venture capital lead at PitchBook.

Aerospace SPAC deals keep launching nonetheless. D-Orbit, an 11-year-old Italian startup offering the Ion Satellite Carrier for in-orbit positioning, on Jan. 27 unveiled a deal with Breeze Holdings that should provide D-Orbit up to \$185 million gross. Small-satellite maker and Earth-observation-service startup Terran Orbital expects to go public in March after its reverse merger with Tailwind Two Acquisition, which could provide it \$345 million gross.

Hopefully, these companies will remain successful long after their proposed public debuts. SPACs, when seen as yet another option to finance aerospace ideas, can be good for the whole sector. But so is the newfound sense of sobriety and, possibly, better capital allocation. 🗎

Catching a Chill

Aerospace SPACs face
a deal-or-no-deal moment



Tomorrow.io provides weather data to customers such as Delta Air Lines.

DELTA AIR LINES



LEADING EDGE

GRAHAM WARWICK

A CENTRAL TENET OF ADVANCED air mobility is that it can bring aviation closer to people—in other words, no driving on congested roads to a crowded airport tens of miles from the city. Instead, aircraft will operate from airfields close to communities or vertiports down the street, or they will deliver packages to a neighbor's yard.

But when bringing aircraft closer to people, noise becomes critical. Any level of annoyance will foster public opposition and could put the brakes on the democratization of aviation before it can gain momentum.

The promise of significantly lower noise from electric vertical-takeoff-and-landing (eVTOL) technology is still that—a promise—although independently measured data is beginning to be collected, by NASA with Joby in September and by Volocopter and its partners at a test site in Paris in March.

The stated goal of leading eVTOL development is to achieve sound levels that blend into the background noise of urban landscapes, so that an air taxi taking off from a rooftop vertiport is inaudible over the traffic noise of city streets. Routes could follow freeways so aircraft can hide in the roar of trucks.

But some locations, and some missions, will require even greater levels of quietness: serving airfields in noise-sensitive rural areas or tourist sites, delivering packages into residential communities or maintaining surveillance of targets without being detected.

Former NASA engineer Mark Moore was a key architect of Uber's Elevate vision for urban aerial ride-sharing, which catalyzed the emergence of the eVTOL industry. The 2016 Elevate white paper underlined the need for urban air mobility to blend into background noise.

Moving on from Elevate, Moore in 2020 co-founded Whisper Aero to develop ultra-quiet electric propulsion. Details are still under wraps, but Whisper plans to build a 55-lb. surveillance drone (see image) to demonstrate the technology with funding support from the U.S. Air Force's AFWERX innovation unit.

"Just because an aircraft is electric doesn't mean it's quiet," Moore said in a March 9 presentation to attendees at the Helicopter Association International Helicopter Expo conference in Dallas. In the surveillance mission,

ultra-quietness will allow the drone to be acoustically undetectable at a distance of just 200 ft. from its target, compared with 2,000-5,000 ft. for an Insitu ScanEagle, he said. This will enable the drone to use simpler, cheaper nongimbaled sensors.

Whisper does not intend to stop with drones and has plans to develop an electric conventional-takeoff-and-landing (CTOL) aircraft, the Cirrus SR22-class Special Operations Jet, and will use funding from Air Force Special Operations Command to study a 15,000-30,000-lb. high-speed VTOL concept using its propulsors.

Sounds of Silence

Ingenuity required to make **electric aircraft ultra-quiet**



WHISPER AERO

But what if an aircraft must be even quieter? In 2018, Massachusetts Institute of Technology (MIT) researchers flew an aircraft on a propulsion system with no moving parts whatsoever. The drone, which weighed barely 5 lb., produced less than 1 lb. of thrust and flew just 160 ft. across a gym. But it was the first-ever flight of an aircraft with solid-state propulsion.

While the flights have proven the feasibility of electroaerodynamic (EAD) propulsion, they did not validate its practicality. To do that, MIT is building a CTOL drone designed to fly outside for 10 min. with a 0.5-lb. payload, and now NASA is funding MIT to scale up the propulsion concept to power a near-silent VTOL delivery drone.

EAD works by accelerating ions between two electrodes, an emitter and a collector. As they flow from emitter to collector, the ions collide with neutral air molecules, transferring energy to the airflow and generating an ionic wind that produces thrust to propel the aircraft.

The delivery drone will use multistage ducted thrusters, in which multiple EAD stages are enclosed inside a duct, to increase the thrust density sufficiently to enable VTOL operation. The objective is to develop a near-silent aircraft capable of delivery missions in noise-sensitive areas or at night.

"We don't yet know for sure if it is achievable, but the target would be something like a 5-lb. payload and 30-min. endurance, but with vertical takeoff and landing, which would then be usable for package delivery applications," says Steven Barrett, professor of aeronautics and astronautics at MIT. ☛

—With Garrett Reim in Dallas

THE LAUNCHPAD

IRENE KLOTZ



WHEN NASA ASTRONAUT MICHAEL

Lopez-Alegria returned from his fourth flight in April 2007, he never imagined that 15 years later he would be heading back

into orbit, this time to oversee a group of paying travelers to the International Space Station.

For his fifth flight, slated to launch as early as March 30 from the Kennedy Space Center, Lopez-Alegria will ride a SpaceX Crew Dragon capsule chartered by his employer, Houston-based Axiom Space. Joining Lopez-Alegria for a planned 10-day mission to the International Space Station (ISS) will be three spaceflight participants, the largest group of non-professional astronauts to visit the outpost at one time.

“This has been a magical tour for me,” Lopez-Alegria, 63, tells Aviation Week. “I left NASA completely content with my career and with no aspirations or expectations of going back.”

The mission, designated Ax-1, marks the first private spaceflight to the ISS under the auspices of NASA, which plans to sponsor two such missions per year as part of a program to bolster commercial development in low Earth orbit.

Russia has conducted nine private astronaut missions to the station brokered by the U.S. company Space Adventures and one mission in partnership with Russia’s Channel One television station.

Lopez-Alegria is among NASA’s most experienced astronauts, having spent 257 days in space over four flights, including six months on the ISS as commander of the September 2006-April 2007 Expedition 14.

He left the agency in 2012 and served as president of the Commercial Spaceflight Federation, an industry advocacy organization. Initially skeptical of private space travel, Lopez-Alegria changed his views after experiencing firsthand the missions of spaceflight participants Anousheh Ansari and Charles Simonyi on the ISS in 2006 and 2007, respectively.

Now flying as the Ax-1 commander, Lopez-Alegria will oversee three paying passengers: Larry Connor, 72, a Dayton, Ohio-based real estate and technology entrepreneur; Mark Pathy, 52, chairman and CEO of Mavrik, a Montreal-based investment firm; and Israeli entrepreneur Eytan Stibbe, 64, founding partner of Vital Capital, an impact investment company that focuses on developing countries (*AW&ST* Feb. 7-20, p. 40).

“The private astronauts are not trained to the level

of the professional astronauts, by any means, but they are qualified to be what are called ‘users’ on several [ISS] systems,” Lopez-Alegria says.

The ISS has three different qualification levels—user, operator and specialist—for each system.

The Ax-1 crew also has trained extensively on emergency procedures in case of fire, spacecraft depressurization, an ammonia leak from the station’s cooling system and a less toxic leak, such as battery acid. In

total, the private astronaut training program takes about 100 hr.

“I’ve been pleasantly surprised at how adept these guys ended up being, though to be fair, two of the three guys had a fair amount of operational background,” Lopez-Alegria says. “Eytan is a fighter pilot, and Larry has [had] a lot of time in acrobatic airplanes, race car driving and those kinds of things. Mark has none of that, but all three are pretty quick studies when it comes to thinking on their feet and reacting to situations.”

Once in orbit, Lopez-Alegria expects his crew will handle their science experiments and other activities much the same as professional astronauts and cosmonauts. The biggest difference will be managing crewmembers who also are his customers. “I try really hard to let all the business between Axiom and the astronauts be via some other channel than me because I want my relationship to them to be one of a crewmate, not a customer-provider kind of exchange,” he says.

Lopez-Alegria is not the only former NASA astronaut heading back to space on private missions. Ax-2, also targeted to launch this year, will be led by astronaut Peggy Whitson, who holds the U.S. record for the most time spent in orbit, 665 days.

Axiom has contracted with SpaceX for four charter flights to the ISS, though only Ax-1 has been approved by NASA. Axiom intends to use the sorties as testbeds and proving grounds for operations of an Axiom-owned wing that is to be added to the ISS beginning in 2024.

The early private astronaut missions are not a money-making effort for Axiom, which reportedly charges customers upward of \$50 million apiece. On those flights, Axiom sells three seats and uses the fourth to fly an employee.

“We need to learn to work with NASA, and NASA needs to learn to work with private entities,” says Mary Lynne Dittmar, Axiom executive vice president for government affairs. “We’re investing in the process.”

Afterlives of Astronauts

Michael Lopez-Alegria heads back to space



BILL INGALLS/NASA

BOMBSHELL

- > U.S. AIR FORCE B-21 AND NGAD PROGRAMS SPAWN AUTONOMOUS SHADOW AIRCRAFT
- > LOYAL WINGMAN PRICED AT UP TO \$320 MILLION EACH
- > PERFORMANCE RECALLS CANCELED J-UCAS DEMONSTRATORS



Steve Trimble Washington and **Brian Everstine** Orlando, Florida

A new proposal by the U.S. Air Force is transforming the concept of a “Loyal Wingman” for the Northrop Grumman B-21 bomber and future Next-Generation Air Dominance aircraft.

Rather than a small, reusable, autonomous aircraft that is cheap enough to sacrifice on any given mission, two new classified programs set to be proposed in the fiscal 2023 budget may call for new types of long-range uncrewed aircraft systems (UAS) capable of carrying thousands of pounds of munitions, with a price tag higher by an order of magnitude compared to the low-cost, attritable systems shown to date.

A new proposal for the Air Force’s “wingman” UAS concepts for the B-21 and Next-Generation Air Dominance (NGAD) aircraft instead recalls the operational versions that were supposed to follow DARPA’s pioneering Joint Unmanned Combat Air Systems (J-UCAS) program before its termination in 2006. They will be designed to accompany and support crewed B-21s and NGAD fighters but will be pow-

erful weapon systems in their own right, costing up to hundreds of millions of dollars each.

“We’re looking for [uncrewed] systems that cost nominally on the order of at least half as much as the manned systems that we’re talking about for both NGAD and for [the] B-21,” Air Force Secretary Frank Kendall said in remarks at the Air Warfare Symposium on March 3.

Such a cost estimate represents a huge escalation for the Loyal Wingman concept. Since 2016, the Air Force Research Laboratory (AFRL) has demonstrated a series of low-cost attritable aircraft platforms typified by the Kratos XQ-58A Valkyrie, an aircraft with a \$3-4 million cost target. In presentations, the AFRL defined the “attritable” term as a UAS costing \$2-20 million—a price range high

enough to field a reusable system but still cheap enough to sacrifice, depending on the mission need.

The AFRL will continue experimenting with low-cost wingman concepts, but Kendall’s remarks show that the Air Force may seek a more sophisticated approach to the “Loyal Wingman” concept for the B-21 and NGAD. The Air Force launched the B-21 program with an average unit cost target of \$550 million, which was readjusted to \$511 million based on Northrop’s cheaper, winning bid. But that number is calculated in 2012 dollars. If adjusted for inflation, the current value of the average unit cost target for the B-21 is about \$640 million.

A half-price “wingman” for the B-21, therefore, would cost about \$320 million, roughly the same as four Lockheed Martin F-35As. The NGAD program has not declared a target for the average unit price of the next crewed fighter, but a December 2018 estimate by the Congressional Budget Office (CBO) forecasts a \$300 million price tag. A half-price wingman of the CBO’s NGAD concept would cost about \$150 million, a number significantly higher than called for by the AFRL’s

The 15-year-old Northrop Grumman X-47B demonstrators are typical of the performance characteristics sought by the U.S. Air Force for an uncrewed wingman to fly alongside the B-21 bomber.



NORTHROP GRUMMAN

version of an attritable Loyal Wingman.

In follow-up remarks after his speech at the symposium, Kendall clarified that the final cost estimate for the two classified uncrewed combat aircraft programs he has proposed remain under debate, with different sides arguing which capabilities on the B-21 or NGAD could be deleted on the uncrewed platforms. But Kendall does not expect the uncrewed aircraft to cost any less than half of a B-21 or NGAD. “The nominal ‘one-half’ is sort of an estimate of what we should shoot to achieve as a minimum at this point. I’d love it to be lower,” Kendall says.

The Air Force’s planned force structure for B-21s and NGADs could be affected by the new revelations about the scope of the two new classified UAS programs. An optimistic scenario might allow the Air Force to use such a large, uncrewed bomber to add to the “more than 100” B-21s in the program of record, with the UAS perhaps helping to achieve Air Force Global Strike Command’s preferred fleet size of about 150 stealth bombers. Alternatively, a pessimistic outlook could jeopardize the Air Force’s plan to buy more than 100 B-21s, as a sub-

set of the mission is diverted to the lower-cost UAS fleet.

In a follow-up interview, Kendall says he remains comfortable with the current number of B-21s in the program of record and that any changes would be speculative.

Lt. Gen. Clinton Hinote, deputy chief of staff for strategy, integration and requirements, says the Air Force is trying to figure out how a part of the long-range strike mission could be performed less expensively by using UAS rather than a B-21.

“We’re asking what our [industry] offerors might be able to do with producing combat capability at a lower price point by using autonomy,” Hinote says. “We don’t know what answers we’re going to get.”

In an interview with Aviation Week, Kendall says the proposal for a half-price, uncrewed wingman for the B-21 may still be dropped based on responses from industry. “I’m quite convinced [as] to the cost-effectiveness of a mix of crewed and uncrewed aircraft for the NGAD family of systems,” he says. “I’m hopeful that we’ll get a similar answer for the longer-range B-21 family, but we want to do the work to make sure that’s true.”

The Air Force needs the future UAS to accompany the B-21 and NGAD for the full length of its mission, Kendall says. In addition to implying a need for broadband stealth features and advanced electronic warfare systems, his remarks point to a need for a large, long-range aircraft. “It has to have range capability to go as far as the crewed system goes and support that system with a reasonable payload when it gets there,” Kendall notes.

Such a UAS may not fit the AFRL’s classic definition of “attritable,” but the term still may apply in other ways. Unlike the AFRL’s \$2-\$20 million price range for an attritable system, Kendall defined the term only as a function of the lack of a human onboard. In this sense of the attritable term, even a \$320 million aircraft can be allowed to take what might be considered a suicidal risk to a human-piloted aircraft during a combat mission.

“They can also be attritable or even sacrificed if doing so confers a major operational advantage—something we would never do with a crewed platform,” Kendall says.

A market survey released to indus-

try in February lists unclassified performance capabilities sought for the B-21’s uncrewed wingman. It calls for an aircraft with subsonic speed and at least 1,500-nm range and a minimum payload of 4,000 lb., along with the ability to operate in a “dense” environment of enemy radars, radio frequency receivers and infrared sensors.

Such characteristics recall the capabilities of the Northrop Grumman X-47B and Boeing X-45C, the DARPA-funded demonstrators for the J-UCAS program more than 15 years ago. Such single-engine aircraft can greatly exceed the cost of stealthy crewed fighters. For example, the average flyaway cost for the unarmed and nonstealthy Boeing MQ-25 carrier-based tanker is about \$121 million, or 28% more than a U.S. Navy F-35C ordered in fiscal 2022.

The market survey’s unclassified list of performance capabilities likely understates the Air Force’s preferred performance targets for the new bomber. Mark Gunzinger, director of Future Aerospace Concepts and Capability Assessments for the Mitchell Institute, tells Aviation Week he expects the “B-21 Wingman” requirements to include 3,000-nm range and 10,000-lb. payload capacity.

Notably, Gunzinger, a retired Air Force colonel and bomber pilot, participated in the 2010 study that led to the Long-Range Strike Bomber program, which called for a family of systems including a bomber, uncrewed aircraft systems and new munitions. “I think we are finally seeing some definition of what the rest of the long-range strike family of systems will be,” he says.

As the J-UCAS program was abandoned in 2006, the Air Force briefly discussed plans to launch development of an operational follow-on. Boeing and Northrop, the J-UCAS competitors, publicly discussed options. The designs included an X-45D with a 125-ft. wingspan, 20,000-lb. payload capacity and the ability to carry up to 80 250-lb. bombs. Northrop’s proposed X-47C, meanwhile, was a B-2-size version of the X-47B and also had the capacity to carry a 20,000-lb. weapons load. ☛

Webinar *Aviation Week editors discuss everything they have learned about the B-21, the first new U.S. stealth bomber in over 30 years:*
[AviationWeek.com/webinar](https://www.aviationweek.com/webinar)





TONY OSBORNE/AW&ST

Germany Favors F-35s in Tornado Successor Reconsideration

- > BERLIN EXPECTED TO ORDER 35 F-35As FOR DETERRENCE MISSION
- > EUROFIGHTER WILL BE ADAPTED FOR ELECTRONIC WARFARE TASK

Tony Osborne London

Hot on the heels of success in Finland and Switzerland, Lockheed Martin's F-35 has won another European customer: Germany.

Berlin's reengagement with the Joint Strike Fighter (JSF), three years after it was spurned in favor of Boeing's F/A-18 Super Hornet—partly as a concession to Franco-German defense collaboration—comes as it prepares to make bolder defense commitments, prompted by Russia's invasion of Ukraine. Finding a successor to Germany's aging Panavia Tornado fleet was one of the priorities of Chancellor Olaf Scholz's planned €100 billion (\$110 billion) defense fund. Once in service, the F-35's primary mission will be nuclear deterrence as a dual-capable aircraft (DCA) using dual-key U.S.-supplied B61 nuclear weapons (*AW&ST* Jan. 24-Feb. 6, p. 23). It is a task that has risen to new prominence in German politics in recent weeks.

"With the F-35, the task of nuclear sharing will be guaranteed in the future," German Defense Minister Christine Lambrecht said March 14.

"[The F-35] offers unique potential for cooperation with NATO allies," Lambrecht said. She noted that eight European NATO countries have now purchased or ordered the aircraft, five of which border Germany.

"This decision is a major policy shift for Germany," says Justin Bronk, airpower and technology research fellow for the London-based Royal United Services Institute. "It suggests a closer link is now being made between combat air procurement decisions and practical operational capability requirements."

The selection of the F-35 appears to end Boeing's hopes of securing a European order for the F/A-18 Super Hornet and EA-18G Growler.

German taxpayers might have had to foot the bill for the potentially costly certification and integration of the B61 weapon on the Super Hornet. Nuclear weapons were removed from U.S. aircraft carriers in the 1990s, so the U.S. Navy never had to integrate the weapon onto the platform. Industry officials had hinted that certifying the Super Hornet to carry the B61 would be straightforward, since the Legacy Hornet model had been cleared to carry the weapon. Regardless, with the F-35, those certification costs have been underwritten by Washington.

But there is potential for fallout with neighbors, as an F-35 selection could sour relations with Paris. Previously, France had threatened to kick Germany from the Future Combat Air

Germany's planned fleet of F-35s will operate alongside Tranche 5-model Eurofighters, including aircraft locally adapted for the electronic warfare mission.

System (FCAS) program had it opted for a JSF buy, but it is unclear whether such threats will follow this time.

French newspapers have described Germany's decision as "irritating" but note that Scholz has committed to European development cooperation, particularly around the FCAS and armored vehicles, describing the projects as Germany's "utmost priority" (*AW&ST* March 7-20, p. 20).

Germany's planned hike in defense spending to 2% of GDP will make it a virtual superpower, the third-largest defense spender in the world after the U.S. and China, more than likely capable of sustaining spending on both an F-35 purchase and FCAS development. Furthermore, Germany is not acquiring large numbers of F-35s, with just 35 planned, as many of the Tornado's missions will be performed by new versions of the Eurofighter Typhoon. The predecessor Merkel administration planned to order 55 Eurofighters, 30 Super Hornets and 15 Growlers to replace the 93-strong Tornado fleet. The number of Eurofighters is likely to remain stable.

German industry's role has not been ignored in the proposals. As well as the development of more advanced Eurofighters, it will move forward development of the proposed Eurofighter ECR electronic warfare aircraft, creating a Growler-like capability on the Eurofighter platform. That development, officials say, could bolster Germany's defense capability and help it secure a "strong role" in the FCAS program.

"[The F-35] strengthens our ability to work with them to secure NATO airspace and defend the alliance," says German Air Force chief Gen. Ingo Gerhartz. "Together with the further development of the Eurofighter for electronic combat, we are taking an important step in preparing the air force and thus the German Armed Forces for the future."

Airbus Defense and Space CEO Michael Schoellhorn welcomes the decision to add the electronic warfare mission to the Eurofighter, but warns that Germany needs to launch development of the Tranche 5 version of the

aircraft so that the type could replace the Tornado by 2030. He suggests there is little concern about an F-35 procurement because the type is being acquired specifically for the nuclear mission. "It would link a U.S. airplane

with the U.S. nuclear shield, meaning existing U.S. 'black boxes' in the electronic/software systems are less of a concern," he says.

Germany's selection means the F-35 has been victorious in virtually

every fighter contest in which it has participated. All eyes are now on Canada's Future Fighter Capability Project, which is expected to make its long-awaited selection in the coming weeks. ☉

U.S. Air Force F-35 Costs To Climb

- LONG-AWAITED FULL-RATE PRODUCTION DECISION COULD SLIP TO FISCAL 2024
- PROGRAM OFFICE AND PRATT & WHITNEY SAY ENGINE "CRISIS" WILL BE IMPROVING SOON

Brian Everstine Washington

The cost of Lockheed Martin F-35s for the U.S. Air Force is expected to grow this year, after years of a downward trend in price, because of delayed negotiations with prime contractor Lockheed Martin.

As the price rises, the decision to move to full-rate production is also appearing likely to slip to 2024, as required high-tech simulations are also delayed.

Despite this double shot of negative news for the program, officials are voicing some optimism in addressing one of the biggest issues facing the fleet. The "crisis" of engine capacity across the program, which had grounded more than four dozen of the aircraft in 2021, could be alleviated by increased depot output. Pratt & Whitney says a quality improvement program it has funded will show results.

"I think 2021 was a pretty good year for the program, despite all of the chaos that seemed to surround it," F-35 Joint Program Executive Officer Lt. Gen. Eric Fick says.

SLOW NEGOTIATIONS

The F-35 Joint Program Office (JPO) and Lockheed have been locked in extensive negotiations for a long-awaited Lot 15-17 contract, which will cover about 400 aircraft and engines. The JPO's self-imposed deadline of late 2021 was missed, and another goal at the end of March is also likely to slip by without a deal, Fick says.

"I'm losing confidence that we'll get it done by the end of [March], which was our revised target, but we're working closely with Lockheed to figure out how we move the needle forward," he says.

Fick notes that the deal has been slowed by "pretty stiff headwinds," which include the impact of COVID-19, supply chain disruptions and inflation. These will cause an increase in the cost per aircraft beyond the \$80 million for an F-35A variant under the last Lot 14 deal.

"We only have so much money, and we need to buy so many airplanes," Fick says. "So we're trying to figure out how . . . to find a place that allows us to get the aircraft we need at a cost that we can afford while still recognizing some of those [factors]," Fick says.

The lower quantity of aircraft and other "key differences" from the prior Lot 12-14 contract have made it

more difficult than expected to agree to an appropriate cost baseline, Lockheed says.

"We continue to engage in earnest discussions with our customer to drive closure on this negotiation so we can deliver critical F-35 capability to the services and our international partners," Lockheed spokesman Brett Ashworth explains. "We will continue to use a data-driven process for as long as it takes to reach agreement based on what it will actually cost to build these aircraft."

DELAYED SIMULATION TESTS

To reach full-rate production, the F-35 needs to go through what is called the Joint Simulation Environment (JSE), a series of intense simulations pitting the aircraft against modern air threats and air-to-ground operations.

Fick says the JPO is working aggressively through the validation, verification and accreditation of the JSE components. The office is targeting completion of this process in May, after which it will move into full system validation and verification, expected around September.

If this process holds, Fick says he expects the F-35 will begin "runs for score," or evaluations in the JSE, in the summer of 2023. The program's subsequent Milestone C full-rate decision will require a Pentagon Director of Operational Test and Evaluation report on the JSE. But since there would be only a couple months in which to compile that report, the full-rate production decision likely could not be made until fiscal 2024.

"In the event that our runs for score were to slip by any appreciable margin, there's not a lot of leeway between the end of the summer, the generation of the report and the ability to have a milestone decision," Fick notes.

Despite the delay of simulated testing against high-end threats, the F-35's capabilities are broadly understood, Fick says, as evidenced by several recent deployments.

SOME ENGINE PROGRESS

The engine crisis peaked in 2021, as a shortage of power modules led to slowed engine deliveries. Last year, the JPO had a target to receive 159 engines; Pratt & Whitney delivered 152 of those, and 148 were late. None of the late engine arrivals affected aircraft deliveries, however.

Fick says the JPO is working with Pratt to return to delivering engines on time, with a goal of 174 in 2022.

Jennifer Latka, Pratt & Whitney's F135 program manager, says the company is making up some of this lost ground and expects to catch up to the delays in deliveries by the end of March. It aims to get ahead of the contract. Delays last year were largely related to the COVID-19 pandemic, especially during the omicron wave, along with supply chain impacts and parts shortages.

Pratt spent more than \$40 million on a quality improvement program to identify problem areas with about 90 of the trickier parts of its F135 production line and bring them up to a higher manufacturing readiness level. This included a focus

on eliminating variations in the production of specific parts, which were to blame for quality issues that caused delays.

For depot overhauls, last year was much better. For example, the Heavy Maintenance Center (HMC) at Tinker AFB, Oklahoma, targeted 40 engine overhauls but ended up delivering 51. Increased throughput at the HMC is one of three steps the JPO and the service branches are taking to increase engine availability, along with growing the global repair network and working to keep engines on aircraft longer.

Tinker “is the heart of our network right now,” Latka says. Pratt spent the second half of 2020 and early 2021 hiring and training more staff and bringing in more equipment to ramp up Tinker’s output. The facility is “always ramping because the fleet is growing,” she says. “We’ll be ramping [up] for the next decade.”



MC SEAMAN LEON VONGUYEN/U.S. NAVY

The fiscal 2022 defense authorization bill calls for the Pentagon to study integrating into the F-35 propulsion systems that were developed under the Adaptive Engine Transition Program (AETP)—the GE Aviation XA100 and Pratt XA101. Additionally, Fick says the JPO is undertaking a business case analysis (BCA), looking at combinations of engines and power and cooling systems, to address a lack of power coming from the F135 engine.

Under Block 3F systems, the F-35 is drawing 30 kW of power from the engine, more than double the system design of 14 kW. This decreases the engine’s life and the time between engine overhauls, Fick says.

The JPO is working with Pratt, Lockheed, GE, the military services and Pentagon leadership on the BCA to calculate what combination would be effective for Block 4 upgrades and beyond. The BCA also is considering other capabilities in which the services have expressed interest, including additional range and fuel savings. Fick says the services should receive the data in the coming months, although the full BCA will not be complete until later in the year.

Pratt has been “deeply involved” in this process, drawing on lessons from the AETP effort and other investments through a Navy program to “bring in as much as we can in the existing F135 architecture” to maintain commonality, Latka says.

The JPO and Pratt also are making progress with the installation of a new coating for the engine’s turbine blades to protect against cracks that occurred in arid locations with a high amount of calcium, magnesium, aluminum and silicate. This was noticed when F-35s deployed to desert regions in the Middle East, and a new coating was included in engine production in the spring of 2020.

All engines produced in 2021 have the coating, as do those that have been repaired at the HMC. While the new coatings are not required for F-35s to deploy, Fick says it is a “best practice,” and the JPO works with operators to take jets only with the coatings replaced. Nonetheless, “sometimes it’s inevitable that you can’t [wait for the coating process to be completed], and so the aircraft will go anyway,” he adds.

LESSONS OF DEPLOYMENT

The F-35 fleet in 2021 saw two notable deployments at sea: F-35Cs aboard the USS Carl Vinson in the South Pacific and F-35Bs aboard the HMS Queen Elizabeth II in the Mediterranean. Each ship lost one F-35 while underway: An F-35C struck the ramp of the Vinson while landing in January, and an F-35B fell from the flight deck while attempting to take off from the Queen Elizabeth II in November. Fick says neither incident caused a fleetwide stand-down

This F-35C operating from the USS Carl Vinson developed severe corrosion during its deployment in the South China Sea last November. The Joint Program Office is investigating the problem and why aircraft deployed in other regions have not experienced it.

or other notification, and the Joint Program Office is continuing to support investigations of both incidents.

Beyond these mishaps, of which video leaked not long after they happened, the deployments

are providing extensive lessons for the F-35 fleet. The first emerged when pictures of the F-35Cs aboard the Vinson were posted online with extensive corrosion to the jets’ low-observable coating.

Even more surprising, Fick says, was that the F-35Bs in the Mediterranean did not have any corrosion issues, pointing to environmental differences causing the problems.

“So we’re working to understand those things, to dig through them. We have folks working [on] that with both the users and Lockheed to try to understand the mechanisms, what might lead to the results that we saw differently on those two different platforms,” he says. “I don’t know the answer yet, but we’re working [on it].”

Additionally, the deployments are teaching the JPO about how to structure deployed spares packages. Fick points to a recent visit aboard the USS Nimitz when he inspected the small space that maintainers pack full of spare parts. The deployments are showing what parts will be needed.

“Because when you’re out at sea, you are truly an island unto yourself,” Fick says. “Making sure we got that right, I think, is going to be part and parcel of us really making a difference for the Navy, for the maintainers, for their ability to generate airpower.”



Denmark and Sweden, represented here by Swedish Air Force Saab Gripens (foreground) and Danish Air Force F-16s, have pledged to raise defense spending to 2% of GDP.

DANISH MINISTRY OF DEFENSE

Europe Unlocks Defense Funding in Face of Russian Aggression

- > POLAND AIMS TO BOOST DEFENSE SPENDING TO 3% OF GDP
- > DENMARK CONSIDERS REPEALING OPT-OUT FROM EUROPEAN DEFENSE AND SECURITY INITIATIVES

Tony Osborne London

European governments have embarked on dramatic increases in expenditures in response to Russia's invasion of Ukraine.

Fears of reduced defense spending after the COVID-19 pandemic appear to have largely evaporated, as nations pledge to accelerate plans to reach or exceed NATO's defense spending target of 2% of GDP.

Aviation Week Network analysis suggests that annual spending for the 16 largest European defense budgets could rise from around €311 billion (\$340 billion) now to over \$400 billion by 2030—and potentially more than \$460 billion if all decide to meet the NATO 2% target.

But European governments will need to reexamine their defense commitments and doctrines before the resources can be used—and the investments are likely to focus on improving

readiness, posture and deployability as much as on equipment modernization over the next decade.

Germany was the first to react to the invasion with budget changes. Chancellor Olaf Scholz announced the creation of a €100 billion (\$110 billion) fund to address urgent capability gaps (see page 16) and an accelerated move toward the NATO defense spending target of 2% of GDP. By comparison, the predecessor Merkel administration had pledged to raise spending to just 1.5% of GDP by 2024 (*AW&ST* March 7-20, p. 20).

Since Scholz's Feb. 27 statement, Germany has been joined by Denmark, France, Latvia, Poland and Sweden in announcing planned increases in defense spending, with more nations expected to follow suit.

French President Emmanuel Macron said in a national address that France

would increase its investments in defense. "[Europe] must become a power for peace," he said.

"We can no longer depend on others to defend us, be it on land, at sea, under the sea, in the air, in space or in cyberspace. . . . To this end, our European defense must step up," Macron said.

Sweden confirmed it will raise defense spending to 2% of GDP. Prime Minister Magdalena Andersson said at a March 10 press conference that the budget increases would be allocated "as soon as it is practically possible."

"In a situation where tensions in our immediate area are worse than in several decades, we need to continue to strengthen our defense capabilities," Andersson said.

Stockholm had already been taking steps to boost its defense capabilities in response to Russia's actions in Crimea in 2014, with ministers originally planning to increase defense spending by 85% between 2014 and 2025, the largest rearmament by the Scandinavian country since the 1950s. Spending is being immediately boosted to strengthen capability in the short term, but work is underway to find "a stable, long-term and solidary financing of the expansion," Andersson noted. "The expansion must rest on a stable foundation for

us to be able to have a strong and secure defense.”

Romanian President Klaus Iohannis says Bucharest will raise spending from 2% of GDP to 2.5%. “[The additional funding will] ensure better conditions for our armed forces, in order to better train and respond more effectively to the operational needs of the Romanian Army and current and future security challenges,” he says. Defense spending in Romania has already more than doubled, to \$6.1 billion from \$2.8 billion, since Crimea’s annexation. Bucharest’s investments included the purchase of more secondhand F-16 fighters, along with Patriot air and missile defense batteries, coastal defense weapons and rocket artillery systems from the U.S.

In early March, Poland’s parliament began drafting new laws that would enable Warsaw to further increase national defense spending to 3% of GDP to give the country’s armed forces a “greater deterrent potential,” says Defense Minister Mariusz Blaszczak. Ministers hope to enable the spending increase next year. It was previously envisioned that Poland would boost defense spending to 2.5% of GDP by 2023.

“This is an act that will allow us not only to increase the size of the Polish Army but also to spend on the Polish Armed Forces, restore the reserve system, encourage soldiers to remain in service and implement the concept of universal defense,” Blaszczak says.

Denmark has also pledged to raise defense spending permanently to 2% of GDP—albeit at a slower rate than some of its neighbors, achieving the goal by 2033. Current annual spending sits at 1.4% of GDP.

In another notable change, Copenhagen is also looking to repeal its opt-out from European defense and security initiatives. The government is planning to hold a referendum in June on reversing the policy.

“Denmark must be fully involved in the development of European defense and security policy,” says Danish Defense Minister Morten Bødskov. “Russia’s aggression on Ukraine threatens European peace and stability. Therefore, the times call for a gear shift.”



Check 6 *Aviation Week editors discuss the flow of materiel on both sides of the war in Ukraine: [AviationWeek.com/podcast](https://www.aviationweek.com/podcast)*

How Will Russia's Invasion of Ukraine Impact U.S. Air Force Planning?

- “IMPERATIVES” INCLUDE UNCREWED TEAMING FOR NEXT-GEN FIGHTER
- KEY LAWMAKERS PREDICT DEFENSE SPENDING BOOST

Brian Everstine Orlando, Florida

Senior U.S. Air Force officials met late last year to determine what the service needs to spend its money on to better prepare for a future war. The discussion focused on specific, hypothetical scenarios: first, a Chinese invasion of Taiwan; second, a Russian ground invasion of a NATO member in Europe.

That meeting was months ago, well before Russia’s full-scale invasion of Ukraine in late February. That ongoing war has prompted the U.S. and NATO to surge aircraft to NATO’s eastern front. The second scenario is looking much less hypothetical.

“We have very visible evidence now that at least one of those is quite possible; so is the other one,” Air Force Secretary Frank Kendall said in a speech at the Air Force Association Air Warfare Symposium on March 3. “Both are characterized by high operational tempos with large numbers of combatants on each side. These are not the types of problems the Department of the Air Force has been focused on since the Cold War ended, and especially not since 9/11. But as current events show, they are the types of problems we must be organized, equipped and ready for.

Not some time in the future, but now.”

The result of that high-level discussion are seven “operational imperatives” that the Air Force released to industry in February through requests for information and which Kendall outlined publicly in March. The quick turnaround means the Air Force will be able to urgently include the ideas in its fiscal 2024 budget planning.

“These imperatives are just that. If we don’t get them right, we will have unacceptable operational risk,” Kendall said. “For those here from industry, please pay attention; this is what the Department of the Air Force will be investing in, and this is where we need your expertise, intellectual capacity and creativity.”

The specific focus areas are: defining how the Space Force will fight in a conflict, accelerating the Air Force’s Advanced Battle Management System effort, defining an uncrewed teaming aircraft for the Next-Generation Air Dominance platform, improving ground and air moving target indicators beyond current aircraft, making operational bases more resilient in a conflict, defining the uncrewed teaming aircraft for the Northrop Grumman B-21 bomber and assessing



Air Force Fiscal 2024 "Operational Imperatives"

1. Defining resilient and effective space order of battle and architectures
2. Achieving operationally optimized Advanced Battle Management Systems/Air Force Joint All-Domain Command and Control
3. Defining the Next-Generation Air Dominance system of systems
4. Achieving moving-target engagement at scale in a challenging operational environment
5. Defining optimized resilient basing, sustainment and communications in a contested environment
6. Defining the Northrop Grumman B-21 Long-Range Strike family of systems
7. Improving Air Force readiness to transition to wartime posture against peer competitors

the Air Force's readiness to transition to a large-scale war.

For each of these topics, the Air Force has assigned experts to discuss with industry how their aircraft, systems and expertise can help the service transition to one that is better prepared for a fight over Taiwan, or a ground war that moves beyond

Ukraine and into NATO territory.

The nascent research is starting as the Pentagon more broadly finalizes its National Defense Strategy as well as a fiscal 2023 budget that will include long-term spending plans. These deliberations all happened before Rus-

As Lockheed Martin F-35s are deploying to Eastern European airspace, the U.S. Air Force is planning how to invest in a next generation of fighter aircraft with uncrewed teaming aircraft.

sian President Vladimir Putin ordered his troops into Ukraine, but Kendall said that the ongoing invasion cannot mean the U.S. military will take its focus away from what he sees as the bigger threat, China.

"Russia and other threats will not be discounted, but China, with both regional and global ambitions, the resources to pursue them and a repressive authoritarian system of government, will be our greatest strategic national security challenge," he said.

Pentagon Press Secretary John Kirby said at a press conference March 4, about one week into Russia's invasion, that military experts were already finalizing the new strategy as Russia began amassing its troops on Ukraine's borders. And though the Defense Department recognizes China as its biggest challenge, that strategy will include a focus on trying to deter Russia.

"It would be foolish for us to think that the crafting of it wasn't also informed by what we've been seeing Russia do," Kirby said. "But is it being rewritten as a result of what we're seeing in Russia? I think that overstates it heavily. But it certainly will be informed by what we've been seeing over the past couple months."

On the spending side, key lawmakers are already predicting that Russia's invasion will mean a further budget increase for the military.

"The Russian invasion of Ukraine fundamentally altered what our national security posture and what our defense posture needs to be," House Armed Services Committee Chairman Rep. Adam Smith (D-Wash.) says. "It made it more complicated, and it made it more expensive. I don't see much way to argue it."

Kendall said a potential conflict with China or Russia would be a challenge with the current Air and Space Forces and that more spending is not the only way to help. Congress also needs to give the military more leniency in cutting older aircraft and base infrastructure.

"We're not flying and training as much as we would like to be, sacrificing in part a significant historical advantage of superior flying experience for our pilots and our aircrews," Kendall said. "We're carrying the costs of a roughly 20% excess capacity of real estate. We have a significant number of programs in the Air Force that are not fully funded beyond the budget year. We have a Space Force that inherited a set of systems designed for an era when we could operate in space with impunity."

Space-based surveillance has been shown as key to U.S. and NATO's ability to track the Russian invasion, but that capacity will be more at risk in a possible direct fight with Russia. For example, Russia last November downed a satellite with a direct-ascent anti-satellite missile in a move that prompted international outrage. Despite that reaction, Moscow has not backed down on the international stage, in fact increasing its threats to the West, including the invasion of Ukraine.

"Our entire military was designed for an era in which our potential adversaries did not possess space systems of their own that actively threaten our terrestrial joint forces," Kendall said. "We've only begun to define, and have not yet fully resourced, the space systems that we will need to secure the nation."

Less than two weeks before Russia invaded, Kendall visited the headquarters of U.S. Cyber Command in Maryland. What he saw convinced him that a major event—one that he said would "shock people into a new understanding of reality"—would happen. Shortly after the visit, he met with close staffers and told them to put a sticky note on their computers to remind themselves that a major conflict could come at any time.

"I was trying to create a stronger sense of urgency about the importance of our work," Kendall said. "I don't think there is much doubt about the possibility of major power acts of aggression at this point." ❁

Ukrainian Users of SpaceX's Starlink Internet Face War Zone Risks

- > STARLINK'S APP WAS THE MOST DOWNLOADED IN UKRAINE, ALONGSIDE AN AIR RAID SHELTER FINDER APP
- > INTERNET USERS RISK TRIANGULATION AND EAVESDROPPING

Garrett Reim

In their desperate struggle against Russian invaders, Ukrainians are using whatever they can get their hands on to survive and fight back.

Farmers are using their John Deere tractors to haul away abandoned Russian armored vehicles. Breweries that once bottled beer now assemble Molotov cocktails. And SpaceX's Starlink, intended to connect users in rural areas to the internet, has become a communications lifeline for Ukrainian citizens and government officials.

SpaceX has delivered several truckloads of Starlink terminals to Ukraine since Mykhailo Fedorov, Ukrainian minister of digital transformation, appealed to CEO Elon Musk on Twitter on Feb. 26 for help amid Russian attacks on Ukraine's internet infrastructure.

Starlink's mobile app was the most downloaded free iPhone app in Ukraine's App Store on March 13, according to Sensor Tower, a mobile app analytics company. The following two days the app, which helps users place and install their satellite dish, was ranked No. 2, behind air raid shelter finder app "Air Alarm."

USER BEWARE

Yet Starlink was not designed to operate in a war zone. As a result, risks to users have been starting to crop up.

Within a few days of the terminals' arrival in Ukraine, lack of electrical power was becoming an issue due to attacks on power plants and other infrastructure by Russian forces. Musk replied to the issue by saying Starlink terminal software would be updated to minimize power consumption.

"Updating software to reduce peak power consumption, so Starlink can be powered from car cigarette lighter," Musk wrote on Twitter March 3. "Mobile roaming enabled, so phased array antenna can maintain signal while on moving vehicle."

Later that day, Musk warned that users risk having their location triangulated.

"Starlink is the only non-Russian communications system still working in some parts of Ukraine, so probability of being targeted is high. Please use with caution," Musk wrote on Twitter. "Turn on Starlink only when needed and place antenna as far away from people as possible. Place light camouflage over antenna to avoid visual detection."

The satellite terminals apparently also became targets of Russian jamming, with Musk announcing on March 4 and March 5 that SpaceX would prioritize enhancing the product's cyberdefenses and ability to bypass signal jamming using a software update.

Musk did not disclose how the Starlink terminals would circumvent jamming, but militaries often use frequency hopping to avoid having their signal pinned down and overwhelmed by an adversary.

Starlink may yet have more undiscovered vulnerabilities, says Josh Lospinoso, chief executive of Shift5, a company specializing in cybersecurity for industrial and military products like aircraft, trains, tanks and satellites. For one thing, unlike government satellites, which operate on private networks, Starlink satellites are plugged into the internet.

"The whole purpose is to provide internet access. They're basically giant solar-powered routers," Lospinoso says. "That opens up another attack vector."

Viasat's KA-SAT satellite internet service across Europe has been heavily degraded since the start of the Russian invasion on Feb. 24, the result of a suspected cyberattack, according to NetBlocks, a watchdog organization that monitors internet access.

There is also the risk that Russia might be able to eavesdrop on Starlink users.

"I'm sure that they have encrypted that signal," says Lospinoso. "But as we all know, cryptography is hard. There are ways of weakening cryptography



UKRAINE MINISTRY OF DIGITAL TRANSFORMATION

SpaceX has sent several truckloads of Starlink satellite terminals to Ukraine.

to the point where it can be cracked. There are probably a dozen examples out there of leaked classified programs over the past 50-60 years where intelligence communities have been doing this to each other back and forth."

CONSTELLATION CONSOLATION

Despite vulnerabilities, Starlink may have strength in numbers. Keith Volkert, chief executive of Satellite Consulting, says the Starlink constellation might be inherently more difficult to jam due to the sheer quantity of its satellites and polar orbit.

"If you have something sitting at [geostationary orbit], and it just sits there, and you know exactly what its uplink and downlink is, you can mess with that," Volkert says.

"If you've got a constellation with thousands of satellites, you can't jam the constellation," he adds. "You have to focus that energy at something. You have to get enough energy to take all the birds above you out at the same time to make that effective."

Gen. James Dickinson, commander of U.S. Space Command, also praised Starlink in a U.S. Senate Armed Services Committee hearing on March 8. "What we are seeing with Elon Musk and the Starlink capability he's providing is . . . what a megaconstellation, or proliferated architecture, can provide in terms of redundancy and capability," he said.

Dickinson said U.S. Space Command is looking at finding ways to integrate commercial satellite providers into its operations and is wargaming the potential use of commercial satellites on the battlefield. 🌐

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No Signs of Normalcy

This Aeroflot Airbus A320, pictured awaiting completion in Toulouse in 2013, was in service with the airline since its delivery but is now subject to tough EU sanctions against Russia.



MARK WAGNER/AVIATION-IMAGES

- > GLOBAL INDUSTRY GRAPPLES WITH DEEP DIRECT AND INDIRECT IMPACT OF RUSSIAN INVASION OF UKRAINE
- > RUSSIAN AEROSPACE DECOUPLING FROM INTERNATIONAL AVIATION ADVANCES

Sean Broderick, Michael Bruno and **Ben Goldstein** Washington, **Guy Norris** Colorado Springs, **Helen Massy-Beresford** Paris, **Thierry Dubois** Lyon and **Jens Flottau** Frankfurt

The Russian invasion of Ukraine has disrupted the aviation industry massively and immediately and likely will have far-reaching consequences even in the long term. Russian airlines have been banned from flying to many regions, including the European Union and the U.S. Most non-Russian airlines are avoiding Russian airspace, if it is not already closed to them anyway. The EU has instructed aircraft lessors to terminate leases by March 28, and neither aircraft nor spare parts can be exported to Russia. Fuel prices have risen steeply, creating more financial pain for highly indebted airlines globally. Prospects for growth and recovery, bright just a few weeks ago, are in question again for airlines, at least in some geographies. And the violence has renewed aviation conflict-zone security concerns. Here are answers to some of the most pressing questions about how the war is affecting commercial air transport.

How do the sanctions impact Russian airlines? Sanctions and voluntary decisions by Western manufacturers and suppliers to cut ties with Russian and Belarusian operators are forcing affected carriers to become self-sufficient quickly. Airworthiness certificates granted by foreign regulators, such as the Irish Aviation Authority, covering aircraft on their registries for tax or other beneficial reasons must be replaced by Russian approvals—a move for which Russian President Vladimir Putin paved the way in new legislation adopted March 14.

Many of the Russian-operated aircraft registered outside the country are leased. Putin's changes included a call for Russian airlines to register these aircraft domestically and take ownership of them. The moves paint a stark picture for lessors of hundreds of Western-built aircraft in Russian hands that they want—or need, based on sanctions—returned.

Meanwhile, spare parts sales are no longer permitted by the major airframe and engine manufacturers. More broadly, the European Union Aviation Safety Agency (EASA) suspended all certificates it has issued, including certificates for products, parts, appliances, organizations and flight-training devices, when the holder of the certificate is based in Russia.

Russian airlines are also blocked from entering the airspace of the EU and U.S., among other regions. Domestic flights are continuing, subject to availability of spare parts.

Are aircraft still insured? The EU is prohibiting insurers and reinsurers from covering risks in air transport in Russia and Belarus. Insurers and reinsurers were effectively required to terminate contracts as of Feb. 26. Russian airlines are likely to have aircraft insured by Russian state-backed insurers for operations inside the country. However,

multibillion-dollar claims by lessors for a total loss of their Russia-based fleet are emerging in the London contingency insurance market that may be contested (see page 27).

What are the chances of the leased fleet being returned?

Most leasing industry executives believe that it is highly unlikely that they will recover any significant number of aircraft from Russia (see page 27). For the most affected companies, around 7% of their portfolio is at stake.

What is the long-term perspective for Russian airlines? Could Russian become another Iran?

Two-thirds of the 1,260 aircraft in Russian scheduled and nonscheduled operators' fleets were built by Airbus, ATR, Boeing, Bombardier (now MHI RJ Aviation) or Embraer, the Aviation Week Intelligence Network's Commercial Aviation Fleet Discovery database shows. Losing access to international markets and the decline in what was a booming domestic sector before the war will create excess capacity—and open the door for parts cannibalization within subfleets if it becomes necessary.

Sustaining operations for any length of time without aftermarket support will require securing parts on the black market or via complex, opaque means similar to how airlines in targeted countries such as Iran have evaded Western sanctions to keep their Airbus and Boeing aircraft flying. Intermediaries such as businesses serving as fronts for the operators in neutral or nonsanctioned countries could purchase needed parts and funnel them into the country, for example. However, EASA has specified that the use of goods, technical assistance or services “whether or not originating in the [European] Union” is prohibited “to any natural or legal person, entity or body in Russia or for use in Russia.”

Such subterfuges cannot fill the entire product-support gap. Russian and Belarusian operators will likely face challenges accessing updated technical data for Airbus and Boeing aircraft—much of it provided electronically. No OEM support also means no consultation on issues such as nondestructive test results or repair needs after hard landings.

How meaningful are the operational challenges of avoiding Russian airspace?

Since the beginning of March, at least 21 airlines have routed flights around Russian airspace, estimates aircraft tracking specialist Flightradar24. Routes between Europe and Asia have been most affected. The penalties include huge increases in fuel burn at a time of high volatility in fuel costs, greater crew and equipment use costs, reduced payloads in some cases and increased exposure to the risks and costs of diversions and aircraft-on-the-ground events.

Finnair, closest to the northern borders of Russian airspace, is among the most directly affected, with additional flight times from Helsinki to Asia ranging from around 1.5 hr. to Singapore to 3.5 hr. on the route to Tokyo. Japan Airlines (JAL) and British Airways are similarly affected on routes linking London with Tokyo, while some services from elsewhere in Europe—such as Paris to Beijing—face even more extreme changes, with up to 6 hr. of additional flight time. The unmanageable extra time led JAL to eventually stop operating European routes, such as to Helsinki, Frankfurt and Paris. It is still flying the London route, explaining:

“It has the shortest flight time when we use the detour route and is most convenient for transit passengers.”

Flights from Southeast Asia to North America have also routinely used Russian airspace until recently. Singapore Airlines' nonstop service from New York to Singapore, for example, since Feb. 23 has been flying a more southerly eastbound route, adding around 40 min. of flight time.

Are concerns regarding aviation security outside Ukraine justified? Airspace restrictions put in place early in the conflict helped ensure that commercial operators had ample warning to steer clear of Russia's advance into Ukraine. Officially, national carrier Ukraine International Airlines, citing a notice to air missions issued by the country's State Aviation Administration closing the country's airspace, has suspended all operations until March 23. The continuing war could cause that time frame to be extended. Other operators have taken similar steps.

Russia's foreign affairs ministry used Twitter to deliver an ominous warning to “international civil aviation and other means of transport” helping Ukraine by transporting weapons. “We call on [European Union and North Atlantic Treaty Organization] countries to stop the thoughtless flooding of the unviable [Kyiv] regime with the latest weapons systems in order to avoid enormous risk,” the ministry tweeted March 10.

Coincidentally, EASA in early March launched the European Information Sharing and Cooperation Platform on Conflict Zones, an initiative meant to give participating states and their operators access to the latest data and information when planning flights near areas of conflict. Started in response to the shooting down of Malaysia Airlines Flight 17 over Eastern Ukraine in July 2014—investigators concluded Russian forces had shot down the Boeing 777-200ER—the initiative went live after a nine-month trial period. The timing of the invitation-only platform's launch “has no direct link to the current Ukraine crisis,” EASA says.

How do the sanctions affect the Irkut MC-21 and Sukhoi Superjet programs? There will almost certainly be more delays to the programs, and it will be hard to sustain operations at scale. The first certified variant of the MC-21 is powered by Pratt & Whitney PW1400G engines and equipped with other Western components now subject to sanctions. As locally produced composites are to be used for wing production in the future, supplemental certification will be needed and is expected by midyear. Also, the Aviadvigatel PD-14-powered version MC-21-310 was slated to be certified this year. The United Aircraft Corp. expects the -310 to be delivered to customers for the first time in 2024.

To mitigate the effect of Russia's isolation, the government has told industry to speed up the Superjet-New project, in which Western components are replaced by Russian parts. The new variant is to be certified within 14 months, according to the latest plans. There will be an impact on spares suppliers for the in-service fleet.

On the Superjet, Thales is in charge of the avionics suite, and the aircraft assembly line will not receive such systems any longer. Safran Aircraft Engines is responsible for 50% of the SaM 146 engine, under the Powerjet joint venture with UEC Saturn. In design and manufacturing,

Safran is in charge of the high-pressure (HP) compressor, HP turbine and nacelle integration. Safran and UEC also share the work of maintenance, repair and overhaul, with the former taking care of the heaviest operations. EU sanctions mean Safran engineers no longer provide maintenance, training, call-center service or documentation.

Are Boeing, Airbus and other OEMs facing parts and material shortages?

In the big picture, OEMs are not facing significant parts and material shortages. The reason is because the COVID-19 pandemic—along with Boeing’s halting production of the 737 MAX and 787 programs—wiped out roughly two years’ worth of production, and OEMs reportedly have mountains of backed-up inventory to process from their supply chains. Titanium, nickel and other raw material supplies are expected to be reliable for 1-2 years.

The war in Ukraine is expected to exacerbate costs of raw materials and energy in the short term. However, costs started rising significantly last summer, and the war’s effects appear to be more of the same rather than a major new shock. At the same time, costs hit different levels of the industrial base differently. Upper-tier companies tend to operate under long-term agreements for materials, for instance, and many contracts have “elevator” clauses that account for rising costs. Lower-tier companies are more vulnerable to quick price escalations.

Also, the International Aerospace Quality Group, which oversees AS9100 certification, has announced it is suspending all Russian member companies and withdrawing all certificates issued in that country. The action will make it much harder for those companies—including Airbus and Embraer—still choosing to buy Russian-sourced titanium, unless they now put in place their own quality systems.

Should Airbus and Boeing revisit plans to raise production rates?

Executives from Airbus and Boeing stood firm on their companies’ planned airliner production rate increases during separate speeches at Aviation Week events in March. The OEMs point to predictable rebounds after crises such as the Sept. 11, 2001, terrorist attacks, the Severe Acute Respiratory Syndrome outbreak or the 2008 financial collapse, as well as the long-term historic growth trend in commercial air traffic due to growth in middle classes worldwide. They also stress the potential for environmental goals, starting with net-zero emissions by 2050, to spur acquisition of new aircraft that are more fuel-efficient. Recent analyst reports show a consensus that Boeing will raise its official 737 production rate to 31 new aircraft this year, although 787 rates will remain in the low single digits. All of Airbus’ rate forecasts are considered relatively feasible after last year’s new-order haul and deliveries.

What is the impact on air travel demand globally? Air travel demand will take a hit around the world following the invasion, although some markets will be hit harder than others. The most affected market will be Russia itself, from which international flying will be mostly gone for the foreseeable future, and domestic demand will be harmed as the ruble plunges and the full weight of economic sanctions is felt. However, because Russia makes up around just 2% of global air travel demand, the direct impact on global available seat kilometers will be minimal.

Elsewhere, rising jet fuel prices will add to the cost of

airfares, putting a damper on price-sensitive leisure travelers that comprised the bulk of the demand recovery in many large domestic markets. At the same time, inflation and rising energy costs mean consumers will have less disposable income to spend on travel. But high rates of saving during the pandemic and strong pent-up demand for travel could help airlines pass along a modest increase in prices.

The greatest impact will probably be felt in long-haul international markets, which require more fuel and have higher trip costs. Fare increases will be especially pronounced on these flights, possibly harming demand at a time when long-haul markets were already struggling to recover from the pandemic. Airlines could trim their international summer schedules from original plans.

What are the consequences for air cargo? Air cargo operators are now experiencing the same challenges as their passenger counterparts: Airspace closures and restrictions mean longer routes—carrying more fuel leaves less room for freight—and the grounding of large chunks of air cargo capacity, including Ukrainian Antonov aircraft and Russian cargo operators such as AirBridge-Cargo Airlines, part of the Volga-Dnepr Group, changes the balance of the air cargo fleet around the world.

“We can expect cargo markets to be impacted by the Russia-Ukraine conflict,” International Air Transport Association (IATA) Director General Willie Walsh says. “Sanction-related shifts in manufacturing and economic activity, rising oil prices and geopolitical uncertainty are converging. Capacity is expected to come under greater pressure, and rates are likely to rise.”

“While we were seeing some clear signs of normality returning, there is still so little slack in the global air cargo system,” CLIVE Data Services managing director Niall van de Wouw says. “It is quite unlikely that the trend of slowly declining rates will continue in March. The war in Ukraine causes immediate capacity issues to Northeast Asia and, therefore, will likely push up rates even more for these particular markets.”

What could be the fallout for the industry’s environmental targets? The EU’s strategy to become less dependent on Russian energy imports and focus on sustainable sources could, in theory, be good news for the environment, providing an incentive to speed up the development of cleaner, greener energy sources.

In the aviation sector, major players are already investing in sustainable aviation fuels (SAF) and e-fuels, which are seen as a practical way to reduce emissions while longer-term solutions such as electric aviation are still in development.

However, in aviation as well as in other sectors, higher energy prices in the short term make investment in longer-term green solutions more difficult.

The war could also end up having an impact on long-term CO₂ reduction targets, given China’s delicate geopolitical position, which could give the country more leverage when it comes to setting out updated climate goals ahead of COP27 this year.

The aviation industry’s 2050 net-zero emission goal, which IATA committed to last October, met with resistance from Chinese carriers: They had wanted to align aviation targets with the country’s less demanding 2060 goal. ☛

Putin Clears Way To Expropriate Foreign Lessors

- > HUNDREDS OF LEASED AIRCRAFT ARE LIKELY TO BE KEPT IN RUSSIA
- > LESSORS PREPARE FOR TOTAL-LOSS SCENARIO
- > CONTINGENCY INSURANCE COVERAGE MIGHT APPLY

Jens Flottau Frankfurt and Sean Broderick Washington

Until just a few weeks ago, Russian airlines were reliable business partners for the global aircraft leasing industry. The Russian sector was one of the least affected by the COVID-19 pandemic because its large domestic market recovered faster than elsewhere. But since President Vladimir Putin started a war in Ukraine, lessors have been facing an unheard-of scenario: a total loss of more than 500 of their aircraft.

countries argue that, given the sanctions, they can no longer supervise the airworthiness of the fleet.

The unfolding drama is likely to redefine the commercial aircraft leasing market, which could exclude Russian customers for a very long time.

“If we have continued risk of nationalization, nobody in their right mind would take that risk,” says the CEO of one large lessor with a substantial fleet operating in Russia, speaking on

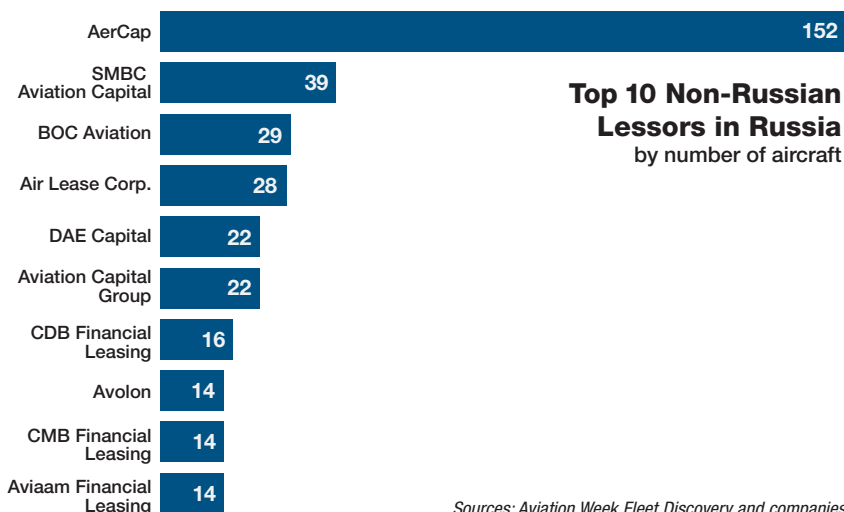
growth in both domestic and international flying and demand for replacements for aging Soviet-era aircraft. While some lessors took a relatively cautious approach to Russia, others were comfortable doing business there. Russian airlines depended on leasing to a large degree, given their precarious financial state after the breakup of the Soviet Union. At the end of 2021, domestic traffic was 20% above 2019 levels—partly because many Russians still could not fly abroad due to COVID-19-related travel restrictions—whereas globally domestic traffic was down 20%.

The Aviation Week Network Fleet Discovery database shows that Russian airlines lease more than 600 large transport aircraft—those certified for 19 or more seats—from lessors based outside Russia. At least 100 more aircraft belong to lessors with Russian roots and subsidiaries based outside the country. Many aircraft are leased through Irish affiliates, as is standard industry practice, and so are subject to EU sanctions. In some cases, determining the status of a leased aircraft is impossible without knowledge of contractual details.

By absolute numbers, AerCap, based in Dublin, Ireland, is the most exposed, with close to 150 of its aircraft operating in Russia (see chart). SMBC Aviation Capital has 36, Air Lease Corp. 32, BOC Aviation 24 and DAE Capital 22. For the largest international lessors to Russian airlines, the exposure is around 7% of their portfolio, which the CEOs of two of those lessors independently described as “manageable.”

How painful would the consequences be if repossessions cannot be made, access to the assets is permanently lost, or their value declines so much over time that they become complete write-offs? These are more than theoretical questions; they are likely scenarios for which the industry has to prepare as Russia tries to keep its air domestic transport industry going amid Western sanctions.

“There will be no repossessions,” says one leasing company CEO. “The state-owned companies are not cooperating. The private ones pretend to but do nothing.” Why? “There are implications for airlines that don’t hold the [official] line,” another executive says. In other words: Even if an airline wanted to adhere to interna-



Sources: Aviation Week Fleet Discovery and companies

European Union sanctions imposed in response to Russia’s invasion of Ukraine require lessors to cut ties with Russian operators by March 28. But stopping sales of parts or new aircraft—which the sanctions also require—is far easier than trying to repossess assets in customers’ hands. The Russian government is advancing plans to have 760 aircraft, many of which are owned by foreign lessors and registered mainly in Bermuda and Ireland, put on the Russian registry as property of the local airlines. The move is linked not only to the upcoming leasing deadline but also to the decisions of authorities in Bermuda and Ireland to revoke airworthiness certificates for all the aircraft. Both

the condition of anonymity. He says it is hard to see an inflection point, even far into the future, that would allow the industry to return. “What is the definition of: ‘It is over’?” he asks.

What the Russian transport ministry calls “nationalization” amounts to illegally taking possession of leased aircraft against the will of their owners and very likely without making purchase payments. Should the government proceed with the plans, “Russia will be an uninvestable country for a long time,” says Agency Partners analyst Sash Tusa.

The country, having opened up to Western suppliers and lessors just about 30 years ago, had turned into a good aviation market, buoyed by

tional law, it has no choice but to break it because of government orders.

“A couple dozen [aircraft] have come out [of Russia],” Bloomberg Intelligence analyst George Ferguson says he has heard. “I think if you don’t have your airplane out now, you’re not going to get it, because the Russians are hiding them.” And even if ultimately some aircraft are returned, they likely will be complete write-offs.

“[The airlines] are probably taking parts off some of the airplanes to keep the others flying,” Ferguson says. “You are going to have parts mixed and mingled, which makes it difficult to keep the record straight. It’s a really bad situation for the lessors.”

“In our view, it is unrealistic for lessors to repossess aircraft within a month because more than 80% of the planes are narrowbody and regional jets that are unlikely to leave Russia for a neutral jurisdiction,” Scope Ratings analyst Dierk Brandenburg writes. “Russia’s aviation legislator has banned international flights with foreign-leased planes from this week. Even under normal circumstances, we would have expected repossessions in Russia to take up to six months.”

“[Given] current airspace and border closures, we question whether any aircraft will exit” Russia, J.P. Morgan Chase analysts write in a March 3 research note issued after an investor conference it hosted. “We don’t believe Russia will simply allow Aeroflot or S7, for example, to fly aircraft out of the country to Western jurisdictions simply because leases have been canceled.”

Avolon was one of very few lessors able to repossess aircraft from Russian carriers: It took possession of a Boeing 737-800 on lease to Aeroflot subsidiary Pobeđa when the aircraft was in Istanbul on Feb. 27.

On March 5, Russia’s Federal Air Transport Agency (Rosaviatsiya) recommended that local carriers with aircraft leased from foreign companies and registered in foreign registers suspend all international passenger and cargo services. The ban for outbound flights took effect on March 6; return flights were stopped starting March 8.

The largest Russian airlines—including Aeroflot and its low-cost subsidiary Pobeda, Ural Airlines, charter carriers Azur Air and Nordwind—responded on March 5 by saying they would cut international operations beginning March 8. S7 and Smartavia

announced similar measures ahead of Rosaviatsiya’s recommendation.

Aeroflot is still operating flights beyond Russia’s borders only to Belarus, Moscow’s ally in the war in Ukraine. Red Wings announced it would still fly to Armenia and Uzbekistan using Russian-made Superjet 100 regional jets leased from Russian lessors. All-Superjet operator Azimuth flies to Armenia, Azerbaijan and Turkey. Azur Air planned to use only Russian-registered Boeing 767s and 757s for international flights after March 8. Utair is continuing international services for the time being, too, as it owns about 40% of its fleet, including 18 Boeing 737-500s and six Boeing 737-400s, and has moved three of them into the Russian register.

With repossessions feasible only when leased aircraft are outside Russia, maintenance shops are moving into the spotlight as well. One lessor told J.P. Morgan Chase analysts that it had four Russian customer airframes in heavy checks outside the country.

Lessors not subject to sanctions still face significant hurdles. Broad sanctions are limiting Russia’s access

to the global financial system, making routine payments difficult, if not impossible. However, one of the main lessors active in Russia said its monthly lease rates had been paid in U.S. dollars the week of Feb. 28.

The payments are unlikely to continue. “[The] suspension of certain Russian banks’ access to SWIFT, the universally used international bank messaging system that facilitates interbank transfers, could disrupt rent and loan payments owed lessors by their Russia-based airline customers,” Moody’s writes in a March 4 research note.

“[While] some Russian airlines may be able to remit lease payments through China, the ability to move U.S. dollars directly from Russia appears [to be] next to impossible,” J.P. Morgan Chase states.

“The initial financial impact to aircraft lessors will be disruptions to their revenues and operating cash flows as near-term payments from Russian airline customers due in March are not likely to be received,” write DRBS Morningstar analysts. “Longer-term, the absence of rental revenue from these aircraft creates an additional



headwind to the lessors' ability to restore their revenue generation to pre-pandemic levels, as revenues remain constrained by rent deferrals granted to airlines looking to navigate the impact of the pandemic."

The DRBS analysts further note: "More importantly, we see the lessors as facing an elevated risk of noteworthy impairments to the value of the aircraft on lease in Russia. Should the aircraft become stranded in Russia with the lessors having no ability to regain possession of the aircraft, then the lessors will likely have to write down the value of the aircraft to a low recovery value that reflects collateral such as letters of credit and maintenance reserves that serve as security as well as any potential insurance proceeds."

If Russian airlines refuse to return leased aircraft after March 28, a portfolio of more than 500 aircraft worth well in excess of \$10 billion would be in limbo, according to Scope Ratings estimates. As a consequence, one industry CEO forecasts that lessors will file claims with their insurers for a total loss of affected aircraft. "It is complicated, and there will be years

Most of Aeroflot's aircraft are leased, and many are subject to European Union sanctions.



KIRILL KUDRYAVTSEV/AFP/GETTY IMAGES

of litigation over this, as some insurers will reject the claims," the leasing industry executive says. "I'm concerned about how the insurance market will absorb this."

Aircraft insurance arrangements usually are complex, but lessors typically require airlines to "carry those types of insurance that are customary in the air transportation industry, including comprehensive liability insurance, aircraft all-risk hull insurance,

"Russia is already preparing for an environment without OEM support"

and war-risk insurance covering risks such as hijacking, terrorism (but excluding coverage for weapons of mass destruction and nuclear events), confiscation, expropriation, seizure, and nationalization," Air Lease Corp. writes in its most recent annual report.

In Russia, airlines are obliged to insure aircraft locally, and most lessors also have contingency coverage for individual aircraft or parts of their fleets where the risk of relying only on airline-managed policies is considered too high. That is the case for most of the Russia-based fleet, according to one insurance industry expert. The contingency policies cover everything or only certain aspects, including war risk or confiscation.

Whether lessors can expect to recover damages through the contingency arrangements is not yet clear. No claims have been filed so far. Plus, the policies are typically handled on the London insurance market, and the UK, unlike the EU, has not yet published the details of its Russia sanctions, which will determine whether the financial impact is covered or not. "A lot of people are very nervous," an insurance official says. He also expects premiums to rise substantially in the future as insurance companies reassess risk profiles.

"Due to sanctions, many insurance companies have canceled coverage or may contest future claims, but certain lessors moved aircraft to their contingent/possession insurance policies," Fitch Ratings writes. "Russian aircraft

are insured in Russia, but the value of these policies is uncertain, if [of] any value at all. Individual insurance and umbrella policies with contingency clauses intend to cover 'act of war' events, and these policies could potentially cover the current aircraft market value under certain terms. . . . Any policy payouts may take time."

Another concern is that the West's major aircraft and engine manufacturers have ceased aftermarket support for Russian operators, either voluntarily or due to sanctions. Without access to around-the-clock technical support, spare parts sales and foreign airframe and engine maintenance services, Russian airlines planning to operate Airbus, ATR, Boeing, Bombardier (MHI RJ Aviation) or Embraer aircraft for any length of time seemingly face an uphill struggle.

Two-thirds of the 1,259 aircraft in Russian scheduled and nonscheduled services were built by Airbus, ATR, Boeing, Bombardier (MHI RJ Aviation) or Embraer. Lost access to international markets and a drop in booming domestic demand will create excess capacity—and open the door for parts cannibalization within subfleets. But long-term operations without support probably will require securing parts on the black market, similar to the way airlines in targeted countries such as Iran evade Western sanctions to keep their Airbus and Boeing aircraft flying. Iran, of course, is a much smaller market by comparison, and far fewer aircraft have had to be sustained.

Russia is already preparing for an environment without OEM support. The transport ministry published a draft government decree on March 5 that automatically extends until Sept. 1 expired airworthiness certificates for foreign-made aircraft registered in Russia. The same measure is suggested for aircraft on foreign registers that are operated in Russia under the Chicago Convention Article 83 bis. Crews can operate these aircraft based on a document issued by the Russian authorities without approval by the country of registration, according to the provision.

The ministry also will allow Russian airlines to use operating and maintenance manuals for foreign-made aircraft without support and updates from the OEMs. The draft decree is open for public consideration until March 28. 🇷🇺

Effects of the Russian Titanium Cutoff

By Kevin Michaels

COMMENTARY **RUSSIA'S INVASION OF UKRAINE** has created a myriad of issues for aviation and aerospace. Front and center is the West's dependence on Russian supplier VSMPO-Avisma, the largest titanium producer in the world. With Russian imports effectively banned, how vulnerable is the aerospace supply chain?

Assessing vulnerability requires unpacking titanium's own complex supply chain. The metal is produced primarily from titanium sponge—an intermediate material created by combining ore, chlorine and magnesium in several energy-intensive processes. Sponge and scrap titanium are then combined to make titanium ingots, which in turn are used to create downstream products.

Titanium is a miracle material. It has the highest strength-to-weight ratio of any metal, excellent corrosion resistance and a high melting temperature, and it is highly compatible with carbon-fiber composite structures. For these reasons it features prominently in a variety of applications, from

Aerospace Titanium Supply Chain

Inputs	Mill Product	Applications
Sponge	Ingots and Billets	Aerostructures
Revert	Sheet and Plate	Aeroengines
	Wire	Systems
		Fasteners

Highest vulnerability in red.

Source: AeroDynamic Advisory

fighters to Boeing 787 and Airbus A350 aerostructures and landing systems to the cold section of aero-engines. Before the COVID-19 pandemic, aerospace consumed some 220 million lb. of titanium per year.

Titanium sponge is the first potential vulnerability. The last domestic U.S. sponge facility in Henderson, Nevada, closed in 2020, and a U.S. government review concluded that while sponge is a strategic material, it did not deserve financial support under a Trade Expansion Act Section 232 tariff. Global sponge production is led by China (51%), Japan (17%) and Russia (13%), followed by Kazakhstan and Ukraine. U.S. titanium producers obtain the lion's share of their sponge from Japanese suppliers—principally Toho Titanium and Osaka Titanium Technologies. Can those suppliers step up to meet additional demand if Russian and Ukrainian supplies go offline and China isn't a real option?

A knock-on effect of the sponge supply situation is that the price of scrap titanium, also known as "revert," has doubled since June 2021 to \$3 per pound.

Moving to mill product, four suppliers comprise 75-80% of aerospace supply: VSMPO-Avisma, Allegheny Technologies Inc. (ATI), TIMET and Howmet. VSMPO is by far the largest and is the major supplier to Boeing (35%), Airbus (more than 50%) and Embraer (nearly 100%). Replacing VSMPO's capacity will be a challenge. The key issue here will not be certification of new suppliers but finding labor for the cast houses and mills in an incredibly tight labor market. The good news here is that the slowdown in twin-

aisle production rates created an inventory buffer with aircraft OEMs and some major suppliers. Boeing, for example, has more than a year's supply of titanium inventory.

The story in the aero-engine supply chain is very different: TIMET and ATI are the largest suppliers, producing the highest-quality titanium (rotating grade) used for aero-engine disks, blades and vanes. GE and Pratt & Whitney have avoided sourcing from VSMPO and have minimal dependence today. But Safran and Rolls-Royce source an estimated 20% or more of their titanium from VSMPO.

In contrast to aircraft manufacturing, inventory in the aero-engine supply chain is tight, with 2-3 months of titanium supply on hand. Moreover, aero-engine production is ramping up while maintenance, repair and overhaul demand is growing by double digits. Potential bottlenecks abound, as evidenced by Pratt's recent announcement that it missed 70 engine deliveries due to casting supplier issues. Rolls-Royce and Safran will need to move smartly to minimize the damage from this new bottleneck.



ROBERT NICKELBERG/GETTY IMAGES

The situation in landing gear also deserves scrutiny. Many of the key components in the 787 and Boeing 777 landing gears are produced in a Russia-based 50,000-lb. forging press, machined by a Boeing-VSMPO joint venture. Replacing this will not be easy. There are few presses of this size in the world, and certification of a new facility could take 18-24 months. Boeing's buffer of 100+ built but not delivered 787s and reduced twin-aisle production rates will help to ameliorate the situation, but the airframer must act fast to reboot its landing gear supply chain. Airbus may face a similar situation with its titanium A350 landing gear.

The Russia titanium saga is the latest for a battered aerospace supply chain that has endured the Boeing 737 MAX grounding and the COVID crisis in recent years. However, there are two silver linings this time. First, governments and OEMs might finally be forced to adopt policies recognizing the strategic nature of aerospace's "miracle material." Airbus, Safran and Tikehau Ace Capital recently signed an agreement to acquire European specialty material supplier Aubert & Duval, which has titanium capability. Perhaps the U.S. will revisit the need to support domestic titanium sponge capacity. The second silver lining is timing, with twin-aisle production rates stuck in neutral and excess inventory abundant. ☺

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

What Titanium Crisis?

By **Rob Spingarn** and **Scott Mikus**

COMMENTARY

INVESTORS HAVE BECOME MORE

and more concerned about the availability of Russian-supplied titanium since the country's forces invaded Ukraine on Feb. 24 and as Boeing and Airbus ramp up production rates.

Over the past month or so, an array of observers have suggested that Russian President Vladimir Putin could shut down the commercial aerospace business. Such statements are based largely on the fact that VSMPO-Avisma—part of Russian state-owned enterprise Rostec—is the largest titanium supplier to the commercial aerospace end market.

We have seen estimates that VSMPO supplies 25-45% of titanium used in the commercial aerospace end market and that Boeing, Airbus and Embraer source 35%, 65% and 100%, respectively, of their titanium from VSMPO.

While concerns about the availability of titanium to support planned commercial airliner production rate hikes are not unfounded, they may be exaggerated, given our channel checks. We do not dispute that VSMPO plays a critical role in the commercial aerospace ecosystem, but its criticality may have waned in recent years as Boeing and Airbus built up buffer inventory of titanium following Russia's invasion of Ukraine's Crimea region in 2014. Many Tier 1

and Tier 2 suppliers have found alternate sources of titanium, particularly from Japan and China.

With production rates well below pre-pandemic levels, particularly for titanium-dependent widebodies such as the Boeing 787, demand is not as high as it was. Before the COVID-19 crisis, 787 production peaked at 14 aircraft a month, and Airbus A350 production peaked at 10 a month. Given the lag in international travel recovery, a return to such widebody production rates is not anticipated for several years, if at all. In fact, one of our industry contacts says Boeing and Airbus potentially have "a few years'" worth of titanium on hand. Six days before Russia invaded Ukraine, the chief commercial and market officer of Allegheny Technologies Inc. (ATI) noted a surplus of titanium in commercial aerospace and suggested that it could take a couple of years before a titanium supply/demand imbalance would emerge for airframes or engines.

For commercial aero-engines, titanium does not appear to be in short supply either. Industry contacts we have spoken to tell us that VSMPO does not and never had significant content on jet engines. GE recently stated that it sources about 1% of its titanium from Russia—and that is

used in only two parts. Additionally, GE has more than a year's supply of titanium in stock. Raytheon Technologies has stated that it is working to ensure its supply chain is secure for the coming 12 months and noted that Pratt & Whitney has two or more sources for titanium and other key materials.

While some may rightfully argue that a year's supply is a temporary stopgap, we expect that suppliers will spend this time requalifying the most vulnerable materials and parts from sources in the U.S. or allied countries such as Japan. For example, Howmet already sources about 95% of its titanium

sponge from Japanese companies under long-term agreements. Toho Titanium has excess capacity and has said it can offer more titanium sponge to the commercial aerospace industry. Precision Castparts, ATI and Howmet can also produce titanium from scrap. In short, Boeing, Airbus, engine OEMs and commercial aerospace suppliers should be able to find a sufficient number of alternative titanium suppliers to meet future production needs.

What about the forgings and finished parts that VSMPO produces? Suppliers should be able to requalify many parts currently produced in Russia in less than a year. The greatest risk is for parts that have never been made elsewhere, in which

case qualification could take longer. That said, qualification is done by the OEM and not the aviation regulator. If an OEM has an urgent need, it can supply its own engineers and technicians to accelerate the qualification process and help the new supplier get the proper tooling in place. This could be the case on the 787 and 777X landing gear, which currently use forgings provided by Boeing's joint venture with VSMPO. Even here there is some buffer, with 110 787s in inventory—more than a year's supply—and another 18 months before the 777X is likely to be certified and start being delivered.

VSMPO has a 75,000-ton hydraulic forging press, second only to an 80,000-ton forging press in China. Howmet and Precision Castparts each have 50,000-ton presses, Weber Metals has a 60,000-ton press and Aubert & Duval—which is being acquired by Airbus, Safran and Ace Capital Consortium—has a 65,000-ton press. They could serve as viable substitutes for forgings that are now produced in Russia. ☛

Rob Spingarn is managing director at Melius Research. Scott Mikus is an associate. This piece is adapted from a research note they wrote for the firm's clients.



ATI

Ukraine War Squeezes Already Stretched Air Cargo Sector



Russia's AirBridgeCargo Airlines is one of the world's largest air freight operators.

PHOTOS: JOEPIRESAVIATION.NET

- > HIGHER JET FUEL PRICES AND LONGER ROUTES WILL ADD TO COSTS
- > RUSSIA AIRSPACE BAN LENGTHENS FLIGHT TIMES BETWEEN EUROPE AND ASIA

Helen Massy-Beresford Paris and **Ben Goldstein** Washington

As the war in Ukraine continues, at huge human cost, the global air cargo sector is also expecting a severe impact. Airspace closures and restrictions as well as reroutings are expected to add to the existing squeeze on air cargo capacity and promise to drive up rates further.

Since the beginning of the COVID-19 crisis air cargo has been in demand, and capacity has been in short supply. Many widebody passenger jets that served long-haul routes before the pandemic are still grounded, removing belly-hold capacity from the market. Meanwhile, rising demand from the e-commerce sector, among others, has been translating into strong demand and rising rates.

According to the International Air Transport Association (IATA), global demand in 2021 measured in cargo metric ton kilometers rose 6.9% compared with 2019 levels, while capacity was down 10.9%.

In the early months of 2022, the relaxing of many COVID-19 restrictions and plans for increased air passenger activity seemed to herald an easing of the capacity pressure. Russia's invasion of Ukraine is likely to change all that for an industry that, IATA says, transports more than \$6 trillion worth of goods annually, accounting for approximately 35% of world trade by value.

Rerouting to avoid Russian airspace will add costs—both in the form of the extra fuel needed to cover the increased distances and in the decreased weight of cargo that can be carried to compensate. And the removal of some players from the market altogether will change the landscape for everyone.

During the height of the personal protective equipment shortage in 2020, shipping rates between North America and Asia nearly reached \$20 per kilogram (2.2 lb.), according to Neel Shah, executive vice president and global head of air freight at Flexport, a San Francisco-based global supply-chain logistics company.

By early 2022, those rates had settled to \$5-8 per kilogram, Shah estimates—still higher than levels before the pandemic, but well off their peak. Shipping rates are rising again in the aftermath of the Russian invasion, with rates back in the \$9-11 per kilogram range, Shah says.

"Things are going to get where they need to go, they're just going to take longer and cost more," Shah says. "Supply chains have already been stretched [due to COVID]. We know the ocean market has been backed up, and the air freight market as well. This is going to exacerbate that. We anticipate that rates are going up from here

and we see longer transit times, particularly between Asia and Europe."

Russia's closure of its national airspace to European airlines presents a big operational and cost challenge. From major cities in Europe such as Amsterdam, London, Helsinki or Stockholm, the most efficient route into Asia is to fly over Russia—sometimes passing over Ukraine—and then directly into North Asia. Bypassing Russia and Ukraine will force European carriers to fly south on much less efficient routes that could add 1-3 hr. to total trip time, Shah says.

In a Feb. 28 market update, logistics specialists SEKO Logistics mapped out some of the implications of the war for the air freight sector. SEKO noted, in particular, that rising fuel costs would have a significant effect on transport costs, while the airspace closures would have a disproportionate impact on carriers from certain regions.

"The ban on [Russian] flights into Europe is having a major impact on the market, as they have many charter agreements and are lower than market rates with agents," the company said. "Russia is the longest overflying route from Asia to Europe, and Russia is unlikely to ban any Asian carriers. . . . A key advantage to this situation is for the Middle Eastern carriers, who have had a major market share in China, operating flight routes that will not be impacted."

Finnair, whose business model relies heavily on connecting European and Asian destinations, and which in normal times relies on overflying Russia, has been quick to respond to the fast-changing situation. In late February it canceled some flights to Asian destinations, dropped its first-quarter financial guidance and warned that prolonged Russian airspace closures would have a significant effect on its finances. The carrier then announced the start of furlough negotiations with staff because of the airspace closure.

But on March 7, Finnair said the increased price of cargo enabled it to continue passenger services to key Asian destinations, even with longer flight times. The company said it would continue to serve Seoul and Shanghai from Helsinki but would cancel flights to Osaka, Japan, and Hong Kong until the end of April.

The flight routes avoid Russian airspace, and the flight time for the

Shanghai and Seoul routes will be 12-14 hr., depending on the direction, Finnair said.

A few days earlier, as the carrier announced the resumption of its Tokyo route, Chief Commercial Officer Ole Orver said: "Japan is one of our most important markets, and we want to continue offering safe and reliable connections between Helsinki and Tokyo in this situation. Japan is also an important cargo market and air connections are needed to keep cargo moving."

Ukraine itself accounts for a substantial portion of the global Antonov freighter fleet. This included what was the only existing—and now possibly destroyed—An-225, the world's largest aircraft and one critical to the movement of oversized cargo. However, a portion of cargo operator Antonov Airlines' fleet of An-124s is safely outside the country and continuing to operate.

Images from Ukraine suggest the six-engine An-225 was badly damaged during fighting at Hostomel. Antonov Co. said on March 3 that it cannot


Finnair says increased cargo rates are enabling it to continue operating to some Asian destinations despite longer flight times.



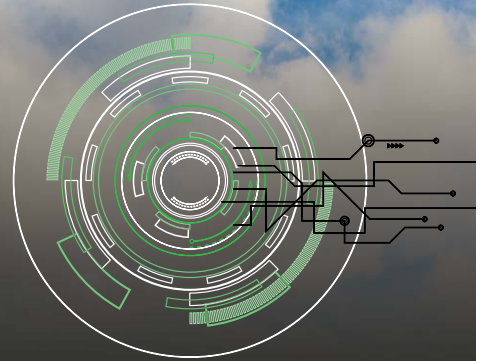
confirm the aircraft's condition until technical experts have inspected it.

Bans imposed by the U.S. and the EU on Russian airlines will further disrupt the global freight market by effectively grounding huge portions of the network of Russia-based Volga-Dnepr Group's AirBridgeCargo Airlines, which operates a fleet of 17 Boeing 747-400/800 freighters and a single 777F. As one of the world's largest cargo operators, AirBridgeCargo carries a significant amount of freight

between Asia and Europe, the U.S. and Europe and Asia and the U.S.

"[There are] still places they can fly, but the network they have been flying will mostly cease to exist, and they'll have to move to a sort of second- or third-tier network," Shah says. "That is significant capacity coming out of the market, and we're already in a tight demand-capacity balance right now, so it will tip the scales further in favor of higher rates and longer transit times." 

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**AVIATION
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NETWORK 

WestJet Aims To Buy Sunwing To Bolster Its Leisure Offerings

> ACQUISITION WOULD PROVIDE "BETTER GEOGRAPHIC COVERAGE" FROM WESTERN AND EASTERN CANADA

> MERGER WOULD BOOST COMPETITION IN LATIN AMERICA, CARIBBEAN

Lori Ranson Washington

Canada's second-largest airline, WestJet, is making a major bet on the resilience of leisure travel in a post-pandemic world through its planned acquisition of Canadian tour operator Sunwing. The move would solidify WestJet's position in vacation markets as the recovery in air travel continues.

Aviation show that Sunwing's largest bases measured by available seat kilometer deployment are Toronto Pearson and Montreal International airports.

National Bank of Canada analyst Cameron Doerksen says that historically WestJet has been strong to sun destinations from Western Canada but less so from Eastern Canada. With

of WestJet and Sunwing to Latin and Caribbean markets from Canada, "we expect the new WestJet Group to be a more formidable foe in the hotly contested leisure segment as well as the charter-vacations business," Syth writes.

Indeed, WestJet says that once the transaction closes, a new tour-operating business will be created under the WestJet Group that will include the vacation businesses of each company and will be led by Sunwing CEO Stephen Hunter. The current shareholders of Sunwing would become shareholders in WestJet Group.

Another potential advantage of WestJet's purchase of Sunwing is that the two operators have a certain level of fleet commonality. The Aviation



WestJet aims to become more competitive in vacation destinations with its proposed purchase of Sunwing.

During the past decade, WestJet diversified its business in numerous ways, ranging from the creation of regional subsidiary Encore, which operates De Havilland Canada Dash 8s, to the formation of its own ultra-low-cost carrier (ULCC), Swoop. The company also added Boeing 787-9 widebodies for long-haul operations.

WestJet embarked on these ventures to ensure that the airline remains competitive in the leisure passenger segment while broadening its reach into the corporate space.

Now, as the COVID-19 pandemic moves into an endemic phase, WestJet aims to bolster its position among Canadians who flock to warm-weather destinations during the winter months.

Sunwing's network is largely focused on offering flights to those warmer markets from Eastern Canada. Data from Aviation Week's CAPA - Centre for

Sunwing, WestJet gains "better geographic coverage" to those destinations from Eastern Canada, he says.

If WestJet and Sunwing receive all the necessary approvals for the acquisition, their combined operations will not drastically alter the domestic and U.S. transborder landscape. In a research note, Raymond James analyst Savanthi Syth explains that Sunwing has a roughly 2% scheduled seat share on service from Canada during the first half of this year, compared with 42% for Air Canada and 27% for WestJet, including Swoop's operations.

"The share in the domestic and U.S. transborder market is de minimis," Syth writes. "However, Sunwing has a 19% share in the [Latin American] and Caribbean markets, giving the combined entity a 42% share versus Air Canada's 34%."

Given that potential new strength

Week Intelligence Network's Fleet Discovery database shows WestJet's mainline has 99 aircraft in service and three in storage. Its in-service fleet comprises 39 Boeing 737-700s, 40 737-800s, 14 737-8s and six 787-9 widebodies. Sunwing's 30 in-service aircraft consist of 23 737-800s and seven 737-8s.

Sunwing has a single 737-8 on order, while WestJet's MAX orders comprise 13 737-7s, 10 737-8s, four 737-10s and four 787-9s.

Typically, Doerksen says, Sunwing maintains a core fleet of its own aircraft and in the winter months surges the size of that fleet with aircraft largely brought over from Europe for the short term through wet leases. Essentially, Sunwing would significantly supplement its capacity for the peak demand period to sun destinations from Canada.

As WestJet and Sunwing close their

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transaction, new startup ULCCs are preparing to launch in Canada, joining Swoop and its fellow ULCC, Flair Airlines. Lynx Air is aiming to launch operations in April, and Jetlines expects to make its debut this year.

Doerksen says he does not see “any way that all of these various airlines are going to be able to operate as independent entities.”

Historically, he says, Canada has had room for two large-scale network

carriers, which are currently Air Canada and WestJet.

“And then you sort of had more niche and leisure-focused players,” Doerksen says, noting that the market is just not big enough. “It doesn’t make sense that we would effectively have three ultra-low-cost airlines in Canada. It’s not a sustainable situation based on what we know today of the capacity growth plans from these various airlines.”

Doerksen also says that if those new

entrants start serving more of the sun markets, “it’s a recipe for no one to make money on those routes.”

Although the fate of new entrants in the Canadian market is tough to predict, WestJet and Sunwing executives expect the airline combination will position the companies to accelerate growth in value-oriented travel, which is already the fastest-growing segment of the airline market, says WestJet’s new CEO, Alexis von Hoensbroech. **✎**

AirAsia and AirAsia X Plot Course for Network Recovery

➤ MALAYSIAN GOVERNMENT PREPARES TO LIFT BORDER RESTRICTIONS

➤ AIRLINES AIM TO ACTIVATE MORE AIRCRAFT FOR INTERNATIONAL ROUTES

Adrian Schofield

AirAsia’s Malaysia-based carriers are making progress in rebuilding their fleets and networks, and these efforts are expected to gain more momentum after the planned reopening of Malaysia’s borders.

when international opportunities more fully emerge from the second quarter onward.

The government intends to reopen Malaysia’s borders for quarantine-free travel starting April 1, a move enabled

movement during the COVID-19 delta variant wave. But the easing of these rules allowed capacity to start rising again in September, and the increase continued through the remainder of 2021 and into 2022. AirAsia’s domestic capacity is now at its highest level in almost two years, reaching more than 76% of pre-pandemic capacity, according to data from CAPA – Centre for Aviation and OAG.

The short-haul low-cost carrier (LCC) has largely kept its dominance of the Malaysian domestic market intact. AirAsia has a 59.7% share of weekly domestic seats, which is very similar to its share before the pandemic struck. The carrier’s market share could be affected by the expected entry of a new LCC competitor this year, MYAirline.

In contrast, AirAsia’s Malaysian international capacity has yet to see any significant improvement. Before the pandemic, the carrier had almost as many international weekly seats as the domestic total. However, for the week of March 7, AirAsia was operating less than 3% of its pre-pandemic international seats.

The introduction of a travel bubble for Malaysian leisure destination Langkawi in November helped spur some international traffic. A bilateral travel lane between Singapore and Malaysia started in the same month.

AirAsia is planning to rebuild its international capacity quickly when borders reopen more broadly this year. It is also looking further ahead to when it can start expanding beyond pre-pandemic levels. The airline is targeting the second half of 2023 and 2024 to ramp up its fleet and network growth trajectory, AirAsia CEO Bo Lingam said during the Aviation CEO Forum at the Singapore Airshow, organized by Experia and FlightGlobal.



AirAsia aims to have two-thirds of its narrowbody fleet flying by year-end.

The COVID-19 pandemic wiped out international services for both AirAsia and its long-haul sister company AirAsia X. AirAsia was also hit by extensive domestic travel restrictions in Malaysia last year, but it has managed to restore much of its domestic flying since the fourth quarter of 2021.

AirAsia X is less fortunate. As it does not have a domestic network, its widebody fleet was grounded for much longer. The airline recently restarted its international network, albeit on a very small scale initially. More growth is planned by both the long-haul and short-haul carriers

by the country’s relatively high vaccination rate. According to the Our World in Data website, 83% of the total population has received at least one dose, and 78.6% are fully vaccinated.

Malaysia’s reopening efforts are proceeding even though the country is still experiencing a surge of COVID-19 cases due to the omicron variant. However, the experience in other countries is that after case numbers hit their peak, they decline just as rapidly.

Last year, AirAsia saw its Malaysian domestic capacity fall away almost entirely from June through August as the government restricted interstate

From a group perspective, AirAsia's Indonesian and Philippine joint ventures have strong growth potential, Lingam said. He also confirmed that AirAsia is considering launching two more overseas joint ventures, with more details about these initiatives expected this year.

AirAsia will also return more of its aircraft to service as it adds back international routes. The in-service total has been steadily increasing since September.

Lingam said AirAsia aims to have two-thirds of its aircraft flying by the end of this year. The short-haul carrier currently has 40% of its fleet of about 100 Airbus narrowbodies in service, according to the Aviation Week Intelligence Network's Commercial Aviation Fleet Discovery database.

AirAsia X has been much slower than AirAsia to begin resuming its operations and is restarting on a very modest scale.

The long-haul carrier grounded its operations early in the pandemic when its international routes dried up. AirAsia X's fleet of Airbus A330s have remained largely inactive for most of the past two years, and the airline has had to go through a drastic restructuring effort to stay afloat.

When AirAsia X did resume flying last year, it was for cargo-only flights. The airline has pivoted its focus much more toward cargo during the pandemic, securing some useful

Aircraft-Makers Remain Bullish Despite Unprecedented Challenges

- > WAR IN UKRAINE ADDS TO REMARKABLE NUMBER OF HURDLES
- > AT AVIATION WEEK EVENT, INDUSTRY LEADERS LOOK TO CLIMB A WALL OF WORRY

Michael Bruno Beverly Hills, California

The more things change, the more they stay the same—or at least that is the take of leading OEMs when it comes to expected production rate ramp-ups of large commercial aircraft.

Executives from Boeing and Airbus stood firm on their companies' planned airliner production rate increases on March 1 in separate speeches to the Aviation Week Raw Materials & Manufacturers Supply Chain Conference in Beverly Hills, California, despite Russia's invasion of Ukraine adding to the panoply of issues facing the aerospace industry.

"The global consumer recovery is on solid footing," said Jeffrey Carpenter, Boeing's senior director of contracts, sourcing and category management for raw materials and standards.

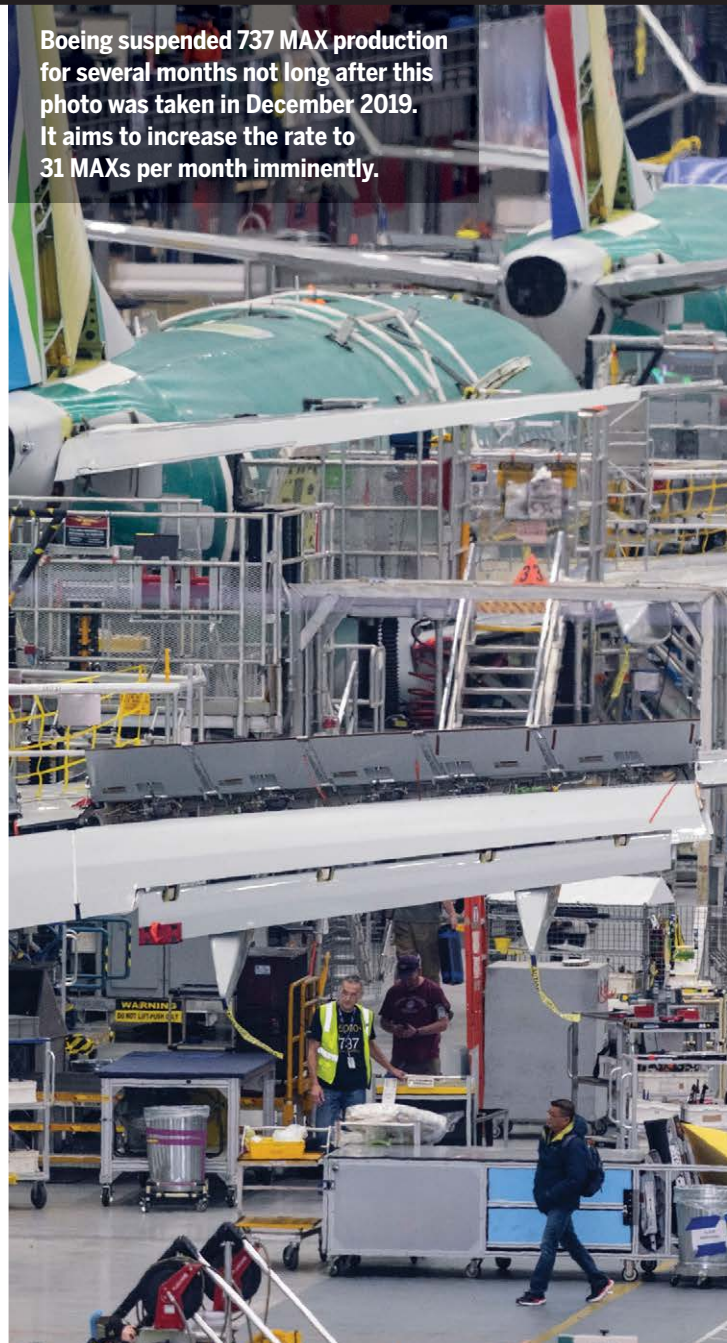
"We need you to follow," Olivier Dreier, Airbus senior vice president for material and parts procurement, told the ballroom full of suppliers, imploring them to have faith in the rate increases. "We count on you not to second-guess."

Both OEM representatives reiterated their company's positions about how the supply chain must be ready for increased production and how their companies are ready to help suppliers. Still, the Airbus and Boeing executives also emphasized notably different messages when it came to other issues that have an impact on suppliers.

Airbus has launched a competitiveness project that includes targeting a 15% cut to procurement costs by 2025. "You can argue that's a lot," said Dreier, who also serves as chairman of the Airbus Material Board. "In times where we speak about inflation, uncertainty and labor scarcity, I still believe we can take costs out.

"It is not a pure margin-targeting program," Dreier added, saying that digitalization of operations and other advances can help Airbus reach the goal.

Boeing suspended 737 MAX production for several months not long after this photo was taken in December 2019. It aims to increase the rate to 31 MAXs per month imminently.



freight arrangements in the process. This greater emphasis on cargo will continue, even when passenger flights return.

It was not until Feb. 14 that the carrier was able to relaunch its first scheduled passenger flight. This was on its Kuala Lumpur-Sydney route.

AirAsia X was operating just three of its A330s in the fourth quarter of 2021, which were used for all-cargo flights. Now it has boosted the operational total to six aircraft, and the

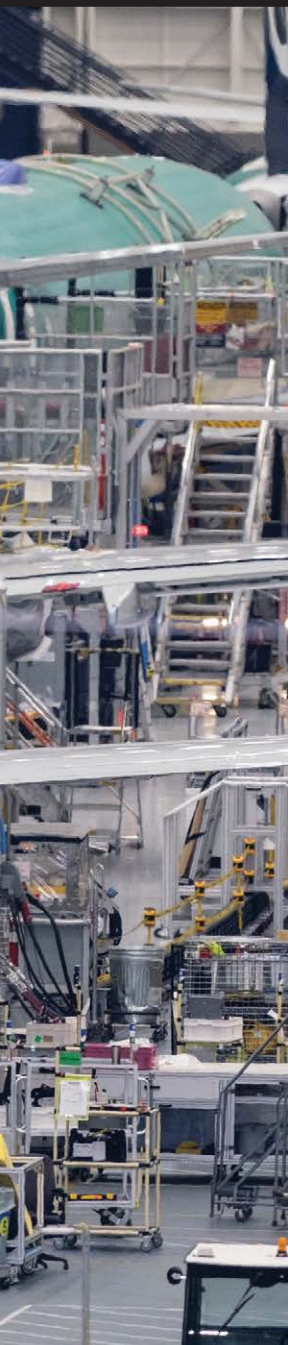
carrier intends to be operating seven by the end of the first quarter.

The airline had about 25 A330s before the pandemic but trimmed its fleet size as part of its restructuring. The carrier has retained 11 of these A330s, including both parked and active aircraft.

AirAsia X expects to have all 11 A330s operational by the end of October. In a move that reflects renewed optimism about border reopenings, AirAsia X said it is in discussions re-

garding the lease of another four aircraft. This would increase its planned fleet size to 15 A330s.

The airline has pared back its aircraft orderbook as part of its restructuring. Before the pandemic, AirAsia X had 78 A330neos and 30 A321XLRs on order. Last year, the carrier reached an agreement with Airbus to reduce this to 15 A330neos and 20 A321XLRs. These orders will still give it a range of options for long-term growth. ☒



The whole industry was facing a list of should-do improvements before the COVID-19 crisis began, but it did not tackle them because OEMs and suppliers alike were already pressed to meet historically high production rates, and the industry was financially healthy. Now OEMs and suppliers must make the necessary changes, Dreier said.

Perhaps the other big change coming for Airbus suppliers is the importance of environmental sustainability goals. Aiming for those goals is becoming a requirement for doing business with the European OEM. "I do believe it is more important than ever," Dreier said. "We don't want to be seen as a problem to sustainability in the end; we want to be seen as a driver for the industry to ensure we have a solution to the problem."

Airbus will incorporate sustainability assessments into its supplier contracting regime. Reviews will be led by Intertek Group, a British assurance, inspection, product testing and certification company. The assessments complement a more general move to sign more long-term agreements with "partners," Dreier tells Aviation Week.

Carpenter from Boeing implored suppliers to meet delivery obligations and to reach out to him for help addressing business problems. "Shortages will not be tolerated," he said. "Ask for help. . . . Flow this down to your teams," Carpenter told the audience. He repeatedly pointed out his email address and phone number on his presentation slides.

Asked when the U.S. OEM's build and deliver rates on the Boeing 737 MAX may finally be realigned, Carpenter acknowledged they probably will not align again until 2023.

The Aviation Week conference was the first appearance for representatives from both OEMs since Russia's invasion of Ukraine began Feb. 24. A consensus across the daylong event was that it was still too soon for the aerospace industry to glean how the war will affect production, but it is easy to imagine consequences such as sanctions on raw materials that would only make business more difficult. Nevertheless, OEMs and top-tier suppliers reportedly have stockpiled reserves or found alternative sourcing for titanium and critical metals to meet midterm needs.

Potential threats to raw material supplies from Russia, Ukraine and even China have become just the latest challenge facing aerospace's recovery from the pandemic crisis. Worker recruitment, training and retention issues, general inflation and logistics problems, widebody airliner woes and uneven COVID-19 vaccination rates worldwide were all cited repeatedly as top concerns by suppliers and consultants at the Aviation Week event. Above all, despite the war in Ukraine or the ongoing pandemic, the supply chain remains the greatest restriction on this upcycle, industry insiders said.

Worryingly for many audience members at the conference, some of whom have decades of experience, today's mix of issues seems unprecedented. While industry has faced similar crises—geopolitical tensions after the Sept. 11, 2001, terrorist attacks; the severe acute respiratory syndrome outbreak in 2003; oil price spikes; commercial passenger trend changes—it has not encountered them all at once.

"I can't remember a time in industry of as much maximum uncertainty like this, in terms of what we're looking at going forward," said Jerrold Lundquist, now chairman of Master Fluid Solutions and a retired McKinsey aerospace and defense practice lead.

Nevertheless, confidence in the sector's long-term prospects remains almost universal. "We are expecting 2022 to be better and the recovery to continue," Peter Zimm, principal of Charles Edwards Management Consulting, said in his keynote address.

The consultancy forecasts 16% growth in aircraft production value this year, rising to \$131 billion from \$113 billion in 2021. That is far above the \$108 billion in 2020 but far below the \$186 billion in 2019. Looking out five years, the industry should see a compound annual growth rate of 10%, achieving \$194 billion a year in 2026, the forecast says. ☒

A&D Manufacturing Join leading manufacturers and suppliers at our senior-level conference May 17-18 in Greensboro, North Carolina: [AviationWeek.com/AD-Manufacturing-2022](https://www.aviationweek.com/AD-Manufacturing-2022)



India Moves Beyond Bubbles With International Reopening

➤ BUBBLE SYSTEM HELPED, BUT IT HAS BECOME AN IMPEDIMENT

➤ NEW LEADERS AND OWNERS WILL SHAPE AIRLINE RECOVERIES

Adrian Schofield

India's domestic capacity has rebounded strongly following the latest COVID-19 wave, and now airlines can also target international gains as the government prepares to lift inbound flight restrictions.

The Ministry of Civil Aviation announced on March 8 that all scheduled international flights will be allowed to resume from March 27. This follows an earlier step in February to remove quarantine requirements for most travelers arriving in the country.

recovery, international capacity has now reached its highest point since the beginning of the pandemic.

International service—from both Indian and overseas carriers—is likely to grow more steeply after late March, when flight restrictions come to an end.

All of the international passenger capacity currently in the Indian market comes from travel bubble agreements reached with various other governments. There were 37 such

data from CAPA and OAG show.

IndiGo continues to be a juggernaut in the Indian domestic market, accounting for almost 50% of weekly domestic seats. The top three domestic carriers are all LCCs.

The planned entry of newcomer LCC Akasa Air and the resurrection of full-service carrier Jet Airways this year will heat up competition. However, they are unlikely to shift domestic market share percentages dramatically, as they will begin with relatively small fleets.

The Indian market is much more evenly divided in the international arena. Full-service carriers from all countries account for 51.5% of India's international capacity, and LCCs contribute a 46.8% share. The remainder is mainly charter operators.

In this case, Air India—combined with its Air India Express subsidiary—is the market leader, ahead of IndiGo.

A notable feature of the Indian international market is the strong presence of Middle East-based carriers. Considering full-service carriers only, Air India has the most capacity, and the next four on the list are Emirates, Qatar Airways, Etihad Airways and Saudia.

As India's airlines prepare for the next phase of recovery and growth, some have made significant leadership moves.

The new owners of Jet Airways appointed industry veteran Sanjiv Kapoor as CEO. Kapoor has previously held senior roles at Vistara and SpiceJet. The airline also recently named Vipula Gunatilleka as chief financial officer. Gunatilleka is a former CEO of SriLankan Airlines. The selection of such a high-profile leadership team underlines the fact that Jet Airways aims to be a serious player in the Indian market.

At IndiGo, Rahul Bhatia, one of the carrier's co-founders and major owners, has taken on a more hands-on role as managing director of the airline.

Meanwhile, Air India has struck a hurdle in its effort to hire its first post-privatization CEO. Tata Group, the new owners of Air India, named former Turkish Airlines Chairman Ilker Ayci CEO on Feb. 14. He was due to take the reins of the company on April 1, but Ayci withdrew from the role on March 1. The Air India board has had to restart its CEO selection process. 🌐

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Air India and other airlines will be able to ramp up flights to and from India after March 27.

India has already restored a significant proportion of its international capacity through an extensive system of bilateral travel bubbles. But this system is an unsatisfactory interim measure that artificially constrains the market.

The government has attempted to remove the flight restrictions before, only for new waves of COVID-19 cases to postpone the reopening. Higher vaccination rates and a rapid decline in new case numbers give more confidence that the target date will stick this time.

Although progress has been slow in the international market, it has at least been growing consistently.

International capacity, as measured in weekly seats, has now reached about 60% of pre-pandemic levels, according to data from CAPA - Centre for Aviation and OAG. While there is obviously a long way to go until full

arrangements as of March 1, although each one has specific restrictions on flights and who can use them.

Aside from these travel bubble flights, regular scheduled service into India has been prohibited since the start of the pandemic.

The strengthening domestic market has been the main bright spot for Indian airlines until now. Domestic capacity was almost back to pre-pandemic levels for the week of March 7, reaching nearly 95% of the total from the same week two years earlier. The latest climb followed a substantial capacity dip in January caused by the onset of the omicron variant.

As capacity levels have rebuilt, some things have not changed. For example, low-cost carriers (LCC) are still the dominant force by a wide margin in India's domestic market. LCCs accounted for nearly 80% of domestic seats for the week of March 7,

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HEAVY WEIGHT

> CHINA BETS ON VARIETY OF LARGE FIGHTER AIRCRAFT

> MOST PRODUCTION FIGHTERS HAVE ADVANCED RADAR

Bradley Perrett Newcastle, Australia

China has a heavy fighter force, and it is getting heavier. The bulk of Chinese fighter acquisition funding is pouring into production lines for large, long-range aircraft that suit western Pacific distances.

But the air force and naval aviation branch fighter fleets are badly fragmented, and no fewer than five major designs are currently in production for them. They are the Avic Chengdu J-10C and J-20A and the Avic Shenyang J-11, J-15 and J-16; the first two are fully indigenous, and the others are developments of the Sukhoi Su-27 Flanker.

shows up in the balance of designs it has in production, the balance of output numbers and, most decisively, the evident balance of funding.

Of five production designs, only one, the J-10C, is not a heavyweight.

As for output, China built 84 fighters in 2021, about the same as the average of the previous six years, according to new estimates by the Aviation Week Intelligence Network (see chart). Of these, only 24 were J-10s.

And J-10s, medium-weight fighters only about 10% bigger than Lockheed Martin F-16s, should not be expensive.

the Flanker force includes Su-30s and Su-35s imported from Russia.

An assessment by think tank Air Power Australia gives some idea of the sort of escort capability that Flankers offer China. “The Su-30s are honest 700-nm+-radius-class [1,300 km+] fighters, with plenty of combat gas to burn at shorter radii,” it says.

Such a radius would allow China’s Flankers to operate southeast of Japan, even without aerial refueling, or to maintain long-endurance patrols around Taiwan.

But the various Flanker designs contribute greatly to the Chinese fighter force’s fragmentation problem. The difficulty is not so much the number of types, since the air force and navy operate only five (the J-7, J-8, J-10, Flanker and J-20). Rather, the problem is versions. Maintainers must contend with at least 19 major design variations among the types.

This has resulted in part from China’s rapid advance in fighter technology: Improved versions arrive at short intervals. For example, the J-10A, deliveries of which began in 2003, had a radar with a mechanically scanned array, but the J-10B of 2013 apparently introduced an electronically scanned array, and the J-10C of 2015 has a radar with even more advanced antenna, an active, electronically scanned array (AESA).

Aviation Week’s figures show that if recent production rates are maintained, and if the fighter force does not change in size, the remaining 226 J-7s and 146 J-8s will be replaced in about 4.5 years—mostly by much larger fighters. In the process, the two services will also ditch the seven versions into which those types are divided.

Probably all fighters in production for the Chinese air force now have AESA radars, raising the possibility, but hardly proving, that the avionics are comparable to such foreign designs as the Boeing F/A-18E/F Block II Super Hornet, which entered service in 2005. The J-15 apparently still uses a mechanically scanned array, but the expected FC-31 derivative should replace that shipboard Flanker and will surely have an AESA.

Shenyang used company funding to design the FC-31 (also called the J-31) as a technology demonstrator, but an industry source said in 2018 that the project was then receiving government money to develop it as a naval fighter.

China is building the J-16 faster than any of its other current fighter designs.

Evidence points to upcoming advances in the form of new J-10 and J-20 versions and, for the navy, an operational development of the Shenyang FC-31 fighter demonstrator. Although China is a great enthusiast for the long-legged Flanker, there is little sign of it working on future versions—yet the possibility of their appearance cannot be ruled out.

Introduction of new fighter designs will hardly help maintenance and logistics organizations, even as they are relieved of the burden of supporting obsolete Chengdu J-7s and Shenyang J-8s, perhaps around 2026.

China’s bias toward heavy fighters

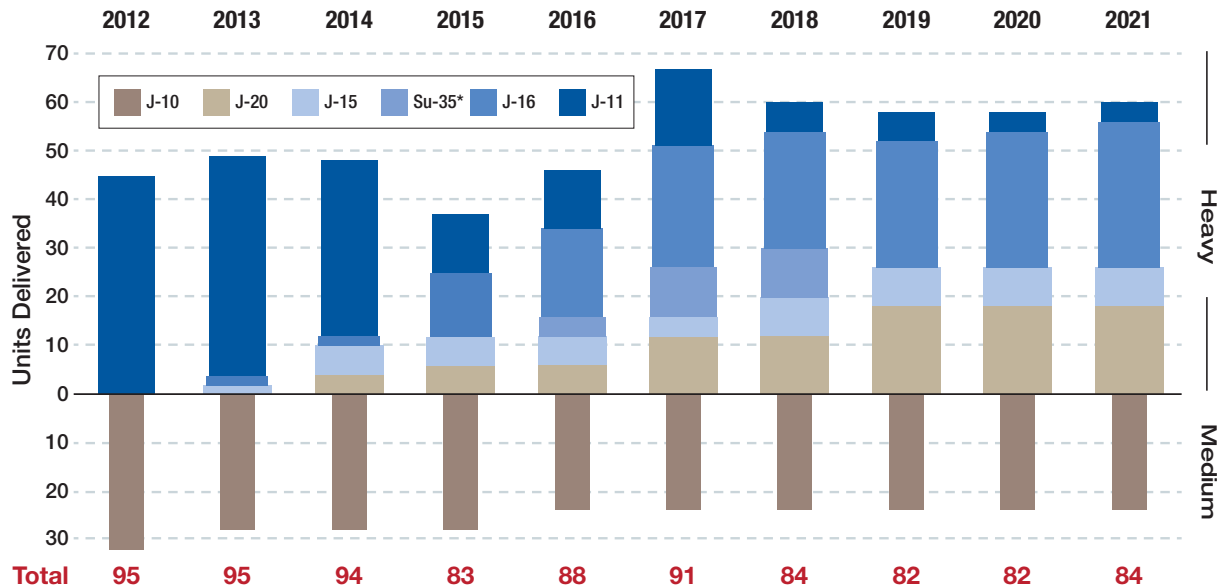
If aircraft empty weight is taken as an index of unit cost, China applied only 18% of fighter production funding to the J-10 program in 2021—and that is probably an overestimate, since the stealthy J-20 is likely to be disproportionately expensive for its size.

The rest of the money is going to heavyweights. These already form 55% of the combined air force and navy fighter fleets. Since big fighters account for more than 70% of current production numbers, the ratio in service will rise, although the FC-31 derivative could be in the medium-weight category.

Apart from J-11s, J-15s and J-16s,



Chinese Fighter Deliveries



*Imported

Note: Column width is proportional to aircraft size.

Source: Aviation Week Intelligence Network

The air force was also interested in it, the source said. However, there has been no confirmation of a version for that service, which obviously rejected it around a decade ago.

The air force presumably thought then that it had enough variation in its fleet already and better things to do with its money and that it could wait for something better than the FC-31 as a successor to the J-10.

That something should be the fighter that Chengdu designer Wang Haifeng has said will be in service by 2035. His timing suggests a prototype should appear this decade. Although it is likely to replace the J-10 in production, the new type need not be in the same weight class.

Meanwhile, the J-20 is very likely being developed as a multirole aircraft as the air force sets aside what was apparently an original plan to limit it to air-to-air missions.

Avic—and specifically J-20 designer Yang Wei—has campaigned for further development of the type for more missions. Since they had to campaign, no such adaptation of the J-20 can have been originally intended.

A long-rumored two-seat version of the J-20 has appeared, perhaps designated the J-20S or J-20AS. (The first operational version is the J-20A; “S” in a Chinese fighter designation stands for “shuang” meaning “twin,” or twin-seat.)

Although a two-seater is useful as a trainer, the J-20 program has got

along so far without one, raising the likelihood that the second crew member in the new version is for strike missions, possibly airborne command and, ultimately, control of loyal-wingmen drones.

If it is to fully preserve its stealth and carry weapons only internally, the J-20 is limited as a strike aircraft. Its main weapon bay is shallow, designed for carrying air-to-air missiles. To preserve a flat underside that is optimal for stealth, the bay doors do not bulge, as do those of the Lockheed Martin F-35 Lightning.

Still, the constricted volume may be acceptable, says Douglas Barrie of the International Institute of Strategic Studies in London, pointing out that improved weapon precision allows for smaller warheads and that a weapon delivered by a stealth aircraft may not need great range. Also, bulging doors could be fitted, at some cost in controlling radar reflections.

A further J-20 upgrade will come when the engine for which it was designed, the WS-15, finally becomes available, perhaps in a few years.

J-20 production is running at 18 aircraft a year, neither fast nor slow by Chinese standards. Aviation Week analysts estimate that 94 J-20As have been delivered.

Another J-10 version, presumably called the J-10D, is probably in the works, since an aircraft of the type has appeared with a thrust-vectoring en-

gine nozzle. The J-10’s production heyday was a decade ago, when it reached 32 units a year.

There is no current indication of another Flanker version, despite reports a few years ago of one called the J-11D. The J-16, a multirole two-seat Flanker, is being built at a rate of 30 a year, including six units of its J-16D electromagnetic-attack subvariant. This is China’s fastest fighter production program.

Shenyang also continues to build J-11s of a two-seat subvariant, the J-11BS, but only slowly. More important, upgrading of the large existing force of J-11s has begun, probably including fitting AESA radars and making the aircraft compatible with new Chinese weapons. The improvements are presumably also incorporated in current production.

The future of China’s Su-30s, all imported, is an interesting question, since replacement by J-16s would offer superior performance, compatibility with new Chinese weapons and lower support costs. This should particularly be a consideration for the navy, which has just 24 Su-30MK2s, which are different to the air force’s 74 Su-30MKKs, another instance of fragmentation.

On the other hand, China has consistently been reluctant to discard fighters. Its retention in the 2020s of J-7s, based on the MiG-21 design of the 1950s, is a notable example of that parsimonious attitude. 🇨🇳

RATIONAL REFORMS

- > SAUDI FORCES ARE ADAPTING FOR INTEROPERABILITY
- > TRANSFORMATION PROGRAM DUE TO BE COMPLETED IN 2028

Tony Osborne Riyadh, Saudi Arabia

Saudi Arabia has embarked on a wholesale transformation of its armed forces, preparing them to work better together and as part of international coalitions.

The reforms call for deep institutional changes in areas such as personnel promotions, acquisitions and joint operations and will even lead to some consolidation of what is one of the most powerful militaries in the Middle East and one of the world's largest defense spenders.

Plans for the reforms date back to 2015, when Saudi Crown Prince Mohammed bin Salman, who was then defense minister, proposed a modernization of the ministry and its armed forces. This prompted the writing of a new defense strategy and development of a new operating model. A

new defense strategy was approved in 2017, and a royal decree was issued in 2018.

Few details of the defense ministry's Transformation Program had emerged until the inaugural World Defense Show, held here on March 6-9, where senior officers openly discussed the project's aims and progress.

The changes will make the forces more "task-oriented, more professional," and they will benefit from "better governance," senior officers told Aviation Week at the show. In all, some 300 initiatives are being rolled out until about 2028, when the reforms are due to be completed.

Perhaps the most eye-catching of the changes are plans to merge two of the country's five armed services—the Royal Saudi Air Force and Royal Saudi Air Defense Forces—combining them under the new banner of the Royal Saudi Air and Space Force. Details of the consolidation, including the structure and doctrines, are still to be worked out. But officers told Aviation Week that designers of the operating model concluded that similar tasks of the two forces would be optimized under a single force structure. Both organizations have worked closely to protect Saudi cities and critical infra-

The sight of Patriot air defense launchers around Riyadh is an eerie reminder that the country still faces attacks from Yemen's Houthi rebels. These Patriot launchers are operated by the air defense forces, which is to be merged with the air force later this decade.



structure from the drone, cruise and ballistic missile attacks launched by the Houthi militants in Yemen.

Another change has been a more centralized approach to procurement with the formation in 2018 of a single organization, the Arms and Materiel Deputyship, which has taken control of acquisition from the individual armed forces. This development has led to more efficient procurements, officials say, including joint equipment purchases.

Other plans include the creation of a Joint Forces Command, similar to those established in Europe and the U.S., to boost interoperability between the various armed services. That command is expected to reach an initial operational capability in the coming months. The defense ministry is also creating a National Defense University, building on the existing capabilities of Riyadh's staff colleges.

The changes to the armed forces are part of bin Salman's broader reforms to the Saudi state, under his Vision 2030 project to diversify the economy away from its reliance on oil. One target of these efforts is the localization of up to 50% of the country's defense procurements through the creation of a local defense industry. To oversee this process, Riyadh has created the General Authority for Military Industries, which regulates the defense industry and guides the direction of national investments into localization.

A newly established General Authority for Defense Development (GADD), formed last year, will define defense research priorities and lead development and innovation activities. GADD is set to benefit from national plans for budget increases in national research and development.

Senior officers say the defense ministry's transformation program represents a third revolution in the history of the country's armed forces. The initial Saudi Arabian Army was formed in the 18th century and became a branch of the armed forces at the beginning of the 20th century.

The reform process has not run entirely smoothly, and timelines for some of the initiatives have moved to the right. The merging of the Air Force with the Air Defense Forces is likely to occur toward the middle of the decade, later than originally anticipated. 🌐

Saudi Arabia Prioritizes Drone Development and Procurement

- INTRA IS WORKING ON INDIGENOUS SAMOOM TWIN-ENGINE UAS
- CHINESE AND SAUDIS COLLABORATE ON UAS PAYLOADS

Tony Osborne Riyadh, Saudi Arabia

The aerospace industry in Saudi Arabia is building up the technical expertise to develop advanced, armed uncrewed aircraft systems.

If that sounds like a familiar story, it is. Saudi Arabia, like many other countries in the Middle East, had sought U.S. platforms such as the General Atomics MQ-1 Predator or MQ-9 Reaper, but their requests were

companies displayed a range of UAVs, some developed locally, others leaning on partnerships with both the West and East. In addition, several foreign providers, notably from India and South Africa, signaled their wish to partner with Saudi industry and help meet localization goals under the kingdom's Vision 2030 plan to diversify the economy away from oil.



TONY OSBORNE/AW&ST

Intra, which has operated and modified Turkish-developed Vestel Karayel systems, is now developing the twin-engine Samoom platform, with a first flight planned for around 2025.

turned down. They instead turned to China, and small deliveries of China Aerospace Science and Technology Corp. CH-4s and Chengdu Aircraft Industry Group Wing Loong IIs quickly followed. However, their use has been limited. Saudi commanders have apparently been frustrated by the unreliability of the platforms, a lack of maintenance support from suppliers and poor fidelity from the electro-optical systems.

Now the Saudi defense ministry is turning to its burgeoning defense industry to provide an answer, and it appears to be responding.

At the inaugural World Defense Show (WDS) here on March 6-9, Saudi

Private Saudi defense firm Intra Defense Technologies is working on an indigenous twin-engine, high-altitude-capable, long-endurance uncrewed aircraft system (UAS) called the Samoom, a scale model of which debuted at the show. Named after a dry, dust-laden wind, the system has a maximum take-off weight of 3,300 kg (7,300 lb.) and is six months into a 2.5-year development program, with a first flight planned for around 2025. The Samoom is designed for the armed intelligence, surveillance and reconnaissance (ISR) role under a sole source contract for the Saudi defense ministry.

The company has already received permission to manufacture from the

General Authority for Military Industries (GAMI), Riyadh's defense industry regulator.

The Samoom builds on Intra's experience with the Haboob, the new name given to modified versions of the Turkish-developed Vestel Karayel tactical armed UAS, on which Intra now owns the intellectual property rights. Intra had designed a modified extended wing and added a beyond-visual-line-of-sight communications capability for the Haboob so it could be controlled via Arabsat communication satellites.

The company had planned to build the Haboob in the kingdom, but the plans are now on hold as the company focuses its efforts on the Samoom.

The Samoom will feature a 24-m (79-ft.) wingspan, with three hardpoints under each wing designed to

Saudi Arabia is buying 12 Tengen Technology TB-001 MALE platforms, which are being marketed locally as the Al-Eqab 2.

carry a range of munitions. The company is also fitting a hardpoint under the fuselage for electronic warfare payloads. The platform is intended to meet U.S. International Traffic in Arms Regulations with components largely sourced within Saudi Arabia and developed by Intra.

A 220-hp piston engine from Europe

will power it, but the supplier was not named. Intra is also developing electro-optical/infrared payloads in conjunction with Hensoldt and is working on its own weapons, a modular-glide-bomb family called the Shalfa. Intra has developed a family of vertical-takeoff fixed-wing systems called the Asef, too.

Asim Khalid Alrebdi, the senior aeronautical engineer working on the Samoom, says the company is working with Saudi Arabia's airworthiness authority, the General Authority of Civil Aviation, to look at certifying the platform for potential civil use. Intra has been positioning itself as a UAS supplier to Saudi Arabia for several years, offering pilots, maintenance and even sensor operators,



Electric Aerial Ram Developed for Anti-Drone Mission

- MARSS INTERCEPTOR USES FOUR DUCTED FANS FOR PROPULSION
- MILITANT GROUPS OVERCOMING ANTI-DRONE JAMMING WITH INERTIAL NAVIGATION



The Interceptor will be capable of taking down several Category 1 or Class 1 drones in a single mission, making it a potentially effective counter to swarms.

MARSS CONCEPT

Tony Osborne Riyadh, Saudi Arabia

During World War I and World War II, aerial ramming was viewed in some air forces as a valid last-ditch tactic against enemy aircraft—albeit one that was often fatal to the pilot. Now the idea has made a return as a potential solution to the threat of drone swarms.

European defense technology company MARSS has developed an electric-powered, vertically launched carbon-fiber and titanium construction aerial vehicle that can potentially bring down multiple adversary drones during its brief flight.

MARSS believes its Interceptor system, which debuted at the World Defense Show here on March 7, could change the economics of drone protection and enable commercial

companies to safeguard critical infrastructure such as power stations and oil refineries. Upon launch, the 10-kg (22-lb.), 90-cm-wingspan (35-in.), quad-ducted, fan-powered Interceptor is guided toward its target by MARSS' NiDAR command-and-control system. Identification is performed by an imaging infrared seeker in the nose that helps the system select the weak point on the adversary air vehicle. The Interceptor will then perform an intentional midair collision, sending the drone crashing to the ground.

If a first attempt fails, the Interceptor can maneuver around for a second encounter and even chase the adversary platform down. The Interceptor's 80-m/sec. (180-mph) velocity gives it a speed advantage over many of the small,

should its customers require them.

Chinese platforms remain an option, however. Long-proposed plans for a final assembly line for Chinese-built platforms in the kingdom have been given the green light by GAMI, according to officials from Saudi manufacturer Science Technology for Investment and Industrial Development Co. Its officials tell Aviation Week they are in the process of supporting a sale for an initial 12 Teng-oen Technology TB-001, twin-boom, twin-engine, medium-altitude, long-endurance (MALE) platforms. A model of the aircraft, marked as the Al-Eqab 2, was at the center stage of the company's stand at WDS.

The Al-Eqab 2 is seen as a "strategic platform," company officials say, and would take on missions such as armed ISR and electronic warfare.

Meanwhile, China Electronics Technology Group Corp. signed strategic agreements with Saudi Arabia's Advanced Communications and Electronics Systems Co. to set up a research, development and manufacturing center for UAS payloads.

Saudi industry is partnering with Western companies, too. Newly formed Riyadh-based Scopa Industries Corp., part of the Ajlan and Bros. Investment Holding Group, agreed on a memorandum of understanding with the UK's UAV Tactical Systems, the company delivering the Watchkeeper tactical UAS to the British Army.

Scopa plans to offer a variant of the Watchkeeper, called the WK-X, to Riyadh, with plans for localization of production and technology transfer. The Watchkeeper itself was derived from the Israeli Elbit Hermes 450 platform.

Among other companies vying for attention from the Saudi defense ministry and investors at WDS were South Africa's Milkor and India's Edge Defense. Milkor displayed a full-scale model of its MALE uncrewed combat aerial vehicle currently under development. With an acquisition unlikely from its own cash-squeezed government, the company has opened offices in Riyadh to develop an interest in the UAV platform. Edge Defense builds a family of low-cost drones, including attritable swarming drones with a price tag of around \$2,000 each. It said it had secured approval for demonstrations to Saudi authorities, and was proposing final assembly of its air vehicles in the kingdom, although production would continue in India because of its lower cost of labor. ☛

MARSS has used a "robust" carbon-fiber and titanium rugby-ball-like construction for the body of the Interceptor air vehicle.

lightweight drones it has been developed to tackle.

Flight endurance is less than 10 min., and range is around 5 km (3 mi.). Operations can be performed in virtually all types of weather as well as by day and by night.

According to the OEM, each Interceptor can survive multiple collisions with so-called Category 1 or Class 1 uncrewed aircraft systems (UAS) weighing up to 20 lb.; however, repeat collisions against Category 2 or Class 2 UAS are unlikely because of their larger size, increased speed and mass.

MARSS has used machine-learning algorithms to study numerous drone configurations so that the Interceptor can hit the most vulnerable part of an adversary drone's airframe.

After its mission, the Interceptor returns to its launch point for inspection and recharging until it is ready for its next mission.

"We can engage multiple [Class 1 or Category 1] UAVs in a single engagement with a single aircraft, and that sets us apart from anything else that's available on the market," says Stephen Scott, MARSS head of research and development. MARSS says the Interceptor costs one-fifth of the price of a surface-to-air missile, but the ability to engage more than one target in the same mission "transforms the cost-per-engagement metric," Scott says, because a missile is likely to be able to engage only one drone at a time.

Given that both the system and the engagement processes are autonomous, the operators require less training, and there is a much lower risk of collateral damage than with missiles.

"We're really opening up the entire market, making sure



that countermeasures against the drone threat are not exclusively for military customers," Scott says. "It is available to anyone who needs it. And it's got the intelligence, the safety and the performance that you would need for a nonmilitary application as well."

The Interceptor system is designed to link with MARSS' NiDAR system by taking inputs from sensors such as radars and electro-optical cameras and to act as another layer of protection against what the company

says is a rapidly growing threat.

MARSS CEO Johannes Pinl says the system was being debuted in Saudi Arabia because the country's experience with drone attacks had inspired its development. Militant groups across the Middle East have been using small drones to fly up to hundreds of kilometers to their targets.

"Right now, we only see this [drone] threat in the Middle East," Pinl says. But "it will be exported," he warns.

Recent months have seen militant groups adapting how they use drones in response to the countermeasures developed against them. Rather than using autonomous GPS guidance, they are now increasingly being equipped with inertial navigation systems, countering the global navigation satellite system jamming approaches sometimes adopted by drone protection systems. Jamming of the wider radio spectrum to stop the drones also can have unintended effects such as disrupting communications signals and even medical equipment. "The new threats can be robust against jamming, so [the drones] can continue to follow their flightpath," Pinl says. "We need kinetic energy to stop them."

The company is nine months into the Interceptor's 18-month development program. MARSS aims to bring the system to market in early 2023. ☛

Europe's Industry Finally Gets MALE Drone Program

> EURODRONE CONTRACTS SIGNED WITH MATERIELS AGENCY

> PARTNER NATIONS BUYING 20 EURODRONE SYSTEMS

Tony Osborne London

Europe's recent aerospace history is littered with various failed attempts to secure the development of a medium-altitude, long-endurance (MALE) uncrewed aircraft system.

Models were produced of the Talarion (by EADS, now Airbus) and the Telemos (by BAE Systems and Dassault), and BAE Systems' Mantis and Piaggio Aerospace's HammerHead managed to reach the prototype stage but never gained serious traction. Europe's needs were instead fulfilled by systems from Israel and the U.S.

But Europe is finally making its entry into the market with development of the Eurodrone, a product of nearly a decade of industry lobbying to be allowed to use technologies on which it spent billions of euros developing.

On Feb. 24, European defense materiel agency OCCAR awarded a long-awaited €7.1 billion (\$7.7 billion) global contract for the Eurodrone's development, production and initial in-service support to Airbus in Germany, with Dassault Aviation in France, Leonardo in Italy and Airbus' Spanish business acting as subcontractors. Twenty systems are on order for partner nations France, Germany, Italy and Spain; each system will feature three of the twin-engine 11-metric-ton air vehicles.

Industry had hoped to finalize the contract in 2020, but the signing was delayed awaiting budgetary approvals. The last to commit was Spain, whose government finally gave the green light at the end of January.

Considerable preparatory work has already occurred through a system requirement review and system preliminary design review (SPDR) that

concluded in 2018, Didier Plantecoste, head of Eurodrone development at Airbus, told Aviation Week on March 1, the first working day of the contract.

"These preparatory activities were necessary to have a successful start," Plantecoste said. "With the contract signing, we are getting ready to enter into the early industrialization and production preparation."

The wait for approvals shifted timelines to the right, however. Work on the prototype will now begin in 2024, and customer deliveries will take place at the end of the decade. But Plantecoste said there will be no effect on the "time frame of the program." Since Germany will be the largest customer, buying seven systems, it has secured the final assembly line for the program at Manching.

Dassault's workshare includes development of the safe flight and landing systems as well as communications maintenance elements. Leonardo will build the platform's 26-m-span (85-ft.) wings and produce electrical, environmental control, mission and armament systems, whereas in Spain, Airbus will build the fuselage and empennage, develop the ground safety control systems and integrate the engines.

Powerplant selection has yet to be made, but a decision is expected "very, very soon," Plantecoste stated. "We are still fine-tuning elements with the bidders," he says.

Two engines have been downselected for potential installation—the Safran Ardiden TP, developed from the Ardiden helicopter turboshaft, and the General Electric Catalyst, developed in the Czech Republic.

"We are really confident that we have all the ingredients from a technical and technology standpoint and that [the] Eurodrone will be a success,"

With a contract in place, program timelines envisage that the first Eurodrone platforms will be delivered at the end of the decade.

Plantecoste said.

Many of the technologies destined for the platform have been derisked through maturation studies. "All of the partner companies have considerable experience. . . . We have a strong competency on building aircraft," he said.

But there are technical challenges. The Eurodrone's physical size is one, Plantecoste admits. Certification is also a challenge—the partners want the platform to be able to operate in unsegregated airspace, mixing with other air traffic from Day 1 of operations. Another key element of the program will be the digital design, manufacturing and services (DDMS) approach used to develop the platform. The Eurodrone will be the guinea pig program for these tools, which Airbus says will improve the way the platform is designed, manufactured and operated.

These techniques will be steadily introduced during the Eurodrone development process, Plantecoste says. "Some bricks of DDMS are already in place," he noted. "But one of the missions of the Eurodrone program will be to implement many more of them." Proving DDMS on the Eurodrone will pave the way for its use on future programs such as the Future Combat Air System with France and Spain. It will also test the industrial partners' ability to cooperate.

"This program will reinforce industry ties and collaboration across European nations and strengthen defense capabilities," Airbus Defense and Space CEO Michael Schoellhorn says.

The European Commission is providing funding support for the early development phase of the Eurodrone program with a €100 million grant provided by the European Defense Industrial Development Program, recognizing the program as a "strategic enabler," the commission states. Exports may also be in the cards. Customers are already planning their own enhancements, and "we have integrated certain provisions to up the capability of the aircraft," Schoellhorn says. 🌐

Predictive Intelligence to Drive Results



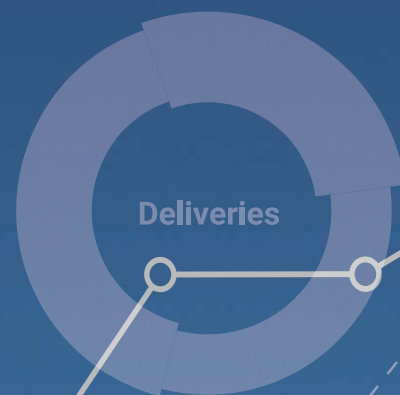
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2022

2031

OPTICAL SWITCHBOARD IN SPACE

- > NASA TO DEMONSTRATE LASER COMMUNICATIONS TO AND FROM GEO
- > EXPERIMENTS EXPECTED TO BEGIN IN APRIL
- > ISS SET TO RECEIVE LASER COMMS TERMINAL

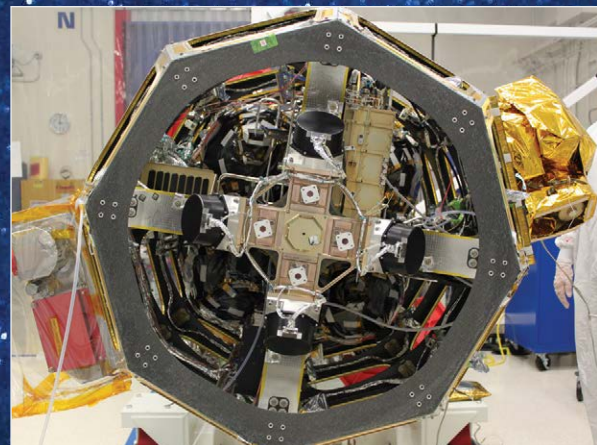


NASA Laser Communications Missions

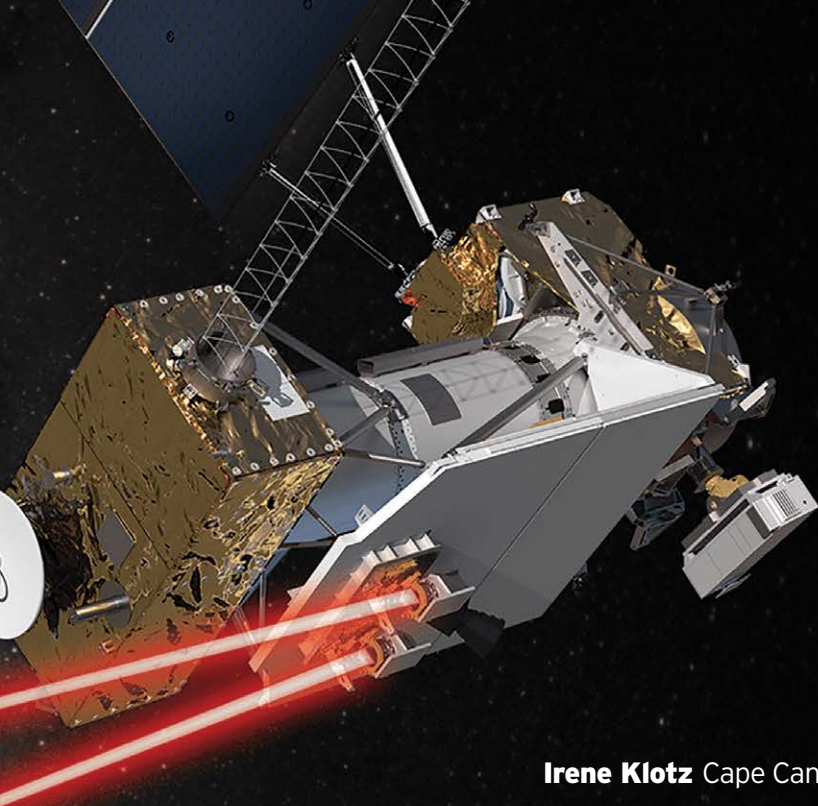
NASA is looking to infuse laser communications into the networks that support spacecraft in Earth orbit and beyond. Here is a look at the agency's technology demonstrations and upcoming operational systems.

2013 | Lunar Laser Communications Demo

The LLCD demonstrated laser communications at 622 Mbps from lunar orbit and 20 Mbps to that orbit. The mission validated the use of laser communications at the Moon and set the stage for further research and development. The system flew on the Lunar Atmosphere and Dust Environment Explorer spacecraft.



NASA



NASA's Laser Communications Relay Demonstration, located in geosynchronous orbit, is expected to begin experiments in April to showcase optical technologies and validate the use of optical relays.

Irene Klotz Cape Canaveral

Among the most obvious differences between the Apollo Moon landings and the upcoming Artemis missions will be how program insiders and the public experience the events. Instead of grainy, black-and-white images and intermittent communications from astronauts on the lunar surface, NASA expects live, high-definition video and clear audio, as well as broadband science, spacecraft and other data, all transmitted via optical links.

After a trio of technology pathfinders—at the Moon, aboard the International Space Station (ISS) and with a set of cubesats in low Earth orbit—NASA is poised to begin experimenting with its first two-way laser relay. “This truly is a first-of-its-kind demonstration,” says Trudy Kortes, director of technology demonstrations at NASA’s Space Technology Mission Directorate.

Launched in December aboard the U.S. Space Force’s Space Test Program Satellite-6, NASA’s Laser Communications Relay Demonstration (LCRD) will test a bidirectional, end-to-end optical communications system capable of data transmission rates 10-100 times faster than traditional radio frequency (RF) systems. Experiments are scheduled to begin in April.

NASA CONCEPT



2014 | Optical Payload for Lasercomm Science

The OPALS experiment was a four-month laser communications demonstration onboard the International Space Station. OPALS downlinked a high-definition video of the 1969 Apollo 11 Moon landing in just 7 sec., a transmission that previously took 12 hr. to uplink with traditional radio frequency communications.



KATE RUBINS/NASA

BACKGROUND: KAMADE/GETTY IMAGES

2017 | Optical Communications and Sensor Demonstration

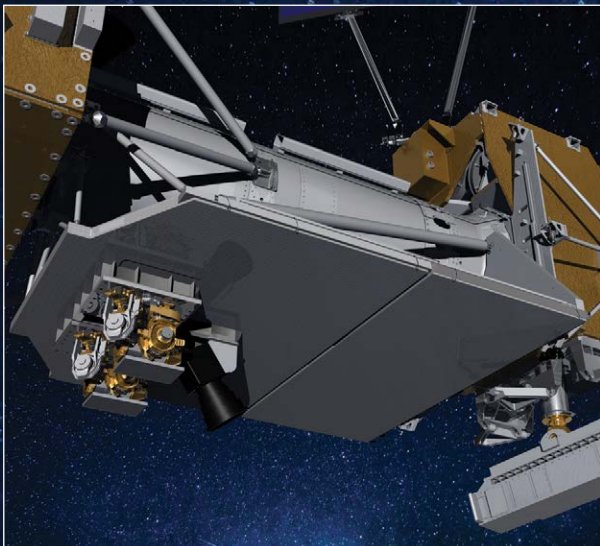


NASA

The OCSD demonstrated the first high-speed laser communications downlink from a cubesat to a ground station, achieving data rates of 2.5 Gbps. Unlike other space-based optical communications

systems, the OCSD laser system is hard-mounted to the spacecraft body. The beam is pointed by controlling the orientation of the entire spacecraft.

2021 | Laser Communications Relay Demonstration



NASA/GODDARD SPACE FLIGHT CENTER

The LCRD is NASA's first end-to-end laser relay system, demonstrating and testing NASA-developed laser technologies from geostationary orbit. The LCRD is outfitted with two optical terminals, each capable of transmitting and receiving 1.2 Gbps. The LCRD is designed to spend at least two years conducting experiments via ground-based laser links before supporting missions in low Earth orbit. Operations are expected to begin in April.

Targeted Launch 2022 | TeraByte Infrared Delivery

The TBIRD will demonstrate a direct-to-Earth laser communications link from a 6U-cubesat in low Earth orbit that can transmit data at a rate of 200 Gbps. The TBIRD will be a hosted payload on the Pathfinder Technology Demonstration 3 mission.



MIT/LINCOLN LABORATORY

The LCRD, which is costing NASA \$320 million, is expected to pave the way for optical communications systems for the agency's Artemis lunar exploration initiative and other deep-space programs. "As missions generate and collect more data, higher bandwidth is needed to relay data back to us. That's exactly what LCRD is testing and demonstrating," Kortez says.

In addition to providing higher data transmission rates, optical communications systems are smaller, lighter weight and require less power than current RF-based technologies. Also, unlike RF, optical frequencies are not regulated by the International Telecommunication Union (ITU), Federal Communications Commission (FCC), National Telecommunications and Information Administration (NTIA) or other agencies.

"The ITU, FCC or NTIA won't try to put on any burdens or showstoppers," says NASA Deputy Associate Administrator Badri Younes, who oversees NASA's Space Communications and Navigation program. "Different communities can share the same optical band and be able to talk to each other, provided they have similar waveforms. This interoperability is critical for us. That's why we are going to push the technology as far as we can."

The overall goal of the LCRD program is not only to benefit NASA, but also to accelerate the growth of the industry. Market researcher NSR projects that sales of satellite optical communications equipment will reach \$2 billion in 2031 (see page 52).

Satellite-based optical communications are not a flash-in-the-pan thing, says former BridgeSat CEO Barry Matsumori. "The reason why is simple: bandwidth.

"RF has pretty much run the gamut," he adds. "As you go up in spectrum, the combination of great propagation capabilities and bandwidth simply is not possible. And as you get high in spectrum, you start getting some of the same characteristics as you have on optical comms but without some of the benefits of optical communications, particularly the very high speeds that are possible and very good propagation."

Unlike SpaceX's Starlink, which is beginning to use lasers to route data among its spacecraft, and Europe's Copernicus network, which uses a similar system to link the Earth-observing satellites, the LCRD will also use lasers to relay data back to the ground. Starlink and Copernicus use conventional radio signals for that.

The LCRD, which operates from geosynchronous orbit, includes two optical terminals, each capable of bidirectional optical comms links. Data can be received on one terminal, switched to the other and then relayed to its destination.

Initially, the LCRD demonstrations will relay data between two ground stations, located on Table Mountain, California, and Hawaii's Haleakala, a dormant volcano. The sites were selected because of their minimal cloud cover.

But the LCRD terminals are designed to track spacecraft in low Earth orbit (LEO), including the ISS, which this year will receive a laser comms terminal known as the Integrated LCRD LEO User Modem and Amplifier Terminal, or Illuma-T.

The primary challenges with space-to-ground optical comms are Earth's atmosphere and clouds. "At a certain point, we can't turn up the power and get past the bad weather like you can on an RF link. You have to steer your laser beam someplace else, so we need to get a lot of operational experience before we're able to use optical communications for

our missions,” says LCRD Principal Investigator Dave Israel, with NASA’s Goddard Space Flight Center.

The LCRD demonstrations, which will last at least two years, will provide operational experience under different atmospheric conditions. During the trials, the two ground stations will act as simulated users, sending data from one station to the LCRD then down to the other. The LCRD’s ability to both send and receive data from spacecraft and ground stations makes it NASA’s first two-way, end-to-end optical relay.

The experiments will measure system performance through atmosphere and cloud cover at the two locations. “We’re doing some of that during the calibration phase, but the stopping and starting currently is now based on what the checkout team has to do, not how long one of the investigators wants to keep the link up and running for a period of time,” Israel says.

Another early experiment will demonstrate bulk data transfer over the links. “That will start to show the relay in action,” Israel says. “There’s the ability to do an optical link from the user to the relay, and then the relay back down to Earth can come either [via] RF or optical. We’ll do all the various combinations—switching the space-to-ground link from optical to RF and back and forth—and see how quickly we can do it and how to minimize data loss.”

Following the experimental phase, the LCRD will support its first operational user—the ISS. Once the Illuma-T system is installed outside the Japanese Kibo laboratory module, it will receive science data from experiments and instruments onboard the station and transfer the data at rates of 1.2 Gbps to the LCRD for transmission to the ground. The data transmission rate is nearly double the 622 Mbps NASA achieved during its 2013 Lunar Laser Communications Demonstration.

NASA also plans to use the LCRD to simulate deep-space optical communications, which present unique technical challenges, such as the loss of signal power (referred to as a “photon-starved environment”) as distances between sender and receiver grow.

The LCRD will demonstrate a pulse-position type modulation, which is useful when signal power declines, as well as modulation that works with stronger links, says Miriam Wennersten, LCRD ground segment manager at Goddard.

The other major challenge for deep-space laser communications is pointing. “The beam is so narrow that you have to point to where Earth is going to be, in its relative orbit, by the time the light gets there,” Wennersten says.

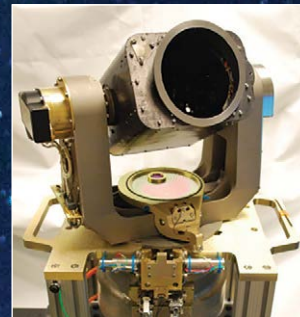
The experiments will pave the way for a deep-space laser comms flight test using a NASA spacecraft scheduled to launch this year on a mission to study the metallic asteroid 16 Psyche, which orbits between Mars and Jupiter. The spacecraft, also named Psyche, is scheduled to arrive in 2026.

NASA expects that by the 2030s, optical technology will be a major part of a reliable and robust space communications network that can operate seamlessly between government and commercial users and providers. “Everything we are doing with LCRD will be made available to the commercial sector,” Younes says. “We are hoping this will drive the cost of the payload way down.”

The LCRD program is led by NASA’s Goddard Space Flight Center, in partnership with NASA’s Jet Propulsion Laboratory and the Massachusetts Institute of Technology’s Lincoln Laboratory. 🌐

Targeted Launch 2022 | Integrated LCRD Low-Earth Orbit User Modem and Amplifier Terminal

Illuma-T will be attached to the International Space Station to provide astronauts and experiments with enhanced data capabilities. Mounted to the Kibo module’s exposed facility, Illuma-T will send data from the space station to NASA’s Laser Communications Relay Demonstration system, located on a spacecraft in geosynchronous orbit via 1.244-Gbps optical links. This data will then be beamed down to optical ground stations.



MIT/LINCOLN LABORATORY

Targeted Launch 2022 | Deep Space Optical Communications



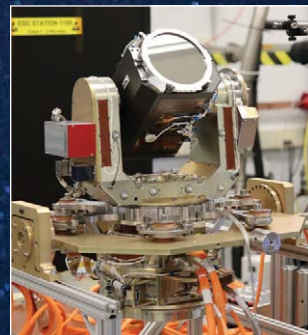
PETER RUBIN/NASA/JPL-CALTECH/ASU

DSOC will test laser communications technologies in deep space. Key technologies developed for the project, which will fly on NASA’s Psyche asteroid

probe, include a lightweight spacecraft disturbance isolation and pointing assembly, high-efficiency flight laser transmitter and a pair of high-efficiency photon-counting detector arrays for the flight optical transceiver and ground-based receiver. The experiment will begin after Psyche reaches the metal asteroid 16 Psyche, located between the orbits of Mars and Jupiter, in 2026.

Targeted Launch 2024 | Orion Artemis II Optical Communications System

The O2O will enable laser comms during the crewed Artemis II mission to the Moon. In addition to transmitting live, 4K ultra-high-definition video, the O2O will relay procedures, pictures, flight plans and voice and other communications between the Orion capsule and Earth. The system comprises a 4-in. telescope and two gimbals to point the telescope toward ground terminals, a modem to convert data to and from laser beams and controller electronics to interface with Orion’s flight avionics and the control and the pointing of the optical module telescope.



NASA

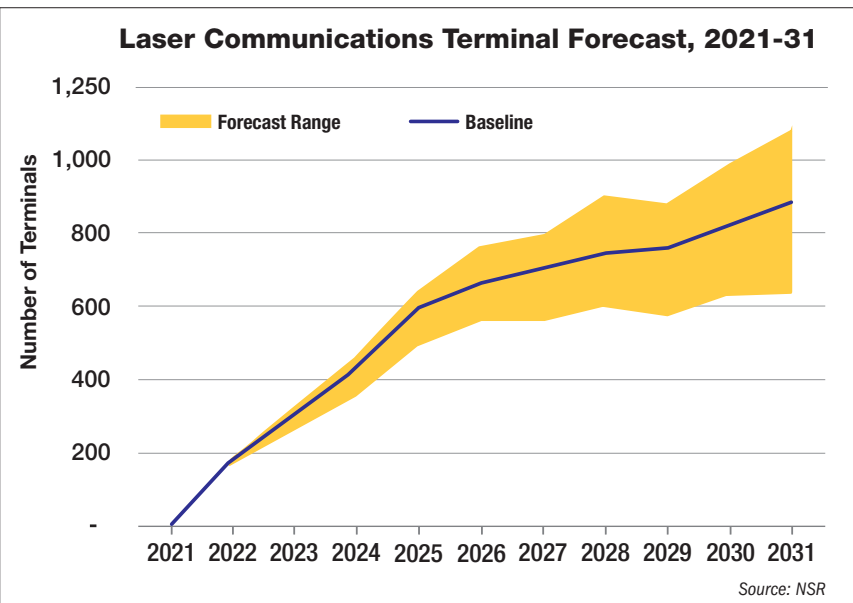
Satellite Laser Communications Business Expected To Blossom

- > ONE HIGH-PROFILE PROVIDER COULD SEE 100% CAGR BY 2025
- > RECENT ACQUISITIONS AND IPO POINT TO GROWING INVESTOR INTEREST

Michael Bruno Washington

Entrepreneurs and investors looking for the next rising star in new space are eyeing laser-based optical communications for satellites.

With tens of thousands of satellites expected to be lofted to low Earth Orbit (LEO) and beyond to serve everywhere from Africa to the Arctic—and connecting everything from smart cars to national intelligence agencies—space laser comms are seen as a critical enabling technology this decade. With customers' real-time demands, high-throughput satellite capabilities and increasingly affordable space access creating new uses, stakeholders are betting the time has come for lasers in space as a backbone service.



“Significant growth is on the horizon, with constellation launches driving demand in the near to midterm,” says analyst Shivaprakash Muruganandham of space market research company NSR.

That company's fourth *Optical Satellite Communications* report, released in February, projects a \$2 billion optical satcom market for equipment by 2031, driven primarily by upcoming nongeostationary constellations. As growth accelerates at a 47% compound annual growth rate (CAGR), demand is projected to reach more than 6,000 laser communication terminal units over the next decade.

Several companies are getting into the game. One major player is Mynaric, based outside Munich, which was spun

out of the state-backed German aerospace center DLR in 2009. Through three different subsidiaries, it offers Condor, an optical intersatellite link (OISL) flight terminal, and Hawk, an airborne flight terminal for air-to-air and air-to-ground links of airborne vehicles. The connectivity can link satellites, high-altitude aircraft, UAVs and ground systems via infrared laser. Mk. 3 Condor terminals are designed to provide data rates of up to 100 Gbps via infrared laser up to 5,000 km (3,100 mi.) in space's vacuum.

Mynaric CEO Bulent Altan told a Canaccord Genuity event in February that laser comms via satellite are analogous to the internet linking personal computing devices in the 1990s. Suddenly, with the power of the World Wide Web in the hands of everyday customers, new markets and wealth were created. “On Earth, we don't like anything disconnected. We are going toward connected everything,” he said. “Why should it be any different in space?”

Executives and analysts see a technology paradigm change coming. Radio frequency (RF) communications are easier to jam or intercept, as they are broadcast widely. RF further is subject to International Telecommunication Union (ITU) licensing. Lasers do not require ITU licenses, use less energy because wavelengths are longer and are harder for adversaries to tap into or block without a direct intercept. And lasers can provide up to 13.16 Tbps, compared with RF's maximum transmission rate of 36 Gbps, according to analysts.

With LEO satellite constellations from SpaceX, Telesat, Amazon and others set to grow the total LEO space fleet more than tenfold, providers such as Mynaric see a burgeoning marketplace. “We are targeting a really healthy sector that is willing to spend quite a bit of money on its communication infrastructure,” Altan said. The total addressable market is \$800 million across telecommunications and military markets today and could grow to more than \$10 billion by 2030 and ultimately more than \$20 billion, according to Mynaric.

Jefferies analysts say market growth is supported by several macro trends:

- U.S. space defense budgets expanding at a 22% CAGR and the military's buildout of a 1,250 small-satellite constellation.

- Pentagon recapitalization of its own fleet with command, control, comput-

ers, communications, intelligence, surveillance and reconnaissance budgets growing at 8%.

- New use cases for space driving commercial satellite expansion to more than 35,000 LEO satellites in orbit over the next 10 years from 4,800 today and more than 2,000 satellites launched per year.

Over the next four years, the analysts estimate Mynaric can grow revenue to €261 million (\$286 million), a 100% CAGR.

Mynaric customers include Northrop Grumman—with whom it is an exclusive terminal provider—as well as Telesat, SpaceLink, Cappella Space, the U.S. military and others. It employs 250 people, mostly in Germany but with about 30 in Hawthorne, California, and a small govern-

ment-relations office in Washington, and it expects to hire another 50 workers this year.

The average sale price of Mynaric's Condor terminal is \$250,000, and the company is targeting a 30-35% gross profit margin on each. Four terminals per satellite are needed to build an effective mesh network. Hawk terminals will sell for the same average sale price, and that product will also spur maintenance, repair and overhaul and spare parts work.

Mynaric customer Northrop in recent weeks won a \$700 million award from the U.S. Space Development Agency as one of three providers for the Tranche 1 Transport Layer, an OISL constellation. Mynaric worked on Tranche 0 also, but that was "just a few" Mk. 2 terminals, with maximum data rates up to 20 Gbps. In 2021, DARPA tapped Mynaric to create an architectural design for the experimental laser communication terminals called for under the Space-Based Adaptive Communications Node (Space BACN) program. Earlier, Mynaric was selected by Telesat under DARPA's Blackjack program for 20 satellites, with first launch slated for later this year.

"We have a tremendously fast-growing market that is being driven by government," Altan said. "The commercial guys are very much following what's happening on the government side to drive their technology adoption and who they buy it from—and we have a very well-developed position."

After opening a new 17,000-ft.² production facility in the third quarter of 2021, Mynaric is targeting being able to make 400-500 terminals annually starting this year, with capacity rising to more than 2,000 a year. The higher rate will be critical to serving the LEO market, where satellites could have life spans of five years or less before replacement.

"There are not too many players out there for this kind of system," NSR's Muruganandham tells Aviation Week. "It's just the expertise that's needed in these systems."

But the list is expanding. Competitors include Thales Alenia, Airbus' Tesat, CACI International's SA Photonics, Voyager Space's Space Micro and Ball Aerospace under the latter's eponymous conglomerate.

CACI's and Voyager Space's acquisitions, which helped them enter the market, occurred just recently. CACI says SA Photonics' CrossBeam technology offers low size, weight, power and cost benefits that transmit data 25 times faster than current RF systems, while using payloads that are half the size. Its high-volume LEO OISL technology complements CACI's free space optical (FSO) offering, optimized for medium Earth orbit and geosynchronous equatorial orbits. The deal was valued at \$275 million.

"With SA Photonics, our combined technology enables us to deliver immediate FSO communications across all domains," CACI CEO and President John Menguucci said in November.

That same month, Voyager Space, a private-equity-backed holding company of new-space upstarts such as Nanoracks,



Markus Knapek, a former DLR senior scientist and a Mynaric co-founder, showcased the company's laser comm terminal prototype in 2018.

announced it acquired a majority stake in Space Micro, a satellite communications specialist that does work for NASA and the U.S. military. "Expanding our already rapidly growing laser and optical communications systems is a top priority going forward," said Space Micro co-founder and CEO David Czajkowski. Financial details were not provided.

Also in November, Mynaric raised almost \$76 million through an initial public offering of shares on the Nasdaq stock exchange.

One challenge to space-based laser comms is a lack of standards. However, according to Muruganandham, the standards could come together relatively more quickly in this subsector because the hardware vendors will want it—typically, hardware-oriented standards are faster to normalize among competitors compared with those in software, over which providers want to protect their potential dominance.

Muruganandham says that while the market should remain viable this decade before product saturation and competitor sclerosis sets in, he does see the potential for some hardware providers to move into adjacent services offerings in the midterm. Part of that is because one trend in the new-space market is to become more full-service space-as-a-service providers. Indeed, the big winners could be so-called downstream service providers that offer a wider portfolio of hardware and services.

There are other challenges, including whether SpaceX, Amazon and others try to develop in-house solutions. SpaceX, the bellwether with its Starlink constellation, already has a dozen OISL-capable assets on orbit and aims to expand deployment to the whole constellation beginning this year.

"Their backing of laser technology is a positive for the future of the industry. However, in our view they are less likely to be a direct customer, particularly given they have typically run a very closed-in supply chain," Greg Konrad and Sheila Kahyaoglu write in a Jefferies report from December. "Nonetheless, given their internal supply, this would be more supportive of the technology rather than a competitive threat."

Even so, outside providers will be pressed for capacity. "While the optical satcom market sits on the cusp of growth, there is still a long road ahead," Muruganandham says. "Few vendors have production facilities with high-volume laser communications terminal manufacturing capabilities and even fewer have legacy hardware." Pricing also remains a challenge, given current low order volumes.

Mynaric's Altan, who became CEO in 2019 after 13 years at SpaceX and a few more as a space investor, is counting on high barriers to entry and scaling up quickly with major constellation players to shield his company. "It is a hard business to get into, and it takes many, many years to build a mature product," Altan says, predicting that some companies soon could drop out. 📡



Photonic Future

- > OPTICAL CROSSLINKS ARE BRINGING NEW CAPABILITIES TO CONSTELLATIONS
- > SPACE-GROUND LASER LINKS WILL UNLOCK NEW BUSINESS MODELS

ESA's HyDRON project is developing technology for a multiorbit, all-optical, high-throughput satellite communications system.

Graham Warwick Washington

Advances in optical communications are removing decades-old limitations on how satellite systems can be imaged and exploited by easing restrictions long imposed by the physics and regulations surrounding the use of radio frequency links.

One of the first markets to reach fruition is that for optical intersatellite links to enable new megaconstellations to form mesh networks in space that can route communications between spacecraft and between orbits to provide global connectivity from low Earth orbit (LEO).

Last September, SpaceX launched its first batch of Starlink satellites with fully operational laser crosslinks. The switch to optical links comes less than halfway through the company's campaign to launch an initial 4,400 LEO satellites to provide low-latency, high-speed internet and marks the arrival of potentially massive demand for space laser communications terminals.

"The communication constellations are all dealing with thousands of satellites," says Barry Matsumori, former CEO of BridgeComm, a startup developing terminals for ground-, air- and space-based optical communications. "Each satellite will have at least four terminals. In the optical world, that's huge volume."

Amazon has not revealed whether the 3,236 satellites in its planned Project Kuiper LEO internet constellation will use laser crosslinks, but Thales Alenia Space plans to use its Optel-C optical intersatellite links to connect the 298 spacecraft it is building for Telesat's Lightspeed LEO constellation.

And the military is again embracing optical communications. More than a decade after the U.S. Air Force canceled TSAT, a geostationary (GEO) satellite communications system with powerful laser links, the Space Development Agency (SDA) is buying fleets of optically interconnected

LEO satellites for its Transport Layer, to provide assured, resilient, low-latency connectivity to military platforms worldwide.

Technology is advancing. Current optical terminals can connect satellites in the same orbital plane, but crosslinking spacecraft in different planes or orbits is more challenging. "If you're cross-planing, you're now looking at satellites that are either moving at a different velocity on a different plane or going in opposite directions. It's impossible for a mechanical gimbal to keep up," Matsumori says.

As a result, most laser links are point-to-point. BridgeComm is developing managed optical communications array (MOCA) technology that enables point-to-multipoint capability, connecting one terminal to many. "The key to multipoint communications is optical beam steering. Traditionally, everyone uses a mechanical gimbal, and that can't support multiple users. It takes too long to slew and acquire. We can steer the beam in tens of microseconds," he says.

In February, the SDA awarded Space Micro a contract to develop one-to-many optical communications for LEO constellations using BridgeComm's MOCA technology. The military is also looking into laser links for air-to-space communications and, in January, Space Micro won an Air Force contract to begin development of Deformo, a pod that would provide aircraft with low-probability-of-intercept/detect high-bandwidth communications via GEO satellites.

This underlines that demand for laser communications is set to expand beyond LEO. "It is focused on LEO communications only because of the sheer volume of satellites involved," Matsumori says. "Already there is dialog about satellite links via GEO that are optical and discussions around medium Earth orbit [MEO] also, and certainly lunar or cislunar communications that are looking for very high bandwidth."



EUROPEAN SPACE AGENCY CONCEPT

Growth is being driven by both advancing optical technology and increasing bandwidth demand. “It’s a combination,” he says. “People are hitting data rates they simply cannot satisfy with [radio frequency], and the spectrum they get does not propagate well. Combine that with the advances in optical terminals, and certain customers are very much looking for the security that comes with optical.”

One emerging market is for relay satellites to provide continuous and secure connectivity from LEO to the ground, particularly for Earth-observation constellations downlinking terabytes of data per day. SpaceLink, a subsidiary of Australia’s Electro Optic Systems Holdings (EOS), plans to build a constellation of MEO satellites using radio frequency (RF) and optical links to relay data from LEO to the ground.

Fast-moving LEO satellites are connected to the ground less than

10% of the time, says SpaceLink, but will always have at least one MEO relay satellite in view. Another advantage is that LEO operators will be able to interlink their satellites via the optical relay using only a single laser terminal, the company says.

In September 2021, SpaceLink selected OHB System to build its Block-1 constellation. Then new optical link technology became available that boosted satellite capacity 50% but increased project cost to \$750 million and delayed initial operations to mid-2024.

Citing “increasingly urgent” customer demand for a secure and resilient communications service, EOS in February announced plans for a constellation of smaller, cheaper Block-0 satellites that can be in service by early 2024 at a cost of \$240 million.

One reason for the urgency is that SpaceLink’s satellites will use Q- and V-band RF downlinks to the ground, and it must initiate use of its allocated spectrum by mid-2024. But the company plans to test laser space-to-ground links and ultimately use both RF and optical to connect to its ground stations.

As optical crosslinks between satellites in orbit proliferate, the data bottleneck will become the RF link to the ground. “The first Earth-observation constellations are getting by on X-band for now. But I think they are finally realizing that X-band pipe, no matter how you optimize it, is still a narrow pipe,” Matsumori says.

Beginning in 2023, Japan’s WarpSpace also intends to provide a data relay service for LEO Earth-observation

constellations, with plans to launch three small optical satellites into MEO. In January, the startup was selected by the Japan Aerospace Exploration Agency to study development of a cislunar optical communication system to support lunar exploration in the 2030s and expand to Mars after 2035.

Another more ambitious MEO constellation is planned by Laser Light Communications, which intends to deploy an all-optical global communications network that combines ground fiber with optical satellites. Using 8-12 small satellites with optical crosslinks and space-to-ground links, this HALO network will provide both a data transport service and an on-demand network for data centers and other major users.

This could signal a shift toward future satellite communications architectures that seamlessly combine optical and RF networks. In December, the New Symphonie consortium won a European Commission (EC) contract to study a secure and resilient multiorbit satellite system. This is building on the European Space Agency’s (ESA) HyDRON project to develop a terabit-capacity, all-optical, high-throughput network in space.

Space-based optical communications are spurring some unique business ideas. LyteLoop is a U.S. startup that plans to use ultra-high-bandwidth lasers to store data in space. Data would be stored in photons that are always in transit along a continuous loop between satellites, reducing power consumption and increasing security compared with ground-based data centers. The company raised \$40 million in February 2021, with plans to launch prototype satellites within three years, but has been quiet since.

One unusual application fast becoming reality is quantum-secure communications. China in 2020 demonstrated quantum key distribution by transmitting entangled photon pairs via optical links from a LEO satellite to two ground stations 700 mi. apart. Now commercial companies are entering the arena.

UK startup Arqit in 2023 plans to launch its first optical satellite that will generate and distribute root keys to ground data centers providing its quantum encryption service. Singapore’s SpeQtral intends to

launch its first quantum key distribution satellite in 2024. And the EC and ESA in 2019 agreed to establish a pan-European quantum-communication infrastructure that includes satellites.

“There is an emerging service market, and it’s optical communications,” says Laser Light CEO Bob Brumley. “The first green shoot is the growing number of vendors entering the market. The next set of green shoots is the government trying to stimulate the market by buying uniquely architected systems.

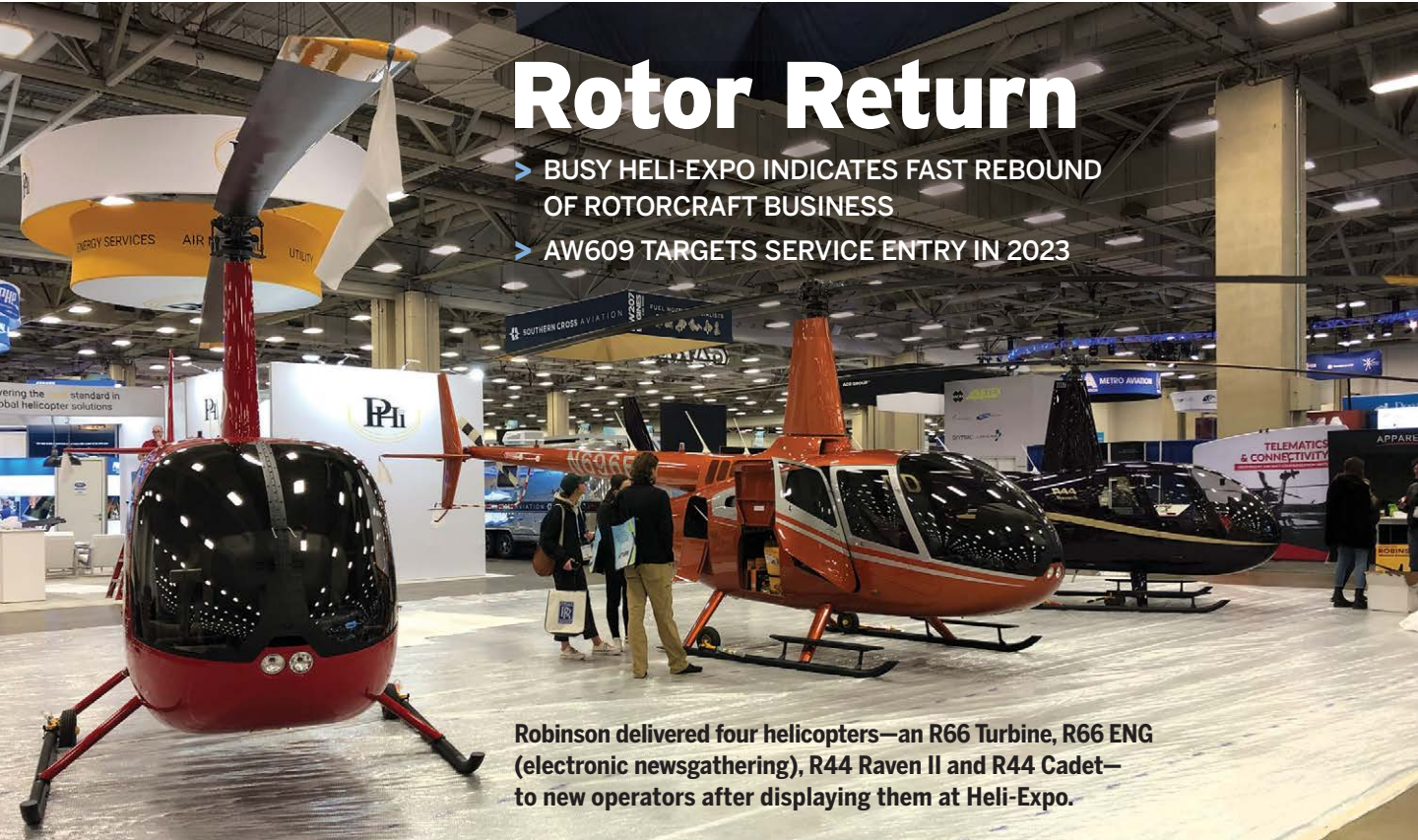
“The third is private companies investing capital themselves, without the interest of government, and driving the market. That’s when it starts to get to mainstream,” he says. “And when it gets to mainstream, the customer doesn’t even know they are on laser communications.”

Companies Supporting Laser-Based Optical Communications From Space

- Archangel Lightworks
- Arqit
- Astrogate Labs
- Axelspace
- Blue Marble Communications
- BridgeComm
- Cailabs
- General Atomics-EMS
- Laser Light
- LyteLoop
- mBryonics
- Mynaric
- NEC
- Odysseus Space
- SpaceLink
- SpeQtral
- TESAT
- WarpSpace
- Xenesis

Rotor Return

- > BUSY HELI-EXPO INDICATES FAST REBOUND OF ROTORCRAFT BUSINESS
- > AW609 TARGETS SERVICE ENTRY IN 2023



Robinson delivered four helicopters—an R66 Turbine, R66 ENG (electronic newsgathering), R44 Raven II and R44 Cadet—to new operators after displaying them at Heli-Expo.

GUY NORRIS/AW&ST

Guy Norris Dallas

With more than 13,000 attendees, a bustling show floor and a steady flow of order announcements, the 2022 Helicopter Association International's Heli-Expo gave every indication that it is back to business as usual for the civil rotorcraft industry's major annual event.

Yet despite the evident enthusiasm of convention-goers attending the first Heli-Expo in person since 2020 and the start of the COVID-19 pandemic, there were also signs that the recovery still has a ways to go. Attendee numbers were approximately 91% of those in 2020 while the 590 exhibitors represented roughly 90% of those who supported the last event two years ago in Anaheim, California, according to Helicopter Association International (HAI) data.

But there was no disguising the resurgent mood of the major helicopter-makers, most of which reported encouraging orderbook rebounds and accelerating progress on new programs. The relentless progress of the emerging generation of electric vertical-takeoff-and-landing (eVTOL) aircraft also resumed where it left off at Heli-Expo 2020, with news on training, alliances and vertiports (see page 57).

After years of delays, Leonardo Helicopters announced it is targeting

service entry of the AW609 commercial tiltrotor in 2023 and aims to clinch long-awaited FAA certification later this year or early next.

"There's light at the end of the tunnel," says Matteo Ragazzi, head of engineering for Leonardo. "We are moving toward the start of FAA [certification] flights." The company hopes to receive FAA type inspection authorization, which clears the way for flight testing to be credited toward certification, "before the summer break," he adds.

Leonardo's update on progress toward certification comes as the company begins flight tests of the first production AW609, and the fifth aircraft overall, at its newly developed final assembly facility in Philadelphia. AC6, the first customer aircraft for Bristow Group, is one of three aircraft currently on the line at the site.

Coming on the heels of what Airbus Helicopters CEO Bruno Even describes as a "strong and solid year in 2021, with 419 orders and 338 deliveries," the European manufacturer announced more orders for the H125/135 light helicopter family and H145 light twin. Airbus is also continuing to build the industrial team for the CityAirbus NextGen eVTOL aircraft, and the company announced at the show it is

partnering with Spirt AeroSystems to design and manufacture the multicop-ter's wings. First flight is targeted for 2023 with certification by 2025.

Bell marked Heli-Expo with a series of new orders for the 407 light and 412 intermediate/medium helicopters, the former model accounting for 56 of the combined 93 aircraft delivered across those families in 2021. With training and parapublic business picking up for the Bell 505, the company also announced plans to collaborate with Safran on test flights of the Arrius 2R-powered light helicopter with sustainable aviation fuel. Bell announced the imminent start of icing certification testing for another long-delayed program, the 525 super-medium helicopter, too.

Amid growing sales of the S-70 Firehawk fire-fighting variant, Sikorsky is offering new-production S-70M Black Hawks to the civil and parapublic markets following restricted category special airworthiness certification for the model from the FAA. At the same time, Sikorsky says it is no longer accepting orders for the S-76D, effectively shutting down the 45-year medium helicopter program.

The Lockheed Martin-owned company, which is evaluating potential partnerships to set up license S-76D

production overseas, is also reviewing options for setting up a new production site for the S-92 following the closure of the S-76D and S-92A final assembly facility at Coatesville, Pennsylvania, in 2021. Sikorsky, meanwhile, is vowing to continue future development of the S-92, including certification of the S-92A+ upgrade kit in 2025.

Robinson Helicopter says it will switch to electric power for its light helicopters when it “makes sense,” adding that it is closely watching progress being made by California-based Tier 1 Engineering on a battery-powered R44 conversion program. President and Chairman Kurt Robinson also still holds to the company’s long-term vision of powering the R44 variant with a diesel engine. “It’s something we’ll probably continue working on,” Robinson says.

The California-based company is once more studying production rate increases after enjoying a resurgence of its conventional piston and turbine-powered products, with deliveries of 244 helicopters in 2021 compared with 177 in 2020. Deliveries included 33 R22s, 10 R44 Cadets, 34 R44 Raven Is, 81 Raven

IIs and 86 turbine-powered R66s, representing a 37% increase over 2020.

Meanwhile, Enstrom Helicopter Corp. plans to reopen in Menominee, Michigan, in late April after being rescued from Chapter 7 bankruptcy by MidTex Aviation. The revamped company will trade as Enstrom Aerospace Industries and will resume production of the turbine 480B and the piston F-28F and 280FX.

“We will also be moving into new markets as the aircraft industry evolves,” says Michael Dixon, MidTex aviation manager. “We’re looking into eVTOLs, military programs and electrification.”

Another pioneering U.S. helicopter-maker planning for a revival is Schweizer RSG. The company aims to double and possibly triple its production output in 2023, with plans to further expand beyond that depending on market demand.

“The biggest thing is to get the production system and supply chain up and running to the point where it’s a well-oiled machine,” says Schweizer President David Horton. The Fort

Worth-based manufacturer, which resumed production only four years ago after acquiring the rights from Sikorsky in 2018, will build and deliver 12 rotorcraft in 2022, he adds.

All the while, Swiss-based engineering company Marenco, led by Martin Stucki, the creator of the former Kopter SH-09, is seeking investors for a new eight-passenger hybrid-electric concept that was unveiled at Heli-Expo. Dubbed the M12/M22, the helicopter family resembles a larger version of the SH-09—now rebranded the AW09 following its acquisition by Leonardo Helicopters—and incorporates a large, multirole cabin capable of air taxi, firefighting, air medical and cargo missions. Designed to carry an external payload of up to 4,400 lb. at sea level and 3,300 lb. at 10,000 ft., the initial single-engine M12 version would be powered by a 1,100-shp turbine/turbogenerator and electrically driven main and tail rotors. ✎

Gallery See more images from the bustling Heli-Expo show: [AviationWeek.com/Heli-Expo-2022](https://www.aviationweek.com/Heli-Expo-2022)



Lack of Data Creates Hazy Regulatory Environment for Vertiports

> FAA OFFERS CONSERVATIVE VERTIPOINT DESIGN GUIDANCE

> SMALL AIRPORTS MAY OFFER EARLY TEST CASE FOR eVTOLS

Garrett Reim Los Angeles

Vertipoint designers and developers of electric vertical-take-off-and-landing aircraft are puzzling over federal and local regulations in the U.S. that remain undefined and, in some cases, are not even being considered.

The formation of local vertipoint regulations will have a major impact on electric vertical-takeoff-and-landing (eVTOL) operators’ future revenue and operating costs. For example, if noise ordinances force vertipoints to be placed in faraway locations, eVTOL operators will struggle with time savings as a selling point to potential customers. As eVTOL technology rapidly advances, however, many cities have not yet considered laws for the nascent urban air mobility industry.

For its part, the FAA is limited in its ability to provide guidance as to how vertipoints should be safely built, because eVTOL flight performance data is lacking. That lack forced the FAA to provide conservative regulatory guidance to potential vertipoint developers in its “Engineering Brief No. 105, Vertipoint Design,” said Rex Alexander, president of helicopter infrastructure consultancy Five-Alpha, at the Helicopter Association International’s Heli-Expo 2022 in Dallas on March 7. The engineering brief was released in late February.

“It’s something that they want to put in place as a good foundational document to build from,” he said.

The engineering brief focuses on items such as vertipoint touchdown

and liftoff, final approach and takeoff and safety areas, as well as visual flight rules approach and departure guidance. It also touches on marking, lighting and visual aids, considerations for charging and electrical infrastructure, on-airport vertipoints and safety concerns such as downwash and turbulence.

The brief outlines design guidance that is not as tight as some might like but which reflects the state of the nascent eVTOL industry and its lack of flight-test data, Alexander said. More than 30 full-scale eVTOL prototypes are in flight testing, according to the Vertical Flight Society. Nevertheless, total flight-test hours remain limited, and developers are reluctant to share data.

“When we look at the infrastructure, we have to look at what the capability of an aircraft is. We also have to look at what the aerodynamic deficiencies may be,” Alexander said. He gave the example of a heliport design, which would be made with consideration for the angle and speed that a helicopter would take on approach.

“We’re still trying to identify what a stabilized approach is for an eVTOL.

So the engineering brief came out probably more prescriptive than a lot of people would like,” he said. “We did surveys, asking for performance numbers, and most surveys came back with ‘to be determined.’ And TBD doesn’t plug into a formula very well.”

SOUND AND PUBLIC FURY?

Noise ordinances and closely related zoning regulations also suffer from a lack of data.

“It’s still kind of the Wild West in terms of metrics,” says Juliet Page, principal engineer at Blue Ridge Research and Consulting, an acoustical engineering company.

an airport. This isn’t going to be anything like that.”

Instead, more variables will have to be considered, including the time of day, surrounding cityscape and overall ambient noise. “We need to consider sound in three dimensions,” Page says. “You get into the field of psychoacoustics.” Psychoacoustics is the study of a human’s perception of sound. It may be necessary for drafting new noise ordinances and deciding where vertiports should or should not be placed, she says.

That might be a tall order for some local jurisdictions that already struggle to regulate heliport operations.

tion to it—will be key to the urban air mobility industry’s growth.

“We’re slowly learning how to quantify public acceptance and annoyance,” says Ben Goldman, acoustics manager with eVTOL developer Archer Aviation.

However, reducing noise requires engineering tradeoffs. “The question becomes, how much is a decibel worth to the design of the vehicle?” Goldman says. “That’s been a challenge in driving the noise down as low as it can go, while still being able to close the business case.”

Given all the regulatory unknowns, early vertiports may not be purpose-built, Alexander said. Though it might seem that heliports could be adapted into vertiports, eVTOLs need more space to support a high passenger throughput, he said. The aircraft need room to park, charge, offload and reload passengers—all while not blocking a landing and takeoff spot. “The acreage is much greater than the average heliport is capable of today,” he said.

Instead of investing in vertiports, which could be sidelined by evolving regulations, developers may turn to local airports, Alexander said.

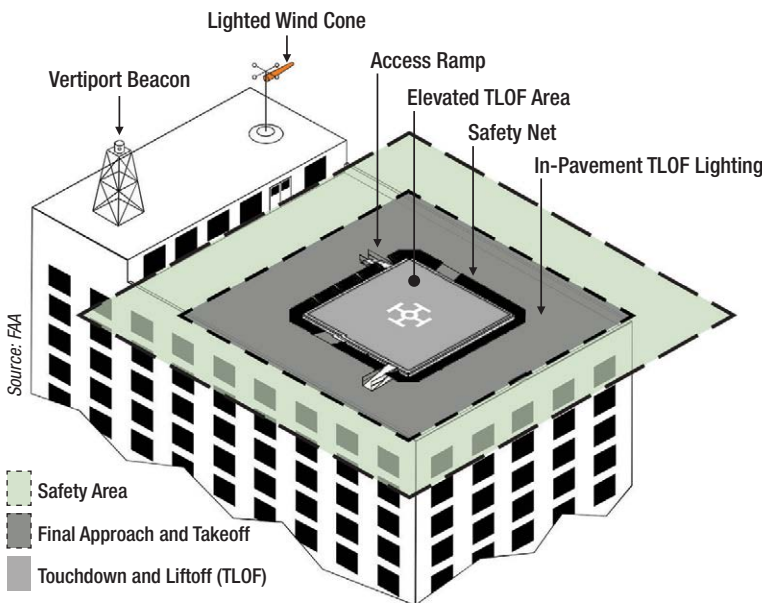
“If we can reduce that [eVTOL] noise footprint, all of a sudden they become very viable as vertiports,” he said, noting that airports usually have access to sufficient electricity for recharging eVTOLs.

Indeed, as part of one advanced air mobility study published last year, NASA noted that the U.S. has thousands of small airports, typically municipal or county airports, that are underused and could host regional fixed-wing electric, hybrid and hydrogen commuter aircraft flights.

About 90% of Americans live within a 30-min. drive of a regional airport, according to a McKinsey & Co. study. Most in the U.S. live within a 16-min. drive of any airport, including larger commercial airports, according to the consultancy. Those airfields may offer an early and cheap test case for urban air mobility.

“It’s really not a lot of infrastructure that needs to be put on the ground other than repainting and resurfacing,” Alexander said. “You already have a runway that can be five or six [touchdown and liftoff] landing areas and [final approach and takeoff areas]. You already have a ramp. Well, that could be all your parking. All you need is a terminal.”

Elevated Vertiport Configuration



The FAA’s initial vertiport regulatory guidance is conservative due to lack of eVTOL flight performance data.

Measuring eVTOL noise in an urban environment is far more complex than gauging the noise of an airliner landing at an airport. For starters, eVTOLs have multiple open rotors, which interact in complex ways, Page says. Operating eVTOLs in the heart of a city will also create noise that will bounce off surrounding buildings. All of this will happen closer to people, and more routinely, than any other type of aircraft operation in history. How the public will react to this novel set of sounds is anyone’s guess.

“It’s not going to be a standard fix,” says Page. “Think about a [day-night average sound level] contour around

“Some local [noise] ordinances, they really make no technical sense,” Page says. “Often the folks that are putting these jurisdictions in place, don’t understand decibels and logarithms. They just may grab something out of the ether that really is not applicable to what they’re trying to do.”

Each city could approach regulation differently. “There could be a whole patchwork of regulations you need to worry about,” she says.

The stringency of local noise ordinances matters not just to the future of vertiports but also to eVTOL developers. They recognize that minimizing noise—and the public’s reac-

Universal Appeal

- > STARTUPS ARE ATTRACTING BOTH SEASONED EXECUTIVES AND NEW GRADUATES
- > ADVANCED AIR MOBILITY COMPANY FOUNDERS BRING DIVERSE BACKGROUNDS



UNIVERSAL HYDROGEN

Carole Rickard Hedden

Watch out, legacy aerospace: Advanced air mobility's new, aggressive companies are targeting talent in various industries—including aerospace—with the aim of helping to decarbonize aviation through startup-style innovation; some even offer company equity as a benefit.

The skills these companies are seeking extend beyond traditional aerospace for a simple reason. The new air vehicles and infrastructure that will be needed are complex and very different from products traditional aerospace has created. In large part this is because the backgrounds of the startup companies' founders contrast sharply with those of most leaders in the legacy aerospace industry.

For instance, Kyle Clark, founder of Beta Technologies, came to advanced air mobility (AAM) with deep experience in electric and high-frequency power and capital investments, not aerospace. A Harvard University graduate, he played hockey in the minor leagues for two years, worked for

Universal Hydrogen's Loris Gliner (left), head of powertrain engineering; Anna Goranson, vice president of people; and Mark Cousin, chief technology officer at the company's Los Angeles headquarters in front of its 1-megawatt iron bird and gaseous hydrogen capsule.

others and finally was able to find a believer in his novel aircraft idea in Martine Rothblatt, founder and CEO of United Therapeutics.

And JoeBen Bivert, founder of Joby and before it Velocity11, is known for automation expertise in the life sciences industry, having worked at Incyte, a biopharmaceutical company. With Joby he has found a way to combine his analytics and automation background with aerospace, creating one of the strongest companies in this new industry segment.

The emerging industry is populated by people from varied backgrounds—a former *New York Times* editor, energy company engineers and executives and consumer products leaders. It includes a fair number of legacy aerospace risk-takers, too. AAM companies are studded with people who have played key roles in the growth of the

aerospace industry—such as former Airbus CEO Tom Enders, Aurora Flight Sciences founder John Langford and former assistant secretary of the U.S. Air Force Will Roper.

For Paul Eremenko, co-founder and CEO of Universal Hydrogen, contributing to solving the climate crisis while preserving the potential of the aviation industry began with buying a house in California. He is known as a serial risk-taker and innovator: first as deputy director and acting director of the Tactical Technology Office at DARPA, as CEO of Airbus Silicon Valley outpost Acubed and Airbus chief technology officer and then as chief technology officer and senior vice president at United Technologies Corp.

In the last few years, living in isolation in a house in Venice, California, with a team of five “new-hires” during

the pandemic, he has created what has become Universal Hydrogen (UH2). The team went back to the roots of advanced technology and aviation, using a garage as the laboratory for UH2's gaseous hydrogen capsule. They used the Venice location partly because UH2 did not have any "real money" at the time. Eremenko housed the employees he brought to UH2, including the company's second employee, 24-year-old Loris Gliner, whom Eremenko first met when Gliner was interning at Airbus, researching autonomous taxiing and landing.

When the concept for UH2 began to take shape, Eremenko knew Gliner was among the top minds he needed. "We had no money, and we basically said to him: 'If this works out, we'll give you equity at some point.' We were able to bring Loris to the U.S. on a genius visa [the O-1 nonimmigrant visa for an individual with extraordinary abilities in the sciences, arts, education, business and several other categories]. [We] bought him a plane ticket and had this house where he

could live until we had some money."

Eremenko also hired Anna Goranson as vice president of people to bring her data analytics and human resources expertise to UH2. Although Eremenko remains the chief salesman of the mission, he says: "I am not a hydrogen evangelist; no background there." Jors Rosenlund, who had been head of strategy for Nel Hydrogen, based in Norway, recently joined UH2 to help with that.


"I am an aviation guy, trained as a private pilot before I could drive," Eremenko says. "My career was about building cool stuff that goes higher, faster, further. But coinciding with the Paris Agreement [the foundation of zero-emission efforts articulated in 2015], I found that the existential problem we face is about decarbonizing the aerospace sector.

"If we don't do that, aviation will become nothing more than a niche in terms of its utility," he continues. "I don't want that. I think aviation is cool, it is a force for good—globalization, international exchange, multina-

tional trade and companies, interconnection as a society and ultimately a peaceful society."

Eremenko takes seriously what it takes to attract individuals. "We survey the heck out of everything and recalibrate quickly what is not working," he says.

UH2 also focuses on onboarding. "Onboarding is always terrible and has a disproportionate impact on how people perceive their company," Eremenko says. "The first three days of a new job are hard—the computer's not there, the phone isn't working, and there are all these forms that need to be filled out. We wanted to change that. So we've paid attention to that process and make onboarding and orientation a half-day thing. The focus of the first day is about meeting your teammates and defining objectives."

As of March 1, UH2 had 65 employees whose average age is 36, two decades younger than the average legacy aerospace company. As for Gliner, the 24-year-old—he is head of powertrain engineering. 

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Supernal 'Mines' To Hire New Employees

- > AAM COMPANIES USE NEW TACTICS TO DRAW SPECIFIC PEOPLE WITH SPECIFIC TALENTS
- > HYUNDAI DIVISION SEEKS CANDIDATES WHERE THEY ARE DOING WHAT THEY LOVE

Carole Rickard Hedden

Not too long after former FAA Deputy Administrator Michael Whitaker reconnected with Jaiwon Shin, former associate director of NASA's Aeronautics Research division, during the final Uber Elevate summit in Washington in 2019, Whitaker joined Shin at Hyundai, where Shin is now CEO of Supernal, the automaker's advanced air mobility business.

"What could be cooler than a flying car?" Whitaker says of moving from the FAA to a startup.

"I'd been advising some of the nontraditional companies, and I'd found that some of them really stumble by not realizing that they are aviation companies," he tells Aviation Week. "If you don't understand the regulatory environment, it makes for a rough road. You see it in the unrealistic expectations regarding safety or that they don't fully get the safety DNA of this industry.

"If we can make airplanes as fast as cars are made, it could change the world," he adds. "So there is a lot of opportunity, particularly when bringing together a car company and an aviation company."

Supernal and Universal Hydrogen are just two of the advanced air mobility (AAM) companies employing hiring strategies they refer to as "mining" for people. The process is a blend of identifying specific skills and the people who have them and reaching out to them via the things they read and do.

Lisa Eisenstat, head of talent acquisition at Supernal, spends a limited portion of her marketing budget—she refers to marketing and brand more than she does recruitment—on traditional university visits and career fairs. "We are focused on going where the people we want are, rather than asking them to come to us," she says.

Supernal's S-A1 electric vertical-takeoff-and-landing vehicle is in development, with full-scale prototype test flights slated to begin in 2023.

"Our metric is not 'days to hire,' it's 'quality of hire.'"

This involves a heavy dose of data analytics obtained from various marketing databases. According to Eisenstat, it is a matter of cross-referencing skills with interests, such as finding people with a particular type of engineering skill who also tend to be outdoor enthusiasts. This led Supernal to advertise with Nike. Reddit, which is used by many of Supernal's current employees, is also a source.

"We are an emerging industry," Eisenstat explains. "We need to use that to our advantage. We can't go to the same universities and the same events that aerospace has relied on for years and think we are going to find these very different skills."

Hiring for AAM is also a learning process. For example, Eisenstat says an engineering hiring manager with a long record with legacy aerospace came to her with a list of job requirements. After interviewing a number of candidates, he returned with a completely new set of requirements. What he thought he had wanted was not what he really needed—which was someone with specific skills more than a pedigree in aerospace.

Supernal is also looking for candidates beyond the usual locations—for example "where kids are still tinkering with their dad's John Deere," Eisenstat says. "We can bring that kid, with mechanical know-how, to Supernal and provide the processes and education that she or he wants to pursue."

The work is paying off, for Supernal at least. Two-thirds of its employees are under the age of 45, and more than half have advanced degrees in fields from engineering to the arts to jurisprudence. 📍

TECH TAKE

By **Graham Warwick**

For the latest, go to AVIATIONWEEK.COM

Swiss To Use Sunlight-to-Liquid Sustainable Fuel

Swiss International Air Lines expects to take delivery of carbon-neutral aviation fuel produced using concentrated sunlight in 2023 under a strategic collaboration with Swiss startup Synhelion.

A spinoff from Swiss research university ETH Zurich, Synhelion plans to build its first industrial-scale solar kerosene plant this year in Julich, Germany, and start production in 2023 with Swiss as the first customer.

SYNHELION



Synhelion plans to build solar concentrators to produce sustainable aviation fuel from water and CO₂.

Swiss and its parent, Lufthansa Group, will also support development of Synhelion's planned commercial-scale plant in Spain. Synhelion expects to scale up production to 875 million liters (230 million gal.) a year by 2030.

In Synhelion's process, solar radiation is reflected by a mirror field and concentrated onto a receiver on a tower, where it is converted to process heat at temperatures above 1,500C (2,730F). The solar heat is fed into a thermochemical reactor that converts water and CO₂ into syngas.

The syngas is then converted to liquid fuels using the established Fischer-Tropsch process. The amount of CO₂ released during combustion of the solar kerosene is equivalent to the amount used during production of the fuel, making it a carbon-neutral sustainable aviation fuel (SAF).

ETH Zurich first demonstrated syngas production in a solar reactor in 2010 and produced its first laboratory quanti-

ties of solar kerosene in 2014. Synhelion, founded in 2016, signed an agreement in 2017 with Italian energy company ENI to industrialize the technology.

A solar minirefinery began producing fuel at ETH Zurich in 2019, and the following year, Synhelion began collaborating with Lufthansa Group and its subsidiaries Swiss and Edelweiss Air as well as Zurich Airport. The startup closed a 16 million Swiss franc (\$17.4 million) Series B funding round in November 2021.

Key to Synhelion's technology is the ability to produce solar process heat exceeding 1,500C, enabling the production of syngas. The milestone was first demonstrated in 2020 using artificial sunlight generated by German aerospace center DLR's Synlight solar simulator in Julich.

Synhelion's plant in Julich will implement the entire process on an industrial scale, from concentrating sunlight to producing synthetic liquid fuel.

Three key innovations that make Synhelion's process viable start with the solar receiver mounted at the top of the tower. The receiver consists of a cavity in which the concentrated solar radiation is absorbed then reradiated to heat a mixture of water vapor and CO₂ to above 1,500C.

This heat transfer fluid then flows through the reactor—bundles of tubes filled with a reactive material—and provides the thermal energy for the chemical reactions that convert the water and CO₂ into syngas.

Excess heat collected by the receiver during sunny hours is stored by flowing the hot heat-transfer fluid through a solid storage material. At night or during cloudy periods, the fluid flows through the thermal energy storage in the other direction, recovering the energy and heating up to power the reactor.

Solar fuels will be more expensive than conventional fossil fuels. A November 2021 analysis by ETH Zurich concluded that solar kerosene could be produced at \$1.40-2.30/liter (\$5.30-8.70/gal.) on a commercial scale. This compares with \$2.65/gal. for conventional jet fuel at the end of February 2022.

Lufthansa is supporting other efforts to develop low-carbon fuels. It signed an offtake agreement for e-kerosene delivered by the world's first production plant for power-to-liquid aviation fuel in Emsland, Germany. The plant was commissioned in October 2021. A second plant is planned for Hamburg.

Pratt To Demo Rotating Detonation Engine

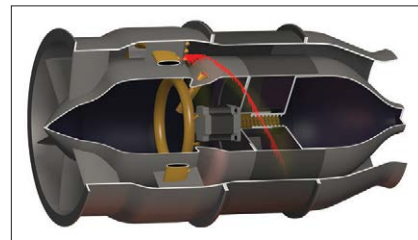
Long-running U.S. interest in applying pressure-gain combustion to high-speed propulsion is stepping up with the award of a U.S. Air Force Research Laboratory (AFRL) contract to Pratt & Whitney for a rotating detonation engine (RDE) demonstrator.

The ground-test demonstration program will be jointly developed by Pratt & Whitney, Raytheon Missiles & Defense and Raytheon Technologies Research Center and follows initial concept development work by Pratt's GatorWorks rapid prototyping unit.

Although no details of the RDE, the engine's potential size or application have been revealed, the novel powerplant "is being designed to fly at higher Mach speeds that will enable and broaden future vehicle designs and applications and will be a key element of Pratt & Whitney's high-speed engine portfolio to meet future customer requirements," the company says.

The award builds on extensive pressure-gain propulsion research by Pratt and Raytheon before their merger in 2020. The award includes an RDE technology development contract awarded to Pratt in 2018 under the first phase of the AFRL-led Advanced Turbine Technologies for Affordable Mission Capability (ATTAM) initiative. In early 2020, Raytheon began studies of an RDE-powered long-range strike missile concept under a DARPA contract.

Research has shown pressure-gain combustion can be beneficial to ramjet efficiency up to Mach 3, although the concept is also applicable to turbojets and rocket engines. RDEs offer a potential step change in thermodynamic efficiency because combustion takes place at constant volume rather than constant pressure. Combustion of the



Pratt & Whitney and Raytheon will ground-test a rotating detonating engine demonstrator.

fuel-air mixture occurs at supersonic speed as a detonation rather than the subsonic deflagration seen in conventional combustors. The process results in a pressure gain—rather than loss—during combustion.

In an RDE, also known as a continuous detonation wave engine, the detonation wave travels around an annulus. As the fuel-air mixture is injected into the annulus, it is ignited by the detonation of the previous wave and the process becomes self-sustaining. The concept is also mechanically simple, with few moving parts, and more efficient than pulse detonation engines, which require the detonation chambers to be purged after each pulse.

—Guy Norris, Colorado Springs

Composite Cryogenic Tank Passes Tests

Boeing has confirmed that tests of an all-composite cryogenic fuel tank at NASA Marshall Space Flight Center used a reusable tank shell originally built as flight hardware for DARPA's Experimental Spaceplane (XSP) program.



The all-composite cryogenic fuel tank at NASA Marshall Space Flight Center.

Completed toward the end of 2021, the tests pave the way for application of the lightweight technology in future spacecraft. Boeing says the cryogenic tanks would also be suitable for use in future liquid-hydrogen-fueled aircraft.

The tests evaluated the 14-ft.-dia. tank over multiple cycles, including a final structural test that it survived despite pressures 3.75 times the design requirement. The work, funded by DARPA and Boeing, included oversight from NASA Armstrong Flight Research Center personnel.

Originally known as the XS-1, the XSP was aimed at demonstrating technology for a reusable, responsive space launcher capable of lofting 3,000-lb. satellites into low Earth orbit 10 times in 10 days.

However, the vertical-launch/horizontal-landing XSP effort effectively ended when prime contractor Boeing withdrew from the program in January 2020.

Boeing says payload mass could be increased by up to 30% if the composite propellant tank is used in place of conventional aluminum-lithium tanks for future versions of the Exploration Upper Stage on NASA's Space Launch System. Construction methods for the cryogenic tank are based on advanced robotic fiber-placement techniques developed for the Boeing 787 airliner program as well as the Composite Cryotank Technologies and Demonstration (CCTD) project with NASA.

The CCTD program focused on proof-of-concept tanks 7.9 ft. and 18 ft. in diameter, while the XSP pressure vessels were about 13 ft. in diameter and longer than either of the NASA sample structures.

—Guy Norris, Colorado Springs

CoFlow Jet Moves To Develop Deflected-Slipstream eV/STOL

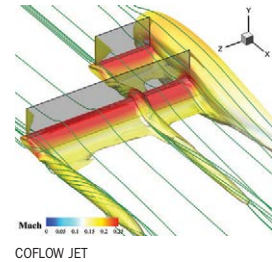
U.S. startup CoFlow Jet has struck an agreement with NASA to commercialize deflected-slipstream technology that would enable an electric vertical/short takeoff and landing (eV/STOL) aircraft to transition to efficient cruise without requiring tilting mechanisms or separate lift rotors.

Founder Gecheng Zha has been developing the CoFlow Jet (CFJ) active flow-control technology at the University of Miami, where he is a professor. A wing that generates both high lift and thrust using CFJ flow control has been demonstrated with funding from DARPA.

In the CFJ concept, a small amount of air is sucked into the airfoil at the trailing edge, pressurized by a micro-compressor inside the airfoil and injected tangentially into the flow over the airfoil near the leading edge.

In CoFlow Jet's eV/STOL concept, the slipstream from multiple propellers on the leading edges of the tandem wings is turned vertically downward to convert all of the thrust into vertical lift—the 90-deg. turn in the airflow enabled by CFJ flow control over the flaps.

CoFlow Jet has completed a preliminary design and is seeking investors. "We plan to have a scaled 400-lb. Phase 1 prototype built and flight-tested in two



CoFlow Jet flow control enables propeller thrust to be deflected downward by flaps for vertical flight.

years. In Phase 2, we will have a full-size, 3,500-lb. urban eV/STOL vehicle built, flight tested and certification started," Zha told Aviation Week. The company's Owl-1 is an all-electric four-seater with a design range of 220 mi. at 180 mph.

"We have demonstrated the CFJ wing system with embedded micro-compressors. It performs very well, with the CL_{max} [maximum lift coefficient] exceeding the theoretical limit," he said. In addition to increasing lift, the system is designed to reduce drag while also producing thrust.

"The uniqueness of CFJ is that the micro-compressor is a part of the integrated propulsion system while increasing the lift at the same time. It always increases the lift and reduces pressure drag at the same time. One cannot separate them," Zha said.

"As a part of the propulsion system, its power density in terms of kW/kg is much higher than a conventional propeller system, by up to an order of magnitude," he continued. "This is because the small compressor radius can allow very high speed, up to 140,000 rpm.

"The microcompressor can be designed to have very high efficiency, greater than 80%," Zha noted. "Typically, at cruise, 20% of the thrust will be generated by the microcompressors with the benefit of high cruise-lift coefficient." This allows a smaller, more highly loaded wing to improve ride comfort.

The embedded microcompressors are electrically powered. "CFJ is able to achieve high lift coefficient at takeoff/landing and high cruise efficiency. Because of all these advantages, the total power consumption is significantly reduced compared with conventional technology," Zha explained. "The power required by CFJ itself is also small.

"All the CFJ microcompressors and distributed propellers are powered independently for redundancy. The likelihood that they all fail at the same time is low," Zha emphasized. Each unit is designed to have extra reserve power, and power-supply redundancy is designed in. 🚀

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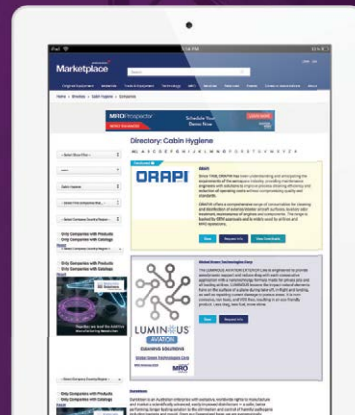


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Aerospace Calendar

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March 21-April 19—RTCA Plenary Sessions/Committee Meetings. Virtual or various locations. See rtca.org/content/upcoming-committee-meetings

March 28-31—Defence Services Asia/Natsec Asia 2022. Malaysia International Trade and Exhibition Center. Kuala Lumpur. See dsaexhibition.com

March 28-31—AEA (Aircraft Electronics Association) International Convention & Trade Show. Ernest N. Morial Convention Center. New Orleans. See aea.net/convention/2022

March 29-31—Amsterdam Drone Week. Hybrid event: Online + RAI Amsterdam. Amsterdam. See amsterdamdroneweek.com

March 29-31—Commercial UAV Expo Europe. Hybrid event: Online + RAI Amsterdam. Amsterdam. See expouav.com/europe

March 29-31—Vertical Flight Society 1st Hydrogen Aero Workshop. Hilton Long Beach. Long Beach, California. See vtol.org/events/2022-hydrogen-aviation-workshop

April 4-6—Sea-Air-Space Exposition. Gaylord National Resort & Convention Center. National Harbor, Maryland. See seairspace.org

April 4-7—37th Space Symposium. The Broadmoor. Colorado Springs. See spacesymposium.org

April 5-7—NBAA Schedulers & Dispatchers Conference. San Diego Convention Center. San Diego. See naaa.org/events/2022-schedulers-dispatchers-conference

April 5-10—FIDAE 2022 International Air & Space Fair. Santiago International Airport. Santiago, Chile. See fidae.cl

April 5-10—Sun-n-Fun Aerospace Expo. Lakeland Linder International Airport. Lakeland, Florida. See flsynf.org

April 6-7—Air Mission Planning and Support. St. James' Court/Buckingham Gate London. See smi-online.co.uk/defence/uk/air-mission-planning

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April 7-8—CAPA Airline Leader Summit: Airlines in Transition. Manchester, England.

April 26-28—MRO Americas. Dallas.

April 27-28—Military Aviation Logistics & Maintenance Symposium. Dallas.

May 17-18—Aerospace Manufacturing Conference. Greenboro, North Carolina.

May 18-20—Routes Europe 2022. Bergen, Norway.

May 25-26—CAPA Americas Aviation & LCCs Summit. San Juan, Puerto Rico.

June 6-8—Routes Asia 2022. Da Nang, Vietnam.

June 7-8—Engine Leasing, Trading and Finance. London.

June 15-16—MRO BEER (Baltics, Eastern Europe & Russia). Istanbul.

June 21—ATW's Airline Industry Achievement Awards. Shanghai.

Aug. 25-26—CAPA Latin America Aviation & LCCs Summit. Salvador, Brazil.

Sept. 7-8—Aero-Engines Europe. Dublin.

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Rethinking Cybersecurity

By **Jono Anderson, Jim Adams, Michael Gomez and Rik Parker**

Cybersecurity matters more than ever, and the cyberthreats faced by companies and critical infrastructure are increasing exponentially. The frequency of cyberattacks has increased significantly in the past five years, and the events in Ukraine have exacerbated anxieties for our national defense assets and companies. KPMG's Global CEO Surveys continue to indicate that cybersecurity risk is a top concern. Cybercrime, supply chain security, critical infrastructure integrity and cyberresiliency impact a company's bottom line and have long-term effects on operations and reputations.

The aerospace and defense industry faces among the highest levels of targeted activity from a wide range of national intelligence agencies, organized crime and bad actors, along with daily attacks from clandestine state actors conducting active cyberespionage. But the ecosystem that must be protected has never been more complex. It includes complex heterogeneous fleets of aircraft, vehicles, ships and spacecraft—along with their electronics and onboard systems—as well as communications networks and critical information to ensure that the craft remain intact. The ecosystem extends deep into the supply chain, upward to customers and out to the individual operators using the equipment, systems and solutions that security experts design, develop and manufacture.

Whether the strategy is to preempt, defeat or deter malicious cyberactivity, the use of artificial intelligence (AI) algorithms in support of “zero-trust models” will be necessary to future integrated security environments. Gone are the days of closed, trusted networks. Future solutions will require significant investment to harden edge devices, increased AI capabilities and preemptive tactics based on a “zero-trust” model where all devices and users continuously authenticate themselves using digital cryptography. This provides a consistent way to access data, validate information, transmit it to a platform, process and collect it and retransmit information back to the cloud for storage. If the network is compromised, it will route around the compromised nodes. If the platform becomes compromised, it will remove itself from the network to minimize impact and reconstruct the network. In this way, future systems will always assume a hostile environment. Every communication, device and flow will be authenticated and authorized as dynamically and as close to real time as possible.

But the true costs of cyberresiliency are vastly underestimated in most forecasts. In a December 2020 report

on U.S. Defense Department software development and cybersecurity practices, the Government Accountability Office found that 47% programs that had failed to conduct vulnerability assessments experienced more schedule slippages and cost increases. The need for resiliency will create demand for solutions to meet the complex requirements of cyberresilient enterprises, supply chains and fleets, as well as their underlying systems, networks, infrastructure and information.



BARANODENIR/GETTY IMAGES

“FUTURE CYBERTEAMS SHOULD ASSEMBLE CYBERAWARE COMMUNITIES TO CROSS-COMMUNICATE AND WORK TOGETHER.”

Another huge challenge: The industry faces a global shortage of nearly three million cybersecurity professionals. Despite demand for talents such as data security, risk identification and management, threat detection, cybercompliance and network security architecture, few schools embed cyberskills into their electrical and computer engineering programs. The public and private sectors need to incentivize academia to incorporate cyberskills training in science, technology, engineering and math related programs.

Organizations and professionals need to ensure that cyberteams have a seat at the table at all stages of conceptualization, design, development, manufacturing and operations. Those teams must be

the immune system protecting the health of the future business supply chain and end-customer environment, with an agility of thought and action that recognizes the speed at which cybercriminals operate.

Future cyberteams should assemble cyberaware communities that can cross-communicate and work together quickly to meet issues head on. The chief information security officer cannot do it all and often does not have the authority to respond quickly enough. New partnerships are necessary. Organizations will need to address the security deficit, align their objectives, evolve the security team, enhance engineering skills and improve their supply chain and procurement capabilities. Above all, past assumptions about resilience need to be challenged. ☞

Jono Anderson is a KPMG deal advisory and strategy partner who leads growth and innovation strategy. Jim Adams is a KPMG deal advisory and strategy partner and is the U.S. aviation, aerospace and defense industry leader. Michael Gomez is a KPMG partner advisory principal who leads the cybersecurity strategy and governance practice. Rik Parker is a KPMG leading advisor in enterprise information, risk management and cyber-program strategy. The views expressed are those of the authors alone and do not represent those of KPMG.

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