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Sustainable Recovery?

RICH MEDIA EXCLUSIVE War in Ukraine

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The Freighter Frenzy

Earth-Observation Satellite Startups

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ARIS MESSINIS/AFP/GETTY IMAGES

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ON THE COVER

The helicopter industry is eyeing the road to recovery, buoyed by increased orders for rotorcraft such as Leonardo's AW169 and looking into sustainable aviation fuel to achieve decarbonization goals. Our analysis of the commercial market begins on page 46.

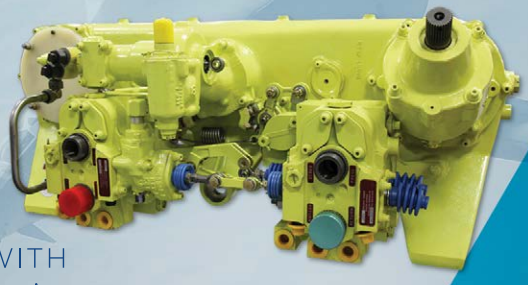
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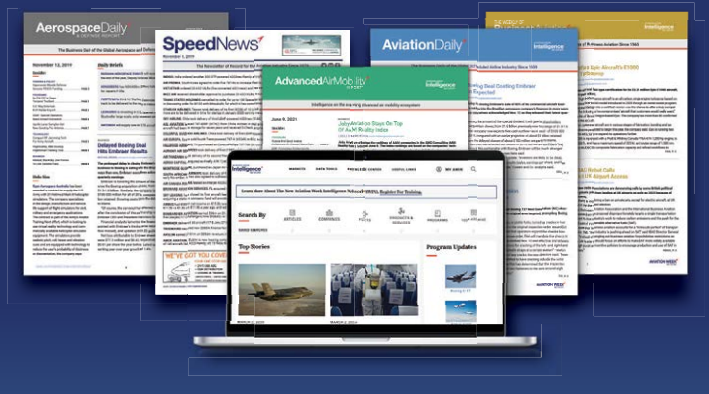
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FEEDBACK

WATER MANAGEMENT

Your article "Methods of Curbing Contrails Are Taking Shape" *(Jan. 10-23, p. 32)* makes a point that caused me to question some current aviation technology trends. The article notes that contrails are responsible for over half of the net atmospheric warming effects of aviation, specifically, surpassing the effects of CO_2. Given this surprising fact, does it make sense for technologists to be pursuing hydrogen fuel cells to power electric engines in aircraft? Will the water produced by the fuel cells be stored onboard, used for onboard water needs, or will some or all of it be dumped overboard to reduce weight? If the latter, does that not reduce the advantages of moving from fossil fuels?

Craig Price, Carmel, Indiana

Editor's note: Water management is a key aspect of hydrogen fuel-cell system design for aircraft. Initially, fuel-cell-powered aircraft are expected to fly at lower altitudes where contrails are not an issue, but for higher altitudes, techniques such as storing the water produced in wing tanks for later dumping are being considered. However, research suggests any contrails formed by water vapor emitted by fuel cells will be short-lived because they will form larger ice crystals that fall faster.

DATA TO JUSTIFY CO-PILOTING?

As a retired captain from a major American airline, I read "Flying Solo" *(Jan. 24-Feb. 6, p. 50)* with interest. Can a single-piloted commercial transport be operated with an equivalent or greater level of safety? If the answer is "yes," then there is no reason not to have a single pilot.

Given the advances in computers, avionics and aircraft design, it is difficult to argue against this proposition. Examples, which would have been difficult to imagine a decade ago, include the Garmin Autoland, available on select G3000s, that will automatically divert and land an aircraft with the push of a single button and DARPA's AlphaDogfight Trials, in which a computer won every engagement against an experienced F-16 pilot.

It is easy to imagine flying with the perfect nonhuman co-pilot—one that would recognize problems instantly, respond faster than any human, be totally knowledgeable in every aircraft system and never have a "bad day" because of sleep or personal problems.

The question isn't whether automatic systems should be on the flight deck but whether there is actually sufficient data that would justify keeping a second human there.

Guy Wroble, Denver, Colorado

TECH SUPPORT

As a former cockpit equipment engineer and aviation psychologist, I found "Flying Solo?" *(Jan. 24-Feb. 6, p. 50)* interesting. I helped design the Cessna Citation flight deck, which was always intended to be flown single-pilot. And as the senior FAA human performance scientist in 1981, I warned the FAA administrator of potential hazards with proposed two-pilot, automated jetliners.

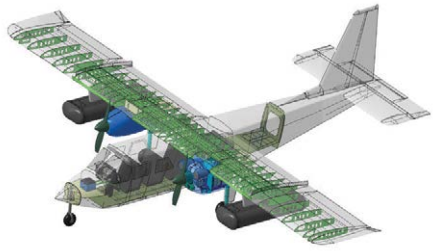
Single-pilot airliners should require even greater caution as well as the development of several innovative technologies and procedures, including:

- Artifical-intelligence-based synthetic co-pilots tested in realistic airline environments with actual line pilots.
- Pilot incapacitation recovery equipment that has demonstrated its capabilities in all expected environmental and weather conditions.
- Ground-based control of aircraft refined to allow a "mission control" operator to rapidly assume control when necessary.
- Installation of multiple video cameras to enhance mission control situational awareness of onboard and external events in real time.
- Equipment allowing cabin crew to quickly contact mission control.
- Systems to monitor pilot health and fatigue as well as better medical and cognitive testing of airmen.
- Crew resource management training refined to include flight deck, cabin and mission control personnel.

Alan E. Diehl, Albuquerque, New Mexico

REFUELING REQUIREMENTS

CAeS CEO Paul Hutton, commenting on the development of the hydrogen-electric-propulsion Britten-Norman



CRANFIELD AEROSPACE SOLUTIONS

Islander *("Big Interest but Small Start for Hydrogen Propulsion Project," Jan. 24-Feb. 6, p. 42)* states: "The Islander is a fixed-wing bus that is used in difficult geographies, but its Achilles' Heel is the cost and availability of avgas."

The aircraft is being designed for 60-min. endurance plus 45 min. reserve, which would indicate it will need to refuel at most if not all of its destinations.

Which begs the question: How costly and available will hydrogen be in those same geographical locations?

Roger Curtiss, Deer Harbor, Washington

KOOL-AID

Your magazine has elected to talk about a relatively immediate cessation of hydrocarbon fuels, replacement of petroleum with "no carbon" fuels, support of hydrogen propulsion and the naive belief in climate change.

Wait until you fully realize how nearly impossible hydrogen fuel is to produce and transport. How would you build a hydrogen tanker truck?

Earth doesn't have nearly the mass to hold hydrogen down, and it's the tiniest element, which will escape the hardiest seal. Transportation is a nightmare, and how are you going to make it—in situ? And battery-powered airplanes? You've drunk the Kool-Aid.

William Wooley, Beaumont, Texas

CORRECTION

"Broken Links" *(Feb. 7-20, p. 16)* should not have stated that Steve Horsburgh, director of product development at Curtiss-Wright, had managed the Pentagon's Link 16 deconfliction server for the Joint Staff.

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



Robert D. Braun has been named the head of space exploration at the *Johns Hopkins Applied Physics Laboratory*, effective March 28. He was director for planetary science at NASA's Jet Propulsion Lab.

Brian Chafe has been hired as CEO of *De Havilland Canada*, which is being consolidated with Viking Air and Pacific Sky Training under the name De Havilland Aircraft of Canada Ltd. Chafe was CEO of the diversified global aerospace PAL Group.

Universal Hydrogen has hired **Jorn Rosenlund** as chief operating officer and **Anna Goranson** as vice president of people. Rosenlund was chief strategy officer at Nel Hydrogen. Goranson led the people function at Airspace. **Adam Metzger** has been named interim chief financial officer; he was vice president at BNP Paribas.



Iridium Communications has promoted **Kathy Morgan** to chief legal officer, succeeding Tom Hickey. As vice president of corporate law, Morgan helped Iridium go public.

MissionGO has appointed **Chris Corgnati** president. Corgnati, a U.S. Navy veteran, has worked with government, consulting and unmanned aircraft system startups of various sizes. He will oversee the unmanned aircraft system's FAA type certification process.



Richard Marston has been promoted to chief commercial officer from director of customer service, sales and marketing for Europe, the Middle East and Africa at *MAAS Aviation*, an exterior coatings specialist. He succeeds Fran Carew, who has retired.

BridgeComm, an optical wireless communications services provider, has hired **Rich Tortorelli** as a chief systems engineer. He was chief systems engineer at General Atomics.

Air transport communications and technology company *SITA* has named **David Lavorel** CEO. He was CEO of SITA at Airports and Borders as well as CEO of SITA for Aircraft.

Dronamics has hired **Andy Cox** as director of systems and avionics, **Atanas Gagov** as director of engineering and project management and **Luis Enrique de la Iglesia y Gotarredona** as director of manufacturing. Cox helped develop the Aquila UAV, Gagov was with Waymo automotive technologies, and Gotarredona has led production teams across seven countries on three continents.

Woolpert has hired U.S. Air Force Lt. Col. (ret.) **Wayne Kinsel** as aviation-design team leader. Kinsel is highly experienced in resource and facilities management, strategic planning and logistics.



Christine Powell has been promoted to lead NASA's Rocket Propulsion Test Program office at *Stennis Space Center*, Mississippi, after achieving federal Senior Executive Service status. She has been with NASA 31 years.

Defense technology provider *Parry Labs* has named **Mark Shepardson** chief technology officer. He was director of capture strategy for Palantir, focusing on federal business.

Tulsa, Oklahoma-based *Werco Manufacturing* has hired **Andy Bartovick** as chief operating officer, **Charlie Douglas** as vice president of programs and **Hisashi Nakamura** as director of engineering. Bartovick, Douglas and Nakamura bring significant experience working with both military contractors and commercial airlines in their areas.



Stanley K. Ng has been appointed interim president and chief operating officer at *Philippine Airlines* following the resignation of Gilbert Gabriel F. Santa Maria. Ng was senior vice president for airline operations and is the first pilot to lead the airline in over 60 years.

Columbia Manufacturing, a supplier of precision metal components for turbine engines, has hired as engineering manager **Dan Lam**, whose background includes 14 years at Pratt & Whitney, and as senior manufacturing engineer **Leo Ostrawski**, whose more than 15 years in aerospace engineering has encompassed production, overhaul and repair.

The *Air Charter Association* has named **Alina Minaeva** as deputy chair of its NextGen group. She is director of Volanteus.



Amanda Gower has been appointed chief commercial officer at *CTS Engines*. Prior to joining CTS, Gower was head of powerplant maintenance services for Amazon Air technical operations.

Orion Engineered Carbons has promoted **Jennifer S. Stroh** to director of sales and marketing for Specialties Americas from strategic marketing manager. Stroh formerly held leadership positions at TPC Group and Sekisui Specialty Chemicals.

Spire Global has hired **Chuck Cash** as vice president of federal sales. Cash was chief revenue officer at Govini and has worked on many U.S. government technical platforms.



James R. Ray, Jr., has been appointed to the board of *Spirit AeroSystems Holdings*. Ray was president of the Stanley Black & Decker fasteners unit and held additional senior leadership roles at TE Connectivity, Delphi Corp. and GM.

Satellogic has named U.S. Marine Corps Gen. (ret.) **Joseph F. Dunford,** Jr., to its board of directors. The former 19th chairman of the Joint Chiefs of Staff also serves on the board of Lockheed Martin.

HONORS AND ELECTIONS

Wally Funk has been selected to receive the National Aeronautic Association's *2021 Katherine and Marjorie Stinson Trophy* for "blazing trails for women in aviation and spaceflight."

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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AIRBUS DEFENSE AND SPACE

DEFENSE

Airbus has demonstrated the launch of an unmanned aircraft system (UAS) from an A400M airlifter, a potential critical component of the European Future Combat Air System.

A development contract for the four-nation Eurodrone medium-altitude, long-endurance UAS was signed by Airbus and European defense materiel agency OCCAR on Feb. 24.

The U.S. Space Development Agency has awarded contracts totaling $1.8 billion to Lockheed Martin, Northrop Grumman and York Space Systems for 126 Tranche 1 Transport Layer satellites.

The United Arab Emirates is to purchase China's Hongdu L-15 advanced jet trainer, with plans to order 12 aircraft with options for another 36.

BAE Systems has received a $1 billion contract to upgrade and extend the service life of Royal Australian Air Force Hawk 127 trainers through 2031.

Northrop Grumman has won a $341 million U.S. Space Force contract to develop a Deep-Space Advanced Radar Capability for enhanced space situational awareness.

India is deploying its HAL Tejas fighters to Europe for the first time, to participate in the multinational Exercise Cobra Warrior in the UK in March.

The UK and France on Feb. 17 signed contracts with MBDA to move the Future Cruise/Anti-Ship Weapon program into an assessment phase.

Turkish Aerospace has certificated a version of its Hurkus turboprop trainer dedicated to training forward air controllers.

SPACE

The Missile Defense Agency has awarded Rocket Lab a $143 million contract to provide 17 spacecraft buses for a new low-Earth-orbit satellite constellation to be owned and operated by Globalstar.


STRATOLAUNCH

Stratolaunch's Roc cycled all its landing gear for the first time on the 385-ft.-wingspan carrier aircraft's fourth test flight on Feb. 24.

Rocket Lab is to locate manufacturing and launch operations for its Neutron medium-lift reusable rocket on Wallops Island, Virginia. Operations from a second pad in New Zealand began on Feb. 28 with an Electron launch.

Northrop Grumman SpaceLogistics' first Mission Robotic Vehicle will be launched in 2024 by SpaceX to attach its first Mission Extension Pod to a communications satellite operated by Australia's Optus (page 40).

The Australian government is putting aside around $47 million to develop three spaceports and to buy slots on space missions for the country's space sector.

China orbited 22 satellites from Wenchang Space Launch Center on Feb. 27 on the first flight of the modified Long March CZ-8Y2 rocket.

COMMERCIAL AVIATION

Embraer has paused flight testing and certification of the E175-E2 for three years, raising doubts about the viability of its smallest E-Jet E2 regional jet (page 30).

An A380 will flight-test a hydrogen-burning turbine engine by the end of 2026 under a collaboration between Airbus and CFM International partners GE Aviation and Safran (page 16).

VIEW FROM MOSCOW

OneWeb Responds to Russian Threat

OneWeb's board voted on March 3 to suspend launches of its broadband satellites from the Russian-leased Baikonur Cosmodrome in Kazakhstan. The vote followed demands by Russian state space company Roscosmos that the UK government sell its stake in OneWeb and that OneWeb provide a legally binding guarantee its satellites will not be used for military purposes.

The decision effectively grounds further deployment of the OneWeb constellation, with 428 of the planned 648 satellites launched, as the remaining six missions were all to fly from Baikonur.

OneWeb has been launching on Russian rockets since 2019, from French Guiana as well as Baikonur and Vostochny in Russia, under a contract with Arianespace and its Starsem affiliate.

OneWeb's 14th launch, carrying 36 satellites, was scheduled to lift off from Baikonur on March 4. Instead, OneWeb and Arianespace personnel departed the launch site late on March 2, leaving behind the export-protected satellites, which were manufactured in Florida.

"Obviously we'd like more satellites," OneWeb says, noting that it could begin commercial service with its current configuration. "We'll be exploring with Arianespace and others what we can do to get more satellites up."

Pratt & Whitney is to design a high-efficiency, hydrogen-fueled turbofan with funding support from the U.S. Advanced Research Projects Agency–Energy.

Air Lease Corp., building on its November order for 111 Airbus narrowbodies, has ordered 50 Boeing 737 MAX aircraft.

ST Engineering is to modify Boeing 757s into aerial water bombers for U.S.-based firefighting service provider Galactic Holdings.

Airbus, Safran and Tikehau Ace Capital have agreed to buy aerospace materials supplier Aubert & Duval from French mining firm Eramet.

TECHNOLOGY

Airworthiness regulations for type certification of EHang's EH216 autonomous air taxi have been published by the Civil Aviation Administration of China.

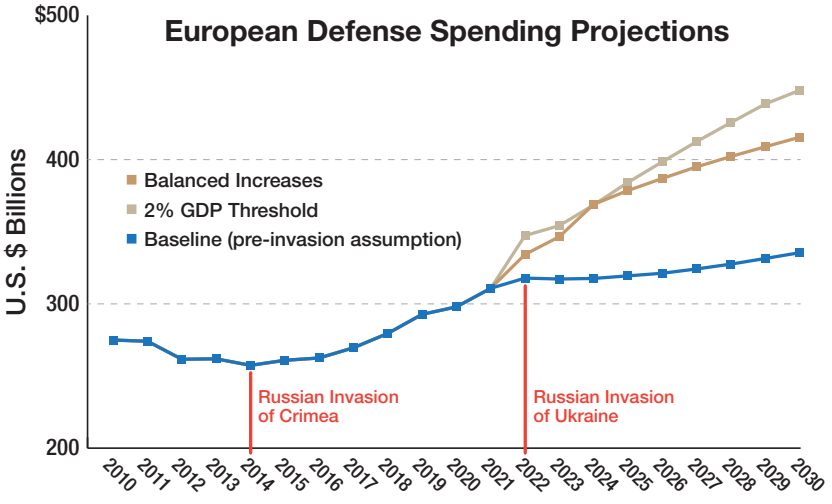
Low-cost carrier AirAsia plans to lease Vertical Aerospace VX4 electric air taxis from Avolon to develop an urban air mobility (UAM) service in Southeast Asia.

South Korea has launched its K-UAM Grand Challenge, a large-scale demonstration project intended to enable the commercialization of UAM from 2025.

Engineering services provider Tech Mahindra is collaborating with Aska on design of the U.S. startup's drive/fly electric vertical-takeoff-and-landing vehicle.

Garrett Reim has joined Aviation Week's editorial team, filling the newly created position of Space and Emerging Technologies Editor. Based in Los Angeles, he bolsters Aviation Week's coverage of the space sector and advanced technologies that are shaping the future of aerospace and defense, including space startups, advanced air mobility and artificial intelligence. Reim comes to Aviation Week from FlightGlobal, where he wrote about military aircraft manufacturers and operators in the Americas. Before that, he covered technology for the *Los Angeles Business Journal*. In 2021, he won a Defense Media Award for his coverage of unmanned systems, and in 2020 he was named Best Young Journalist at the Aerospace Media Awards.

Will War in Ukraine Boost Europe's Defense Spending?

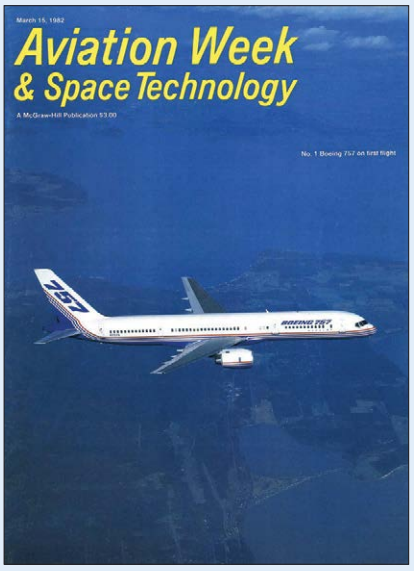


Source: Craig Caffrey/Aviation Week Intelligence Network

With Germany planning an unprecedented boost in military spending following Russia's invasion of Ukraine, the sustained growth in European defense budgets that followed the 2014 annexation of Crimea could continue and potentially accelerate. If all European NATO members increase expenditure to at least 2% of GDP, this would lead to a 45% real increase in spending across Europe's 16 largest defense budgets by 2030. Another more feasible scenario would see spending increase by around 34%.

Coverage of the war in Ukraine begins on page 18.

40 YEARS AGO IN AVIATION WEEK



Designed to be up to 80% more fuel efficient than the Boeing 727, the medium-range Boeing 757—developed concurrently with the larger 767—first took to the skies on Feb. 19, 1982. But the new airliner experienced a technical hiccup during the inaugural test flight from Renton, Washington. Its No. 2 Rolls-Royce R.B. 211-535C engine, which had been purposefully idled, stalled after being hit with a blast of high-pressure air when a valve was left open in the interconnect system between the two powerplants. The engine was restarted, and the 757 landed normally after a 2 hr. 31 min. flight. Test pilot John H. Armstrong reported that all of the objectives of the flight test had been achieved, but Boeing changed out the engine as a precautionary measure. It took nearly a month, but an image from the flight was featured on our cover of March 15. The 757 would go on to robust commercial success, with 1,050 being built before production ended in 2005. There are still more than 600 757s in fleets today, according to the Aviation Week Network Fleet Discovery database.

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UP FRONT

RICHARD ABOULAFIA



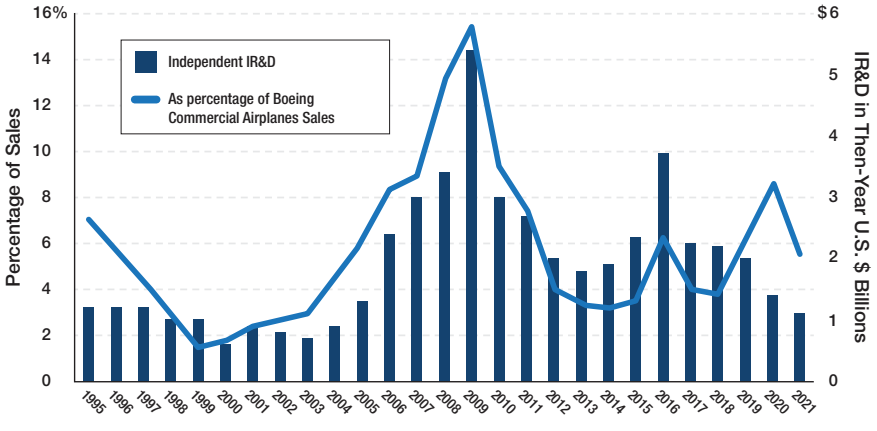
If Not Now, When?

Boeing Commercial Airplanes' **crucial year**

PERHAPS THE BIGGEST QUESTION in the aviation industry today is whether Boeing will create a new jet, specifically a midmarket one. The market clearly wants a new product in this class, and the company clearly needs one to compete against Airbus. But an examination of both the company and the market indicates that time is of the essence.

First, the market. The middle of the market—200-250-seat jets with 4,000-5,000-nm range—is easily the healthiest part of the industry in terms of orders. The orderbook for the Airbus A321neo—4,079 jets—is now the same size as Boeing's entire MAX orderbook (686 delivered plus 3,405 on backlog, after ASC606 accounting adjustments). Notably, Airbus received 667 A321neo orders in 2020-21, when orders otherwise collapsed, and more than 1,000 in the last three years.

Boeing Commercial Airplanes' Independent R&D



Source: AeroDynamic Advisory

While Boeing's MAX 10 had a few good orders in 2021, the A321neo appears to be ahead of Boeing's largest single-aisle jet by at least seven to one.

The A321neo is far from perfect for the middle of the market, but many airlines seem to have concluded that this segment is the future and the Airbus jet is the best option available. Boeing needs a more robust response before the A321neo tips what was a duopoly into a 60-40 Airbus victory or even a 65-35 outcome. Given current trends, the A321neo orderbook is likely to top 5,000 by mid-2023.

Second, there is Boeing's ability to create a new jet and the broader context of workforce trends. Boeing last launched an all-new jet, the 787, in 2004. This 18-year gap is a record in Boeing's history. Boeing Commercial Airplanes' (BCA) independent R&D funding fell 30% in 2020 from 2019, and it fell 21% in 2021 from 2020 (see chart). Boeing says this key metric will start to grow again this year.

While engineering headcount did not fall precisely in line with these cuts, it has fallen markedly. Between early 2020 and mid-2021, BCA lost roughly 18% of its engineering and technical workforce, according to Bloomberg, following serious cuts in the previous decade. Here again, Boeing says it is starting to hire engineers; this is another measure to watch in 2022.

When, or if, Boeing does launch a new jet, it will be difficult to restore its engineering staff, thanks to inflationary salary trends. A very strong tech sector is paying very high salaries. SpaceX and other new space ventures are hiring aggressively, as are many well-funded advanced air mobility startups.

The good news for Boeing is that the very same airlines and lessors that are eagerly ordering A321neos—and other financiers—would cheer a new Boeing midmarket jet and provide hundreds of up-front orders. Boeing also has a history of arriving late to a segment with a winning jet, as with the 777 (after the MD-11 and A330/340) and 787 (after the A330-200). With the right jet, Boeing could even recover its lost position as the world's biggest jetliner company.

Mitigating against a new Boeing airliner is the company's difficult financial state: It has $16.2 billion in cash but $58.1 billion in debt. There are few doubts about Boeing's ability to access additional cash through debt or equity, though. And in the broader context, starting a new program with $500 million per year, say, in incremental spending would not make a serious difference to the company's financial position.

Boeing cites the wasted time and money associated with the new midmarket airplane (NMA), which it pursued before recognizing that a twin-aisle jet would have a hard time competing with a single-aisle. Boeing now regards the NMA experience as a reason to proceed cautiously with new products.

But caution can be a rationalization for inaction. Considering market trends, and the company itself, if Boeing does not begin a new program this year, its ability to launch one will be increasingly constrained. Customers will simply get in line for more A321neos. And Boeing will have a harder time reconstituting the design team needed to create something new.

Contributing columnist Richard Aboulafia is managing director at AeroDynamic Advisory.

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GOING CONCERNS
MICHAEL BRUNO

THERE IS A HUMBLING FACT OF life facing every Aviation Week writer: No matter what is published in any given edition of the magazine, one of the most widely read features is the "Who's Where" column. If recent activity is any indication, that column might soon need more than one page—and the implications may signal a paradigm shift for the aerospace and defense sector.

Revolving Doors

Leadership churn could become a **bigger issue**

In the first two months of 2022, aerospace and defense news outlets have resounded with announcements or revelations of sudden departures or surprising leadership changes. To be sure, most of them revolve around new-space or advanced air mobility startups.

Space-tourism company Virgin Galactic, whose stock price has been on a proverbial roller coaster since last summer, said Feb. 18 that **Chamath Palihapitiya** immediately was no longer board chairman or even a board member. Palihapitiya, the Facebook veteran and founder of investment group Social Capital Hedosophia, became chairman after Social Capital led Virgin Galactic's public stock trading debut via a special-purpose acquisition company in October 2019.



ILYA S. SAVENOK/GETTY IMAGES

The suborbital company, first associated with aviation entrepreneur and billionaire Richard Branson, said Palihapitiya departed to "focus on other public company board commitments." Yet Palihapitiya's departure also marks the end of hands-on involvement by the celebrities who drove Virgin Galactic to current fame. Both Branson and Palihapitiya have sold off shares over time. Virgin Galactic further revealed a new brand that distanced itself from Branson.

The past decade has seen a surge in new aerospace and defense companies, especially entrepreneurial ventures. But startups can depend on their leaders' personalities as much as their business models. Egos clash, differences emerge, or people just move on, especially those used to starting something new.



REVOLUTION.AERO



AEROMONTREAL

Take electric aviation startup Eviation and its electric-engine cousin, MagniX, for example. **Roei Ganzarski** stepped down from helming both companies in January, sending a shockwave through the young advanced air mobility industry (*AW&ST* Feb. 21-March 7, p. 58). Just when things seemed to have calmed down, Eviation cofounder **Omer Bar-Yohay** suddenly left as CEO in February.

Sometimes external factors seem to swing the revolving doors. After 15 months, **Fred Kennedy** resigned in January as president of Momentus, the space-tug startup that suffered a rocky go-public debut. The company last year also was caught up in growing, bipartisan foreign-investor investigations in Washington under the Committee on Foreign Investment in the United States, which recently forced out Max Polyakov, a Ukrainian co-founder of launch company Firefly Aerospace.



ROCKETREACH



CIRCOR

Several well-known publicly traded companies have seen executive churn, too. Circor President and CEO **Scott Buckhout** left the embattled flow-control products and services provider in January. Chairman Helmuth Ludwig said the change was related to the board's desire "to unlock the potential of Circor and accelerate progress on our strategic priorities."



NDIA

Also in January, **Bradley Feldmann** left Cubic's corner office as the new private owners of the storied 70-year-old defense contractor appoint new leadership. A longtime Cubic employee who rose to chairman, CEO and president, Feldmann had led the defense specialist's growth and reorganization since 2014. Indeed, his ascent had capped the first change in leadership after Walter Zable, Cubic founder and CEO, died in 2012.



ROLLS-ROYCE

Another surprise change at the top is happening at Rolls-Royce. CEO **Warren East** announced on Feb. 24 that he plans to depart by year-end. In what could foreshadow the course for Boeing CEO Dave Calhoun, East eagerly took over the aerospace engine giant after it hit hard times but then found turning it around was harder than expected.

And a public tug-of-war is raging in the boardroom of aerospace propulsion provider Aerojet Rocketdyne. Executive Chairman and investor Warren Lichtenstein and CEO Eileen Drake reportedly are leading opposing factions in the wake of the company's failed $4.4 billion sale to Lockheed Martin. The spat—which may not end until a shareholder meeting, traditionally around May of each year—includes an internal investigation and counterlawsuits. It is hard to see both leaders remaining.

One thing all of these companies have in common is the collapse of once-expected financial glory. Whether at a startup or a storied public business responding to post-pandemic market conditions, aerospace and defense looks primed to experience more dashed expectations. This may be a shock in a sector used to founder-engineers who reigned for decades and whose names became staple icons of industry. But the churn is a necessary—albeit at times ugly—side of business.

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INSIDE BUSINESS AVIATION
WILLIAM GARVEY

Happy Birthday, Bonanza!

A post-war bet that is still **paying off**

LET'S HEAR A CHEER FOR A GEEZER year. While 1947 never came close to resonating like the one that 24 months earlier marked the end of humanity's most horrible conflict, the 20th century's two score and seven annum had its share of noteworthy events.

After all, it was the year in which the Marshall Plan was launched, helping lift Europe from economic ruin. That spring Jackie Robinson donned a Brooklyn Dodgers uniform, becoming Major League Baseball's first Black player. Bell Labs unveiled a tiny electrical device that would change, well, everything: the transistor. An unfamiliar double "Wham!" sounded as Chuck Yeager piloted the X-1 rocket plane faster than sound itself. At the other end of the auditory and aeronautical spectrum, a plastic disc for tossing was perfected, and the "Frisbee" was born.

Aiming for performance between those two airspeed extremes, in March 1947 Beech Aircraft introduced an airplane without precedent: an all-metal, low-wing, retractable gear, single-engine model with a signature V-tail, able to transport four people safely, reliably and in high comfort anywhere, cruising at 175 mph.

Forgoing the low-cost trainer market altogether, the Wichita aircraft-maker was betting its radical, pricey, executive air transport would help it transition from wartime production to successful and sustainable civil aircraft output. It called its all-new venture the "Bonanza," and never did a name prove more propitious.

The response was immediate and surely heartening to Walter Beech. According to the American Bonanza Society, which formed 20 years later, orders for the stylish aircraft were so numerous that Beech Aircraft delivered 1,500 in the Bonanza's first two years of production. The predictions of a post-war boom in general aviation seemed validated.

However, the stampede of war vets wanting private wings never really materialized. Turns out most were more inclined to spend $7,000-8,000 for a house in the new "suburbs" than $9,000 on Beech's "flying Cadillac." Still, among four-place singles, the Bonanza shone brightest. For many today, it has not lost a single lumen.

One of those many is Pat Epps, the founder of Epps Aviation, a major fixed-base operator, aircraft charter, maintenance and sales outfit based at Atlanta's DeKalb-Peachtree Airport. A veteran pilot, in 1975 Epps bought a Bonanza, one certified for aerobatics, for personal travel.

In August 1980, he set the Bonanza's mag compass to "0" and kept it there. Days later, upon reaching the magnetic source—the "chicken pole," he called it—he put the aircraft at the right speed and attitude and then "rolled the pole," creating an aerobatic footnote prompted by wanting "just something to do." Epps owns and flies that same airplane still and has nothing but bouquets for the Bonanza. Says he, Beech "did it right."



TEXTRON AVIATION

Dave Hurley is all about aviation. A former top sales executive for Cessna and Canadair, he ran his own jet charter/management company, holds an Air Transport Pilot certificate and 10 type ratings, is a member of the Society of Experimental Test Pilots, chaired the Smithsonian's National Air and Space Museum board and through the years, among other things, has owned, leased or operated 14 Bonanzas, logging over 3,000 hr. in them.

His assessment: "I can only praise the design's safety, efficiency and reliability. Handling fidelity is directly connected to your brain and control inputs." In summation, "I love it." So Walter got it right? "Oh boy, did he ever."

Those kinds of endorsements have kept Bonanzas in steady production, with more than 18,000 delivered so far. And save for a "brief pause" last year, production has held steady for three-quarters of a century, the longest of any aircraft ever.

During that span, the design evolved, most notably with engine and avionics upgrades. For several years Beech produced both the V-tail and a standard-tail version; production of the former ended in 1982 and the latter, originally called "Debonair," in 1994. The airframe was stretched to accommodate six in 1968, and so continues. A specially outfitted limited edition version (see photo) will be delivered this year, sporting a vintage "Bubble B" on the fin and commemorating Olive Ann Beech, Walter's widow, who ran the company for more than three decades after his death in 1950.

Now with a base price of $1 million per aircraft, Bonanza production averaged just one a month over the last six years. But while it contributes modestly to owner Textron Aviation's bottom line, a spokesman says its continued production is "a matter of pride for many."

And well-earned by Beech's baby boomer.

William Garvey was editor-in-chief of Business & Commercial Aviation *from 2000 to 2020.*

AIRLINE INTEL

JENS FLOTTAU



Into the Next Crisis

Aviation is just beginning to feel **the impact of the invasion of Ukraine**

THE AIR TRANSPORT INDUSTRY and its suppliers have been hoping for a much better year in 2022. Needless to say, 2020 was the sector's worst in history, and 2021 turned out to be better but not as good as hoped, since the recovery took longer and suffered many setbacks. Severely bruised and highly indebted, airlines in many parts of the world have been betting on the upcoming summer season for good cash flow and the beginning of balance-sheet repair.

The coronavirus pandemic is not over yet, rebuilding capacity is expensive, and now the industry is facing its next major crisis: Russia's invasion of Ukraine. For now, it is not nearly as severe as the global health crisis, and its effects vary greatly by subsector and geography. The depth of the effect on commercial aviation will depend on how long the invasion continues and how much aggression escalates. Although nothing can be said with any certainty at this stage, some consequences are discernible already.



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Russian airlines have been hit hardest. They are banned from many international markets, and lessors might repossess large parts of their fleets, a measure announced as a consequence of Western sanctions against Russia. About half of the commercial aircraft fleet in Russia is leased; according to the Aviation Week Fleet Discovery database, Aeroflot Russian Airlines leases essentially its entire fleet. Some aircraft are owned and financed by Russian lessors, but the list of international lessors that have placed aircraft with Aeroflot and its low-cost affiliate, Pobeda, reads like the who's who of the sector: AerCap, Avolon, BOC Aviation, Dubai Aerospace, Goshawk, SMBC Aviation Capital and many others. Of course, sanctions on the export to Russia of aviation products like spare parts will soon make operating even the owned fleet challenging, if not impossible.

Lessors are taking a hit, but the exposure to the Russian airline market is generally not that high. AerCap, which leases some 100 aircraft to Aeroflot and Pobeda, says Russia comprises about 5% of its portfolio. Nonetheless, the whole process will surely be painful for everyone involved unless there is a quick resolution.

Similarly, Russia is not a major market for Western European airlines even in normal times. The coronavirus pandemic has further reduced traffic, in part because the EU has not certified Russia's Sputnik vaccine and so severe travel restrictions remain in place for Russians.

Building up long-haul capacity to Asia will become more problematic and expensive for European, Asian and North American airlines with the closure of Siberian airspace that is routinely used for flights from North America to Southeast Asia and China or from Japan to Europe. Some connections may become unviable—Finnair has canceled services to some destinations as a consequence (see page 26). Some will involve significantly longer flight times to avoid Russian airspace and thus incur higher costs. On the other hand, airlines will no longer have to pay the expensive overflight fees.

Much like for traffic to Russia, the effect on U.S. and European long-haul operators is lighter than it would have been in pre-pandemic times, as their Asia operations are still much smaller in proportion to their remaining networks.

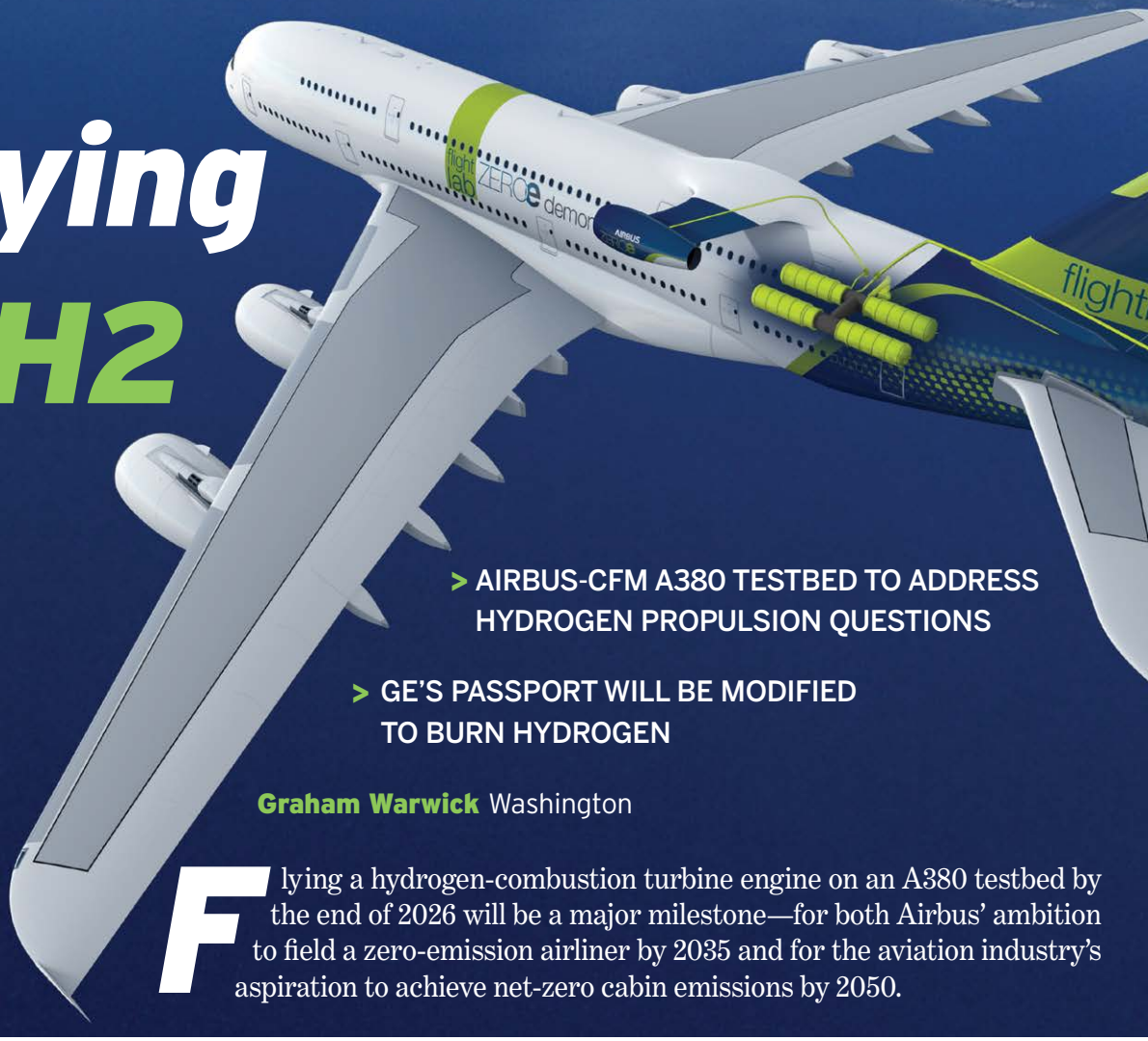
But that does not mean the effects on operating costs can be ignored. Indirect consequences must be taken into account, especially the steep rise in the price of oil.

On the manufacturing side, Airbus and Boeing have relatively little exposure to orders from Russian carriers; their combined backlog is 89 aircraft. However, Aeroflot is due to take delivery of six Airbus A350s each in 2022 and 2023, a significant part of production at currently very low rates. Similarly, AirBridge Cargo has four Boeing 777Fs scheduled for delivery this year and another two in 2023. UTAir's Boeing 737-8s are to be handed over starting in 2024, according to Fleet Discovery. But there is time to reallocate the aircraft if necessary.

Russia is an important supplier of raw materials, however. Aircraft- and engine-makers say they have taken the precaution of stocking up, but disruption could occur, particularly as Boeing and Airbus ramp up production.

The United Aircraft Corp.'s MC-21 is an entirely different story. Due to sanctions imposed before the invasion of Ukraine, the aircraft has undergone major changes from Western to Russian suppliers, adding several years to the development timetable. The first MC-21 was expected to be delivered by mid-2022—with Pratt & Whitney PW1400G engines. Whether that will still be possible remains to be seen. The indigenous Aviadvigatel PD-14 powerplant is slated to be certified this year, but first deliveries are not expected before 2024.

Flying on LH2



> AIRBUS-CFM A380 TESTBED TO ADDRESS HYDROGEN PROPULSION QUESTIONS

> GE'S PASSPORT WILL BE MODIFIED TO BURN HYDROGEN

Graham Warwick Washington

Flying a hydrogen-combustion turbine engine on an A380 testbed by the end of 2026 will be a major milestone—for both Airbus' ambition to field a zero-emission airliner by 2035 and for the aviation industry's aspiration to achieve net-zero cabin emissions by 2050.

The flight tests will answer key questions as Airbus prepares to make its technical choices in 2027, ahead of a product launch decision by the end of the decade. But flying an A380 on liquid hydrogen (LH2) will not provide solutions to all of the challenges involved in bringing a new energy source to a commercial aviation industry that has relied on fossil fuels since its inception more than a century ago.

Questions about the availability of clean hydrogen, the investment required to deploy distribution and storage infrastructure, and the effect on airline operations of resulting changes in ground procedures and aircraft performance all require answers that Airbus is striving to provide through its ZEROe zero-emission initiative unveiled in September 2020.

Critics argue green LH2 will be more expensive than sustainable aviation fuels (SAF), including electrolyzer and liquefaction costs as well as boil-off losses during transport and storage of the cryogenic fluid. While Airbus is not making a choice between hydrogen and SAF—it is pursuing both—only one can fulfill its zero-emission ambition.

Hydrogen propulsion development is already underway at startups, beginning with 20-50-seat regional aircraft able to fly up to 500 nm on fuel cells. Airbus is looking at aircraft with capacities of 100-200 passengers and ranges of 1,000-2,000 nm. While the A380 project is focused on hydrogen combustion, Airbus is still evaluating fuel cells, says Sabine Klauke, chief technical officer.

The A380 flight laboratory may be the largest and most visible element of the ZEROe initiative, but it is only one part. The manufacturer has partnered with airlines to understand the challenges of flying hydrogen-powered aircraft, airports to study development of the supporting infrastructure and hydrogen producers to assess the feasibility of supplying green hydrogen globally on the scale required.

The company is working with Air New Zealand, EasyJet, Korean Air and SAS and with airport operators in France, Italy, Singapore and South Korea, with more to come, says Jeff Knittel, chairman and CEO of Airbus Americas. Airbus is partnered with hydrogen producers Air Liquide, Linde and Plug Power.

The plan to flight-test a hydrogen-burning turbine engine is a collaboration between Airbus and CFM International partners GE Aviation and Safran. Describing it as an "historic partnership," CFM CEO Gael Meheust says: "We have the dream team in place to demonstrate hydrogen propulsion in this decade. We have work to do, but we don't see any insurmountable technical challenges."

The first A380 test aircraft, MSN001, will be fitted with a GE Passport business-jet engine modified to burn



Via a cryogenic fuel distribution system, liquid hydrogen tanks will feed a Passport engine modified for hydrogen combustion.

AIRBUS

hydrogen and mounted on a stub support above the aft fuselage. Four cryogenic LH2 tanks will be installed in a hermetically sealed container and mounted in the lower aft fuselage.

The modified A380 will be used to ground- and flight-test direct hydrogen combustion in a turbine engine, including measuring emissions of nitrogen oxides (NOx) and water vapor in flight. Burning hydrogen produces three times the water vapor of jet fuel.

At altitude, water vapor in the engine exhaust can lead to the formation of contrail cirrus, which can have a climate impact. Flights of the A380 will collect data to characterize the effect of hydrogen combustion on contrail formation in the cruise phase in different atmospheric conditions.

Mounting the test engine at the top of the rear fuselage, where it is isolated from the A380's four turbofans, will make it easier to measure its emissions, says Klauke, while making it simpler to connect the engine and tanks via a new cryogenic LH2 fuel distribution system.

GE's Passport has been selected because it is smaller and lighter than CFM's Leap turbofan, requiring fewer structural changes to the A380, but its core is similar to those of the latest commercial powerplants. "The Passport is representative of airline engines, and scaling the effects to other engines is something we know how to do," says Mohamed Ali, vice president of engineering for GE Aviation, which has more than 8 million hr. of experience with aeroderivative ground engines operating on hydrogen.

The four tanks will store 400 kg (880 lb.) of LH2 at -250C (-420F), enough to provide "a meaningful demonstration for a real aircraft," Klauke says. The tanks will be provided by Airbus' Zero-Emissions Development Centers in Madrid; Bremen, Germany, and Nantes, France, which are evaluating both carbon-fiber and metallic designs.

The cryogenic fuel distribution system will require new pumps, piping, seals and materials, says Michel Brioude, vice president of engineering, research and technology at Safran Aircraft Engines. The LH2 will be converted to gas for injection into the engine's combustion chamber using a new heat exchanger with higher differential temperature and pressure than conventional aircraft systems, he adds. Airbus plans to begin ground tests of the fuel system this year, Klauke says.

Hydrogen burns hotter than jet fuel, and the modified Passport will require new materials, coatings and cooling in the combustor and turbine. Higher temperatures produce more NOx, so "we will leverage our experience of how to minimize NOx," Ali says. Hydrogen also burns 10 times faster than jet fuel, which will require new technology to control the flame and stabilize combustion, he adds.

Demonstrating the ability to relight a hydrogen-fueled engine at altitude will also be a key goal of the A380 flight testing, Brioude says.

The tanks, distribution system and engine will be highly instrumented and monitored by a flight-test engineering station in the aircraft. The cockpit will be modified with a throttle lever and dedicated display for the hydrogen engine. The modified A380 "will allow us to evolve the storage, distribution and propulsion system over time," says Glenn Llewellyn, Airbus vice president for zero-emission aircraft.

The A380 will not be the first commercial aircraft to fly on LH2 and hydrogen combustion. The first to fly, in April 1988, was Tupolev's Tu-155 flying laboratory. This was a Tu-154 airliner with one of its three Kuznetsov NK-8 turbofans modified to burn hydrogen and an LH2 tank in the rear fuselage. The cryogenic tank, holding 1,200 kg of liquid hydrogen, was installed in a special nitrogen-inerted compartment isolated from the rest of the fuselage, with a ventilation system in the tail.

With the renewed interest in hydrogen, propulsion initiatives for large commercial aircraft are gathering pace in other countries. The Japan Aerospace Exploration Agency plans to launch a research project in April to develop an LH2-fueled turbofan engine. Running to 2030, the project will focus on stable hydrogen combustion, an LH2 electric pump and composite cryogenic tanks.

In the U.S., the Energy Department's Advanced Research Projects Agency-Energy has awarded Pratt & Whitney $3.8 million for design of the Hydrogen Steam-Injected Intercooled Turbine Engine. Intended to power single-aisle airliners, the project is designed to eliminate CO_2 emissions by burning hydrogen while using steam injection to significantly reduce NOx emissions.

Because of its high power-to-weight ratio and zero carbon emissions, the UK government-funded FlyZero project in September identified LH2 as having the greatest potential to power the next generation of commercial aircraft. The study has identified hydrogen gas turbines, fuel cells and dry wings as areas of opportunity for UK industry.

For CFM, work on hydrogen combustion comes under the joint company's RISE program (for Revolutionary Innovation for Sustainable Engines), launched in June 2021 to demonstrate a suite of technologies for future ultra-efficient powerplants, including open rotors.

Launched to help the commercial aviation industry meet its stated goal of achieving net-zero carbon emissions by 2050, one objective of RISE is to ensure future CFM engines are equally able to run on SAF and hydrogen. "Hydrogen is a challenge, but it is necessary," CFM's Meheust says.

SHOCK AND . . . NAUGHT

> UKRAINIAN AIRSPACE REMAINS CONTESTED

> RUSSIAN ADVANCE STALLS NEAR KYIV

> U.S., UK REJECT CALLS TO IMPOSE NO-FLY ZONES



A Ukrainian Air Force An-26 transport was shot down in the first hours of the Russian invasion on Feb. 24.

Steve Trimble Washington and **Piotr Butowski** Gdansk, Poland

U.S. and British defense experts knew what to expect on the morning of Feb. 24 as Russian President Vladimir Putin angrily ordered a "special military operation" against Ukraine to commence:

■ Ukraine's air defenses, air force and command centers would be pummeled in an opening airstrike by potentially hundreds of standoff missiles.

■ Major eastern cities, such as Kharkiv, would fall on the first day, as dozens of Russian battalion tactical groups swarmed past an outgunned Ukrainian Army.

■ Ukrainian President Volodymyr Zelenskyy would be at risk of capture or death within the first two days, as Russian forces swept into Kyiv to bring a brutally swift end to a widely condemned war.

But widespread expectations of a decisive victory over Ukraine proved wildly optimistic during the first week of fighting, as a stout defense and resilient leadership met an often disjointed and underachieving Russian advance from three directions.

"We've seen it has been a lot more costly and a lot harder than Putin and his military would have expected," Mara Karlin, the acting deputy undersecretary of defense for policy, told lawmakers on March 1.

As of March 3, Russian military units had made gains along the edges of Ukraine's northern, eastern and southern borders, especially along the coast of the Sea of Azov and the Black Sea.

However, despite official Russian claims to the contrary, Ukrainian aircraft still flew, and the air defense network survived the initial onslaught, endangering presumably surprised Russian Air Force and Army pilots.

Not only has Kharkiv remained in the defenders' hands after the first week of fighting, no major Ukrainian city had clearly fallen after a week of fighting, with the UK Defense Ministry saying on March 3 that the military situation in the outhern port of Kherson was still unclear despite Russian claims of victory there.

Once the conflict ends and ambiguities created by the fog of war are cleared up, the disparity between expectations and the reported reality during the first week of the war may lead to reassessments of Russia's readiness to fight a major conventional war against the NATO alliance.

But some unusual metrics already stand out only a week into the conflict. For example, Russia fired more than 450 cruise and ballistic missiles at Ukrainian targets during the



MINISTRY OF INTERNAL AFFAIRS OF UKRAINE

first week, a senior U.S. defense official said on March 2. In 2003, the U.S. military launched the invasion of Iraq by firing 504 cruise missiles on the first night alone.

The disparity could be the result of several factors, including limited Russian stocks of precision-guided munitions, a lack of over-the-horizon targeting capability against mobile systems and an operational philosophy that emphasizes heavy armor and artillery over tightly choreographed operations by air and land forces.

Early setbacks also stymied Russia's optimistic war plan, perhaps none more significant than the Battle of Antonov Airport. As the home of Antonov Airlines' global cargo operations and the base of the iconic An-225 Mriya heavy lifter, Russian war planners seemed to identify the airfield as an attractive site for landing a shock force less than 30 km (19 mi.) from the center of Kyiv.

Apparently conceived as a daring attempt to leapfrog over entrenched Ukrainian defenses, more than two dozen Russian Mil Mi-8s staged an air assault on the morning of Feb. 24. Videos later posted on social media showed Ukrainian defenders shooting down at least one Mi-24 or Mi-35M and at least two Kamov Ka-52 gunships during the attack. The Mi-8s landed a force of airborne troops to seize the airport, with Russia's 334th Military Transport Aviation Regiment poised to follow aboard Ilyushin Il-76 transports set to take off from Pskov, Russia.

"That force was going to be one of the spearhead forces to take the capital," says Lt. Col. Tyson Wetzel, an active duty U.S. Air Force intelligence officer now serving at the Atlantic Council think tank.

The Ukrainian Armed Forces recognized the air assault as a high-priority threat and immediately deployed the 4th Rapid Reaction Brigade to lead a counterattack against the airport. The brigade is considered one of Ukraine's elite military units, having been among the first to be trained by foreign advisors to operate according to NATO standards.

Ukrainian officials reported that the airport had been recaptured by nightfall Feb. 24, with the Russian attackers fleeing to the wooded areas on the perimeter. But a second Russian air assault, reportedly comprised of more than 200 helicopters landed on Feb. 25, driving the Ukrainians back on the defensive. The battle for the airport continued for at least another day before it fell into Russian hands permanently. By Feb. 28, an unclassified British intelligence assessment stated that Ukrainian forces still held the adjacent town of Hostomel but said nothing about the status of the airport.

Although the Russians ultimately won possession of the airport, the damage caused by the battle likely rendered the site unusable by either side. Videos posted online showed the scars of artillery and missile strikes around the airfield, including severe damage caused to the An-225 itself. For the Ukrainians, the tactical loss was an operational victory, as it prevented the Russians from landing a large assault force almost within sight of the capital city on the first day of the war.

"I think that had a major impact on the battle for Kyiv," Wetzel said on his Airminded podcast. "Battles and wars sometimes turn on very small events. It's tough to say for sure, but I think the battle for [Antonov Airport] may be one of those."

The wider impact of the battle perhaps could be seen in satellite photos showing a stalled column of Russian vehicles stretching 40 mi. long. The column had started a roughly 100-mi. road trip from the southern border of Belarus to Kyiv on Feb. 24 or Feb. 25 but was still 20 mi. short of the objective a week later. According to a March 3 update by British military intelligence, the column had barely moved in three days, noting that it had been "delayed by staunch Ukrainian resistance, mechanical breakdown and congestion."

Footage on social networks shows a surprisingly large number of Russian vehicles abandoned on the roads, sometimes entire columns. At the same time, one cannot see any damage—the fuel has just run out.

Russian soldiers and officers have had their cellphones taken from them so that they cannot be tracked by the Ukrainians. Along with this, they were left without satellite navigation, which had previously been widely used in exercises.

Moreover, the Ukrainians used an old and simple trick by changing signposts, and Russian military columns began to get lost. There are records from webcam networks covering Ukrainian roads showing vehicles passing the same place several times. After the fuel ran out, the Russians abandoned their vehicles, which the Ukrainian resistance set on fire overnight.

A potential dark outcome of Russia's failure to secure an easy victory is a prolonged war and a shift to more lethal tactics. During a monthlong bombing of eastern Aleppo, Syria, in 2016, for example, Russian warplanes struck more than 950 targets in densely populated cities with weapons that included cluster munitions and incendiary bombs, according to a contemporary report by Human Rights Watch.

In a televised address on Feb. 24, Putin said that Russian military forces would not target Ukrainian civilians. The promise swiftly proved empty by the middle of the first week of the invasion, as videos showed artillery and military strikes on residential buildings and Russian aircraft firing rockets in civilian areas. If major cities such as Odesa, Kharkiv and Kyiv are besieged and stocks of precision-guided munitions run low, the risk of indiscriminate violence rises.

The Ukrainians' plight has drawn some analysts to amplify calls by Zelenskyy for Western powers to establish "no-fly zones" over parts of Ukraine or conduct airstrikes on columns of exposed Russian military vehicles. U.S. and British government officials immediately rejected such proposals, saying NATO countries would not directly fight their nuclear-armed adversary to help Ukraine. The strength of the West's policy will be tested if Russia attempts to force Ukraine to surrender by escalating attacks on civilians with unguided weapons or even chemical agents.

Check 6 *Aviation Week editors discuss the opening days of the war and Europe's renewed focus on defense:* **AviationWeek.com/podcast**

Europe's United Stand

- GERMANY IS ESTABLISHING €100 BILLION DEFENSE FUND TO FILL CAPABILITY GAPS
- EU PROVIDES WEAPONS AND EQUIPMENT TO A NON-EU MEMBER FOR THE FIRST TIME

Tony Osborne London



Europe has reacted swiftly to the Kremlin's formidable assault on Ukraine by supplying arms and imposing heavy sanctions in a bid to slow Russia's forces and weaken Moscow's ability to fund the conflict.

MINISTRY OF INTERNAL AFFAIRS OF UKRAINE

For years, Russian dark money has been used to create rifts and subvert Europe's society and politics. President Vladimir Putin expected his strategy would fragment trust and weaken governments and institutions such as the European Union and NATO. But it has backfired, and the Kremlin's bloody and badly choreographed invasion of Ukraine has had the opposite effect, galvanizing Europe and isolating Russia as a pariah state.

Reaction has been swift. Berlin ended its special relationship with Moscow, reformed its foreign policy and has set itself on course to become one of the world's top defense spenders. Finland and Sweden, both militarily nonaligned for decades, are now considering accession to NATO. Neutral Switzerland broke with tradition and imposed financial sanctions on Russia. And the European Union is supplying military equipment—so-called lethal aid—to a non-EU member for the first time.

Ukraine's forces are benefiting from missiles, guns, ammunition and equipment pledged by some 20 European countries, as well as Australia, Canada and the U.S.

European Commission President Ursula von der Leyen told the European Parliament that European security and defense had "evolved more in the last six days than in the last two decades."

European security and defense have

"evolved more in the last six days than in the last two decades"

"Mr. Putin says he doesn't want a strong NATO on his Western flank. He's getting exactly that," said U.S. Defense Secretary Lloyd Austin. "I have never seen the alliance more united and resolute than I see it today."

European leaders have been angered by the subterfuge shown by Putin and his ministers, who repeatedly told French President Emmanuel Macron, German Chancellor Olaf Scholz and others that no invasion was planned.

"The sad reality is that it took bombs exploding in Kyiv and Kharkiv to wake up Germany and others from their strategic hibernation over the last 30 years," Bastian Giegerich, the director of defense and military analysis at the London-based International Institute and Strategic Studies, tells Aviation Week. "This is a new epoch—the realization that foreign, security policy preferences of the past just no longer fit in reality."

Until the invasion, Germany had been a reluctant player in the efforts to strengthen Ukraine's armed forces. Indeed, many German politicians had seen the buildup of Russian forces on Ukraine's borders as a "big bluff," says Rafael Loss, an expert in German and European foreign and security policy at the European Council on Foreign Relations. An offer to send 5,000 helmets was widely mocked as Germany's neighbors airlifted in anti-tank weapons and surface-to-air missiles.

When the bombs began falling, a dramatic U-turn ensued. Berlin halted certification of the controversial Nord Stream 2 gas pipeline linking Russia with Germany, approved the supply of weapons to Kyiv and green lit heavy-hitting sanctions.

This was followed on Feb. 27 with a dramatic speech by Scholz confirming wholesale changes to the country's defense, foreign and energy policies. At its heart is the creation this year of a €100 billion ($111 billion) fund that would address urgent capability and funding gaps in defense. Berlin also will meet NATO's call for alliance members to spend 2% of their gross domestic product (GDP) on national defense, potentially surging Germany's annual defense spend to an estimated €90 billion, making it the third-largest defense spender in the world.

By comparison, the Merkel administration had pledged to raise spending to just 1.5% of GDP by 2024.

"We are not only striving for this goal because we have promised our friends and allies that we will increase our defense spending to 2% of our economic output by 2024," Scholz said.

"We also do this for ourselves, for our own security, knowing full well that not all future threats can be contained with the resources of the Bundeswehr [German armed forces]."

The €100 billion likely will be spent on priority projects. The Future Combat Air System with France and Spain was mentioned by Scholz, as was a successor to the Panavia Tornado, the dual-capable platform that performs Germany's nuclear deterrence mission with U.S. dual-key special weapons. Lockheed Martin's F-35 Joint Strike Fighter would be a "potential carrier" for the nuclear mission, Scholz said, with the Eurofighter Typhoon enabled for electronic warfare.

There was no mention of Boeing's F/A-18 Super Hornet selected by the previous administration as the Tornado replacement.

The money may also fund new heavy-lift helicopters, ground-based air defenses and armed remotely piloted air vehicles.

"This [€100 billion] sounds like a truckload of money, but it isn't," Giegerich says. "It is really the investment that most people understood was required to fund the capability ambition that Germany has."

But it does give Germany the financial means to "turn itself again into a significant component of NATO's conventional deterrence," he says.

Germany is likely just the first European state to announce new budgetary measures over the coming months. Romania's President Klaus Iohannis also says his country should raise its defense budget to 2.5% of GDP. Since the annexation of Crimea, Romania has more than doubled its defense budget to $6.1 billion from $2.8 billion.

Despite concerns that European defense spending could plateau post-pandemic, it now looks set to grow by a minimum of 19% between 2022 and 2030, rising to $371 billion from $311 billion.

The appeal of a stronger NATO appears to have prompted renewed dialog about the potential accession to the alliance of Finland and Sweden, too. Both countries are already involved with the alliance through cooperation agreements, regular exercises and, in the case of Sweden, deploying on NATO-led operations and, in Finland's case, purchase of the F-35. But neither has formally committed to the pact.

However, public opinion appears to be swaying, given Russia's actions in Ukraine. Polls on NATO membership found that 53% of Finns now support joining NATO, and this figure is even higher if Sweden joins with Finland.

In response, the Finnish Parliament on March 1 discussed the issue and the possibility of a referendum on membership.

Commentators suggest that if both countries were to become NATO members, they would likely do it jointly, a "side effect" of Putin's actions, Giegerich says. "[Putin] is creating exactly the kind of unity that he says he's worried about," he adds.

The EU has also played a significant role in coordinating sanctions on behalf of its member states and working alongside the U.S. And it became a weapons supplier in its own right, funding a €450 million package of lethal aid for the Ukrainian armed forces.

But plans to supply combat aircraft as hinted by EU High Representative for Foreign Affairs Josep Borrell Fontelles appear to have fallen short. Fontelles told journalists on Feb. 27 that Warsaw Pact platforms such as the Mikoyan MiG-29 Fulcrum and the Sukhoi Su-25 still being flown by Eastern European air forces including Bulgaria, Poland and Slovakia could be transferred to Ukraine and flown by air force pilots. However, the three countries denied that aircraft would be handed over, and EU officials stated that it would be up to the individual nations to implement such aid.

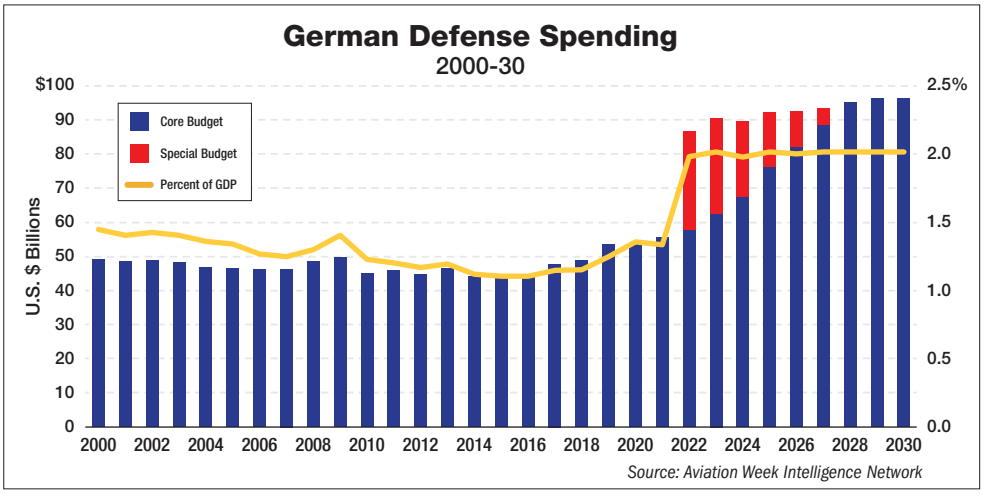
More broadly, Europe's defense doctrines are likely to face a major review when the dust and debris settle, and much depends on whether diplomacy can bring the conflict to an end or Russia throws more forces into the fight and how that fight might be conducted going forward. NATO has been urging members states to raise their defense spending to 2% of GDP or more since Russia's annexation of Crimea, and many did, but numerous others did not. Observers question whether plans for an Asia-Pacific pivot, notably by the UK in its Integrated Review published last year, but also by France and Germany, will continue.

One key priority for Europe's militaries will be to deepen munition stocks, says Justin Bronk, a research fellow for the London-based Royal United Services Institute. "There is no getting away from the fact that we in pretty much all non-U.S. NATO countries have allowed weapons stockpiles to get really quite scarily small," he says.

"With modern precision-guided munitions, rebuilding those stocks to what may need to be Cold War levels will be an expensive thing to do," says Bronk. "But there is no way around it."

There may also be a realization that capabilities that were slated to be retired in favor of advanced technology may still be relevant, Giegerich suggests. Ultimately, Europe will need to rebuild forces that have been "hollowed out over the last 15-20 years," he says. "Rebuilding that will take a lot of money."

—With Craig Caffery in London



NATO Aircraft Assemble Outside Ukrainian Border



- DEPLOYMENTS INCLUDE F-35As FROM MULTIPLE NATIONS
- NATO AND ALLIES ARE ADAMANT THAT A NO-FLY ZONE IS NOT AN OPTION

GERMAN AIR FORCE

Brian Everstine Washington

Russia's invasion of Ukraine in late February prompted a surge of NATO combat aircraft to allied nations on the organization's eastern front.

Fighter aircraft from a number of nations, supported by refueling tankers of several types, have flown constant combat air patrols to protect NATO, while multinational surveillance aircraft have kept watch on the limited air war that has taken place above Russia's violent bombardment of Ukraine.

"Over the last weeks, in response to Russia's attack on Ukraine, we have increased our defensive presence, with over 100 jets at high alert operating from 30 different locations," NATO Secretary General Jens Stoltenberg says.

Some deployments have been short-notice taskings of some of the newest fighter aircraft across the alliance. For example, the U.S. Air Force deployed six F-35As from its three-month-old squadron at RAF Lakenheath, England, to bases in Estonia and Lithuania. The Royal Netherlands Air Force deployed two of its F-35As to Eastern Europe in late February, although the service had announced it had planned to send the fighters on a separate NATO air policing deployment to Bulgaria in March.



SGT. AGUSTIN MONTANEZ/U.S. ARMY NATIONAL GUARD

The day Russia began its invasion of Ukraine, Germany sent additional Eurofighters to Romania, where they joined an Italian contingent.

While the deployment of combat aircraft attempts to send a message to Russia not to move beyond operations in Ukraine and into NATO, senior alliance officials have repeatedly and emphatically said that a possible no-fly zone in Ukraine or any operation outside NATO territory is off the table.

"Our forces are not going to Europe to fight in Ukraine, but to defend our NATO allies in the event [Russian President Vladimir] Putin decides to keep moving west," U.S. President Joe Biden said in his first State of the Union speech on March 1. "For that purpose, we've mobilized ground forces, air squadrons and ship deployments to protect NATO countries including Poland, Romania, Latvia, Lithuania and Estonia. As I have made crystal clear, the United States and our allies will defend every inch of territory of NATO countries with the full force of our collective power."

NATO, in the runup to the invasion and after Russia crossed over Ukraine's borders, announced deployments to:

- **Bulgaria** Spanish Eurofighter Typhoons operating at Graf Ignatievo air base.
- **Estonia** Belgian Air Force F-16s and U.S. Air Force F-35s operating at Amari air base.
- **Latvia** U.S. Army AH-64 Apaches at Lielvarde air base.
- **Lithuania** Danish and Polish F-16s and U.S. Air Force F-35As at Siauliai air base.
- **Poland** U.S. Air Force F-15s, U.S. Army AH-64s and UH-60s at Lask air base, Royal Netherlands Air Force F-35s and Royal Danish Air Force F-16s also deployed to Poland.
- **Romania** U.S. Air Force F-16s and F-35As at Fetesti air base; Italian and German Eurofighters at Mihail Kogalniceanu air base.

Additionally, many NATO aircraft are flying into the region with tanker support for regular combat air patrols. For example, U.S. Navy F/A-18s from the USS Harry S. Truman in the Mediterranean Sea are flying air policing

The U.S. Army has sent Boeing AH-64 Apache and Sikorsky UH-60 Black Hawk helicopters to Poland.

Three F-35As arrived in Lithuania to support NATO's Enhanced Air Policing missions in the Baltic region.



SENIOR AIRMAN JOHN R. WRIGHT/U.S. AIR FORCE

missions supported by German Air Force A-400M tankers. The UK Royal Air Force has deployed additional Eurofighter Typhoons to RAF Akrotiri, Cyprus, along with long-range flights from RAF Coningsby, England, to patrol airspace in Poland and Romania with support from Voyager tankers. The French Air and Space Force said Rafale fighters and A330 Multi-Role Tanker Transports were flying 3-hr. patrols twice per day from their home bases in France.

The intelligence and surveillance mission has seen high operations with dozens of aircraft watching the border, including NATO and U.S. Air Force E-3 Airborne Warning and Control Systems (AWACS); U.S. Air Force E-8C Joint STARS, RC-135 Rivet Joints and RQ-4 Global Hawks; and the U.S. Army's Artemis surveillance jet, among others. NATO AWACS are flying into the region from multiple bases, including in Belgium, Germany and Turkey. Crews said the mission is largely similar to what they have regularly flown—monitoring NATO's eastern front—although the pace has dramatically increased.

"Our radar has a range that's over 400 km [250 mi.], so it really depends on where we are orbiting as far as how far into any country we can see," says Maj. Dan Reinhardt, the tactical director for NATO's Airborne Early Warning and Control Force. "But we can see far enough into both [Belarus and Russia] that we can protect our NATO partners, and they will not be surprised by anything that's flying in their vicinity."



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Commercial Aviation OEMs Expect Limited Impact From Ukraine Crisis

- > RUSSIAN FLEETS AND ORDERS ARE RELATIVELY SMALL
- > MANUFACTURERS STRIVE TO MITIGATE MEDIUM-TERM TITANIUM SUPPLY RISK

Thierry Dubois Lyon, **Guy Norris** Colorado Springs, **Michael Bruno** Los Angeles and **Sean Broderick** Washington

Civil aircraft manufacturing must face yet another calamity even as it begins its recovery from the COVID-19 pandemic crisis—the Ukraine war and its extensive ramifications.

The war's impact on the sector can be seen from two different angles. The first is the effectiveness of the sanctions Western governments are imposing on Russia, which relies heavily on Western suppliers for air transport. Since the early 1990s, it has failed to develop a fully fledged commercial aircraft manufacturing sector, despite a strong basis in engineering and multiple collaborative projects with the West.

Russian carrier S7 has ordered Boeing 737-8s, which the Russian Federal Air Transport Agency is now unlikely to recertify soon.

The sanctions could cripple Russian commercial aviation in just a few weeks. Willingly or not, civil aerospace companies in the EU and North America may be key players in the penalties' success.

A second angle is the war's effect on airframers and engine-makers as well as their suppliers. The small size of the Russian market lessens the impact on OEMs, even as the sanctions annihilate their trade with Russian carriers.

What is unclear is how much of a medium-term effect there will be from certain factors. Western aerospace companies require raw materials such as titanium, of which Russian providers supply a large share globally. And energy prices may rise as the war affects oil and gas markets.

In short, while Russia will quickly feel the pain of the sanctions, the aerospace industry might also see important problems emerge, even if at a slower pace.

The EU sanctions are wide-ranging. "We prohibit the repair and maintenance of any aircraft or aeronautical equipment by EU companies and organizations," says Adina Valean, European commissioner for transport. "We prohibit the sale, supply, transfer or export of all goods and technology linked to aircraft, helicopters and spacecraft."

The sanctions' most immediate effect will arguably be reduced spare parts availability. There are 327 Airbus aircraft in the Russian commercial fleet, according to the Aviation Week Network Fleet Discovery database, so carriers will be badly hit.

Regional turboprop manufacturer ATR has three operators in Russia—KrasAvia, NordStar Airlines and Utair, with a total 22 aircraft—and is required to stop supporting them.

Boeing has voluntarily suspended support of Russian airlines operating its products, including spare parts sales and engineering services.

Lufthansa Technik, a major maintenance, repair and overhaul (MRO) service provider in Europe, has contracts with "a large number of airlines in Russia," a spokesman says. "The range of services mainly includes component and engine support." For instance, Lufthansa Technik has been providing engine services to Rossiya Airlines since 2019 for CFM International CFM56-5B and General Electric CF6-80 turbofans, at sites located outside of Russia. All that work now has to stop.

Cannibalization of aircraft of Western airliners by Russian operators is a concern. Some speakers on a March 1 webinar by consultancy IBA said they expect Russian operators will do some local parts-farming to keep aircraft flying, although they will want to limit it to keep good relations with lessor owners, assuming the crisis ends relatively soon.

Could Russia rely on its national industry? Some carriers operate Sukhoi Superjet 100s for domestic flights, but capacity is limited. The fleet stands at 122, according to Fleet Discovery, and the aircraft all have fewer than 100 seats.



JOE WALKER

Making the situation worse are the partnerships Sukhoi established with Western companies. Thales is in charge of the avionics suite, and Safran Aircraft Engines is responsible for 50% of the engine, under the PowerJet joint venture with Russia's UEC Saturn. EU sanctions mean engineers will no longer provide maintenance, training, call-center service or documentation, a Safran spokesperson points out.

The Superjets are part of a 336-strong indigenous fleet, a number of which are aging types such as the Antonov An-24. Even the in-development Irkut MC-21 narrowbody program involves a number of Western partners.

An Airbus spokesman says it is premature to comment in detail about the effect of sanctions. The Russian fleet is a small part of Airbus' 12,434 in-service aircraft. In terms of production backlog, "our exposure is limited to 14 Aeroflot A350s and about 40 single-aisle aircraft [A220- and A320-family] to be delivered through lessors," the spokesman says.

Boeing, with 50% of the Western-built Russian commercial fleet and eight subsidiaries, research facilities and joint ventures across the country, finds itself significantly exposed by the crisis in Ukraine. It has worked hard to build industrial, commercial and space links with Russia since the dissolution of the Soviet Union in December 1991.

Operations at Boeing's Ukraine facilities were immediately affected. The OEM has over 100 employees at its Kyiv office and about 1,000 engineers at its partner design and engineering facilities elsewhere in the country.

Russian Airline Orderbook

	On Order
Boeing	
737 MAX 8	**37**
S7 Airlines	7
Ural Airlines	2
Utair Aviation	28
777-200F/LR	**6**
AirBridgeCargo Airlines	6
Airbus	
A220-300	**20**
Azimuth (Rostov-Russia)	6
Ilyushin Finance Co.	14
A320-200N	**13**
S7 Airlines	13
A350-900	**13**
Aeroflot Russian Airlines	13
Ilyushin	
Ilyushin IL-96-300	**2**
Rossiya Airlines	2
Irkut	
Irkut MC-21-200	**18**
Avia Capital-Service LLC	18
Irkut MC-21-300	**157**
Aeroflot Russian Airlines	50
Alrosa Mirny Air Enterprise	3
Avia Capital-Service LLC	17
Ilyushin Finance Co.	31
Iraero	10
Red Wings	16
VEB-Leasing	30
Sukhoi	
Sukhoi Superjet 100-95	**77**
Aeroflot Russian Airlines	73
Ilyushin Finance Co.	2
Severstal Airco.	2
Grand Total	**343**

As of the end of February

Source: Aviation Week Intelligence Network Fleet Discovery

"We have suspended major operations in Moscow and temporarily closed our office in Kyiv," says the manufacturer.

The long-term status of the Boeing Design Center (BDC) in Moscow remains unclear. Opened in 1998 as an offshoot of the Boeing Technical Research Center—the company's first Russian site, founded in 1993—the BDC is the largest Boeing engineering center for computer-aided design of aerospace structures outside the U.S.

The site has played a key role in support of the 737, 747, 767, 777 and 787 programs. It employs more than 300 people who manage a team of over 1,000 contract engineers in Russia and Ukraine.

The deteriorating relationship between Washington and Moscow also does not bode well for the timely completion of the recertification process of the 737 MAX by the Russian Federal Air Transport Agency. After China, Russia is the last of the major customer nations yet to approve the aircraft's return to service. The hostile political climate also casts a long shadow over the potential nondelivery of more than 40 737s and 777Fs in the firm order backlog as well.

Following the U.S. government's March 1 decision to close its airspace to Russian aircraft, Boeing is also being forced to look for alternate ways to transport completed wingboxes for 767-300Fs from its supplier in Florida to the final production line in Everett, Washington. A batch of 18 subassemblies, each weighing 23,000 lb., were slated to be delivered on a series of six charter flights by Volga-Dnepr Airlines-operated Antonov An-124s between mid-March and early April.

The outsize loads, which cannot be carried even by the modified 747-400 Dreamlifter fleet, are "urgently needed" by Boeing to "meet its deadlines and not to delay the 767 production line," says Volga-Dnepr. Details were obtained by Aviation Week from a Feb. 24 filing by the carrier to the U.S. Transportation Department for an emergency exemption to regulations prohibiting overseas air carriers from transporting commercial traffic between U.S. destinations.

All the major Western engine-makers also face significant questions about their future support of installed fleets in Russia and Ukraine, as well as whether significant orders will be fulfilled. Most affected are General Electric and its CFM joint venture partner Safran.

GE Aviation currently has 296 engines in service and a further 44 in storage in the region. The manufacturer is also supplying the 12 GE90-115Bs due to power the 777Fs on order from Russia's AirBridgeCargo Airlines.

CFM powers the vast majority of the more than 300 Airbus A320-family aircraft in service in Russia and is the exclusive provider for the 241 737s operating there. It has 1,240 engines planned for the region, of which 960 are in service or in storage, and another 280 on order or option.

Pratt & Whitney, which provides PW1400 geared turbofans (GTF) for the recently certificated MC-21-300, has also seen recent growth in the Russian fleet of GTF-powered Airbus A220/320neos. Together with PW2000-, PW4000- and V2500-powered aircraft, it has almost 240 engines in service or storage in Russia. It is due to provide 40 PW1500Gs for A220s on order by Azimuth Airlines and the Ilyushin Finance Co., too.

Rolls-Royce appears to be the least affected, with around 100 RB211 and Trent engines in service or storage. However, the OEM was due to see its Russian fleet increase—Aeroflot was planning to add 13 Trent XWB-powered A350-900s to the seven in service or storage.

The March 1 Aviation Week Raw Materials and Manufacturers Supply Chain Conference in Los Angeles was the first public appearance for representatives from both Airbus and Boeing since the Russian invasion of Ukraine began in late February. A consensus across the event was that while it was still too soon for the aerospace industry to discern all the effects of the war, it was easy to imagine that some consequences, such as sanctions on raw materials, would make business more difficult. In preparation, OEMs and top-tier suppliers have stockpiled reserves or alternative sourcing for titanium and critical metals to meet midterm needs.

The supply of titanium is high on the list of many aerospace supply chain watchers. The light, strong metal is a staple of current-generation aircraft and engine designs. Boeing depends on its partner and supplier, Russia's VSMPO-Avisma, for 35% of its critical titanium supply and—through its Ural Boeing Manufacturing joint venture with that company—for machined forgings for the 737, 777 and 787.

So far, sanctions have avoided raw-material supply, including titanium. Even if that changes, the consequences would not be significant—at least not at first. "We believe U.S. and EU sanctions are unlikely to affect titanium. However, the Kremlin could restrict titanium and aluminum exports to counter Western sanctions," Jefferies analysts wrote in a Feb. 24 update. "We see a subdued impact from potential sanctions, with enough inventory in the supply chain."

Some manufacturers prepared for possible disruption by altering their sourcing strategies. Safran, which along with CFM joint-venture partner GE has used dual sourcing from the beginning on the Leap engine program, is increasing its non-Russian titanium supply base.

Airlines Count the Cost of Russia's Ukraine Invasion



- RISING JET FUEL PRICES CONCERN AIRLINES
- RUSSIAN AIRSPACE BAN INCREASES FLIGHT TIMES FOR ROUTES TO ASIA

JOEPRIESAVIATION.NET

Helen Massy-Beresford Paris and **Sean Broderick** Washington

As the world watches the human tragedy unfolding in the wake of Russia's invasion of Ukraine, airlines and the broader aviation industry are facing up to the fact that beyond short-term operational complications, the crisis could delay the sector's recovery.

Carriers' early-2022 hopes that as omicron-related travel restrictions gradually eased, it would be smooth sailing toward healthier traffic levels proved to be short-lived.

Now, rising jet fuel prices as well as the operational impact of airspace closures expanding beyond the immediate conflict zone are likely to hit the profitability of airlines in the short-term—and if the war drags on, the impact will only worsen.

As part of attempts to put pressure on Russian President Vladimir Putin, Europe, Canada and the U.S. have closed their airspace to Russian aircraft while Russia has banned flights from a number of countries, forcing airlines to reroute many flights and cancel others. This is having an immediate impact on carriers, whether they ordinarily serve Russian destinations or have to alter their flight paths.

Russian airlines themselves represent around 6% of the ASKs (available seat kilometers) offered by all airlines across the globe in 2021, according to consultancy IBA, while for Russian airlines Aeroflot and S7 domestic routes accounted for about 87% of traffic in the first two months of 2022.

But the effect on non-Russian airlines will be significant in some cases. Finnair, whose business model relies heavily on connecting European and Asian destinations and which in normal times relies on overflying Russia, has withdrawn its first-quarter guidance and warned that prolonged Russian airspace closures would have a significant impact on its finances.

"Bypassing the Russian airspace lengthens flight times to Asia considerably and, thus the operation of most of our passenger and cargo flights to Asia is not economically sustainable or competitive," Finnair CEO Topi Manner said Feb 28. "We are implementing our contingency plan as the situation has a considerable impact on Finnair."

Finnair has had to suspend and reroute several flights to Asian destinations to avoid Russian airspace.

"Finnair's entire business model is built on acting as a transfer hub from Europe to Asia—avoiding Russian airspace is essentially impossible for them," former IAG executive and founder of Gridpoint Consulting Robert Boyle writes in a blog post, noting that a large amount of the carrier's business also comes from Russia.

Finnair has had to suspend and reroute several flights to Asia to avoid Russian airspace.

Scandinavian Airlines (SAS) confirmed March 2 that it was suspending its Copenhagen-Tokyo flight until May 1 and rerouting its Copenhagen-Shanghai flight, while two seasonal flights planned to serve St. Petersburg over Easter have been canceled.

Boyle notes that although extra flight time on routes to Southeast Asia will add to airlines' costs, that is offset by the high fees ordinarily charged by Russia for overflying the country, meaning a lower net impact on costs for European carriers. "It is a different story for more northerly points, such as China, Japan and Korea, where the extra distance involved in avoiding Russia is much bigger," Boyle says. Of course, Chinese airlines can also still access Russian airspace.

For European carriers relying more heavily on transatlantic routes, the impact will be less severe, said Geoff Van Klaveren, head of advisory at IBA, during a March 1 webinar.

"The key part of their profitability is across the North Atlantic—especially at the moment, that's where they are really focusing capacity," he said. "So we don't see a large impact on their profitability. The exception is perhaps Finnair due to its geographical location and its business model, which makes it very exposed to this crisis." On the flip side, the airlines Van Klaveren describes as "super-connectors" such as Emirates, Etihad and Qatar as well as Turkish Airlines could benefit, as it is much easier for them to avoid Russian airspace, he added.

Although some short-haul operators in Europe have exposure to the Ukrainian market, where airspace has been closed to civil flights since the situation worsened in late February, that needs to be put into perspective. Ryanair was the second-largest airline in the Ukrainian market in February, with a market share of 12.3%, while Wizz Air was ranked fourth with 9.6%. However, while those operators will undoubtedly be looking to move their aircraft to other bases, services to Ukraine only represent 2% and 4% of their total flights, respectively, according to IBA.

Wizz Air said on March 2 that "as the only EU airline to have bases and aircraft based in Ukraine, with three aircraft located in Kyiv and one aircraft in Lviv, we have an evacuation plan ready to bring the assets out of the country when it is safe to do so."

The airline has suspended all flights to and from Ukraine and Russia while operating its Moldova flights out of Iasi, Romania, and will continue to review the suspensions as the situation unfolds.

Wizz Air said its full-year operating loss guidance should be materially consistent with the guidance it has already provided for a slightly greater fourth-quarter operating

loss than in the third quarter, "subject to preserving the integrity of our assets on the ground or other further developments in March 2022."

"We continue to work through the operational challenges arising from the crisis in Ukraine, and we are redistributing capacity to routes and bases where we can drive demand in line with our proven [ultra-low-cost-carrier] model," CEO Jozsef Varadi said. The airline is also offering 100,000 free seats on short-haul flights departing from countries bordering Ukraine for refugees and is offering evacuated employees positions elsewhere in the network.

As the Ukraine crisis hits energy markets and drives up jet fuel prices, airlines are set to face higher fuel costs, which make up a significant chunk of their operating expenses.

For Wizz Air, which approved a "no-hedge" policy in 2021, the crisis will be felt more in rising fuel costs, while Ryanair's greater hedging will provide more protection. The Dublin-based carrier is almost fully hedged for the three months through the end of March, 80% hedged for April-September and 70% hedged for October-March.

The International Air Transport Association's (IATA) jet fuel price monitor shows that the price ended up 3.8% week-over-week Feb. 25 at $111.1 per barrel, with further rises in recent days leaving airlines—many of which are not hedged or less hedged than they were before the COVID-19 crisis—exposed to record fuel prices.

"The bigger problem with Russia and the invasion of Ukraine, and the interruption of energy markets around the world is jet [fuel] prices are [going] up and getting out of hand. Jet fuel is well above 2019 levels—that's a challenge," said Bloomberg Intelligence analyst George Ferguson during IBA's March 1 webinar.

He noted that the three major U.S. airlines have stepped back from hedging their fuel requirements, leaving them more exposed to rising jet fuel costs.

"Costs are rising and fares aren't—what we see is that airline profitability is impacted," Ferguson added.

Sanctions imposed on Russia could hit Russian airlines hard, with a large number of their leased aircraft set to be returned to lessors, even if the process of recovering aircraft leased in the country could prove complicated in the current scenario.

The lessor with the most exposure to the Russian market is AerCap, with 152 aircraft placed in Russia, according to Aviation Week Fleet Discovery data (see chart). AerCap said Feb. 28 that international sanctions would affect its leases to Russian carriers. Around 5% of its fleet by value was leased to Russian airlines as of Dec. 31.

"These sanctions include prohibitions regarding the supply of aircraft and aircraft components to Russian entities or for use in Russia, subject to certain wind-down periods. AerCap intends to fully comply with all applicable sanctions, which will require us to cease our leasing activity with Russian airlines," AerCap said in a filing.

Sanctions targeting Russia's airlines and broader economy will disrupt one of the strongest post-downturn domestic-market recoveries and put much of its international flying—more than a quarter of the market's airline activity—at immediate risk, an Aviation Week analysis shows.

Russian operators flew just over 49,000 domestic cycles in January—nearly 10% more than January 2019's comparable figure. Peak summer 2021 activity saw airlines top 60,000 cycles in June, July, August, and September—a figure not reached once in 2019 or 2020, with a stretch that saw the monthly figure bottom out at 13,000 in April 2020 because of COVID-19-related restrictions.

IATA's full-year 2021 figures showed Russia's domestic market generated 24% more revenue passenger kilometers (RPK) and 19% more capacity than in 2019—both tops among the seven major markets IATA tracks. Russia's domestic RPKs accounted for 4.5% of the world's total last year.

Flight bans by nearly 40 countries, including the entire 27-nation European Union, and Russia's retaliatory bans will strike a strong blow to the country's airlines. International flying accounted for 27% of Russian operators' cycles and 40% of flight hours in January, Aviation Week's Tracked Aircraft Utilization shows.

Even with limited reliance on international traffic, leisure traffic depends on disposable income, and general economic sanctions could have an indirect impact on consumers, leading to a decline in domestic travel demand.

With Russia representing about 6% of global airline capacity, if the conflict continues for a large part of 2022, it could delay the global recovery by about two months, IBA estimates. If, as seems likely, the crisis carries on for an extended period of time, the effects on the broader aviation industry will only deepen.

—With Victoria Moores and Daniel Williams in London

Top Five Lessors With Aircraft in Russia

		Number of Aircraft
Aercap Holdings		**152**
Boeing	737-700	3
	737-800	20
	737-800F	8
	737-900ER	4
	747-400ERF	2
	757-200	2
	767-300ER	6
	777-200ER	6
	777-300ER	10
Airbus	A319-100	22
	A320-200	16
	A320-200N	16
	A321-200	12
	A321-200N	2
	A330-300	5
	ACJ319/A319LR	1
Embraer	Embraer 170	17
SMBC Aviation Capital Ltd.		**39**
Boeing	737-800	7
Airbus	A320-200	11
	A320-200N	11
	A321-200	2
	A321-200N	6
	A350-900	2
BOC Aviation Ltd.		**29**
Boeing	737-700	2
	737-800	11
	747-8F	3
Airbus	A319-100	1
	A320-200	8
	A320-200N	2
	A321-200N	2
Air Lease Corp.		**28**
Boeing	737 MAX 8	1
	737-800	4
	777-300ER	1
Airbus	A320-200	5
	A321-200	6
	A321-200N	7
	A330-200	1
	A330-300	3
Dubai Aerospace Enterprise		**23**
Boeing	737-800	5
	767-300ER	2
	777-200F/LR	1
	777-300ER	3
Airbus	A320-200	8
	A321-200	1
	A330-200	3
	Grand Total	**271**

Source: Aviation Week Intelligence Network Fleet Discovery

Ukraine's Space Industry Faces Uncertain Future

- NORTHROP HAS ENOUGH FIRST-STAGE ANTARES ROCKETS FOR CYGNUS MISSIONS
- OTHER PROJECTS MAY BE DESTABILIZED BY CONFLICT

Anatoly Zak

Still in its early stages, the Russian invasion of Ukraine has dealt a terrible blow to the already struggling Ukrainian space industry. Although it is difficult to predict how this war will end, there is a very good chance that the main rocket development center in Dnipro, in the east of the country, might be taken out of business for years—if not entirely.

The Yuzhny (southern) machine-building plant, or Yuzhmash, was founded in the mid-1950s in what was then the city of Dniepropetrovsk, as an industrial base for mass production of early Soviet ballistic missiles. Given that the Soviet Union considered ICBMs the ultimate Cold War weapon, the factory quickly expanded and formed its own research and development (R&D) center, or a design bureau in Russian terms, known as KB Yuzhnoye. The organization, along with the plant and extensive testing base, grew into one of three leading industrial institutions in the Soviet Union, building a wide range of rocket equipment—and later, space hardware.



NORTHROP GRUMMAN

Yuzhmash is responsible for building the first stage of Northrop Grumman's Antares rocket, which launches cargo to the ISS.

In the first two decades of the post-Soviet period, the design bureau and factory retained extensive relations with contractors and suppliers in Russia. KB Yuzhnoye also turned into an expertise center in rocket propulsion for emerging space powers, including Brazil, China, India, Saudi Arabia and South Korea.

However, Yuzhnoye's cooperation with Russia abruptly ended in 2014, in the wake of the Russian occupation of Crimea. Since Russia was by far Yuzhnoye's largest customer, the center struggled to stay afloat. The manufacturing part of the complex in Dnipro, which became known as the Yuzhmash machine-building plant, was hit especially hard because it lost all Russian orders for the Zenit rocket, its largest product at the time. With the Zenit gone, the factory was left with just serial production of the first stage for the Antares rocket, built under a contract with U.S.-based Northrop Grumman, and work on the liquid-propellant engine for the upper stage of the European Vega rocket.

By February of this year, Northrop had launched a total of 16 Antares rockets carrying Cygnus cargo ships to the International Space Station (ISS) under a contract with NASA.

During a press conference before the Antares launch of Cygnus NG-17 on Feb. 19, Northrop Grumman said that it had all the necessary hardware for two extra missions to complete its Commercial Resupply Services (CRS-2) contract with NASA for the supply of cargo to the ISS. The company also had planned to bid for the CRS-3 contract with an upgraded Antares rocket but says it has to reevaluate its plans given the latest situation.

At least two fresh Antares boosters were completed in Dnipro and possibly even moved to the port of Mykolaiv on the Black Sea for shipment to the U.S., according to unconfirmed reports. But at the time of the Russian invasion on Feb. 24, with Mykolaiv reported to be under attack, the boosters appeared to be trapped in Ukraine.

As of Feb. 24, operations continued at the Yuzhmash plant, sources say. And the next day, despite internet reports that the Yuzhmash plant was completely destroyed, it remained intact, a source in the city says. Only one warehouse facility on the edge of the complex was hit during the first night of violence, according to multiple sources.

However, even if the facility survived the initial waves of the war, its prospects look bleak. If Russian President Vladimir Putin takes a long-term hold on the country or its eastern regions, neither the U.S. nor Europe would place any new orders for Antares or Vega projects.

In any case, the production of the Antares' first stage and the Vega engine were approaching their natural end even before the invasion began. Additionally, Putin is not likely to invest in the revival of sensitive strategic work in Ukraine.

Similarly grim prospects face the design and engineering team at Yuzhnoye. At the time of the invasion, the bureau was kept afloat by foreign contracts for rocket engine development. One such project was slow-going work on a kerosene-oxygen engine for an upper stage of a space launcher being considered by Saudi Arabia. Another prospective program was a rocket engine concept for China based on the Soviet-era RD-120 engine, which originally propelled the Zenit rocket's second stage.

None of the ventures between KB Yuzhnoye and its international customers would be viable under Russian control, one expert familiar with the matter says.

Even if the Russians wanted to resume R&D activities and to use the surviving infrastructure, they could also face a shortage of specialists willing to work for them. Despite a long tradition of space development in the city of Dnipro, it is a big question how much personnel would be available to the new regime. One KB Yuzhnoye veteran tells Aviation Week, "If Dnipro falls, I will do everything possible to leave the country."

ISS Partnership Is Being Put to the Test by War

> EXOMARS ROVER LIKELY GROUNDED

> POST-2024 FUNDING FOR STATION UNCERTAIN

Irene Klotz Cape Canaveral

Technically intertwined and physically remote, the 15-nation International Space Station (ISS) partnership has persevered through multiple administrations, changing mission goals, funding challenges, launch accidents and other problems. Yet those trials may pale in comparison to what lies ahead, as sanctions stemming from Russia's invasion of Ukraine continue to mount.

"There was a purposeful decision made in 1993 to make the station interdependent," says John Logsdon, former director of the George Washington University Space Policy Institute. "That makes it very difficult to decouple the Russian and U.S. elements.

"Over the years, whoever has been in charge of space policy in the White House has built walls around the space station to insulate it from the ups and downs of the U.S.-Russian relationship," Logsdon adds. "There's a purposeful attempt to keep the station out of contemporary political issues."

For example, despite airspace closures and other sanctions following Russia's invasion of Ukraine, on March 30 NASA astronaut Mark Vande Hei is scheduled to climb aboard the Russian Soyuz MS-19 capsule, currently docked at the station, and return to Earth, wrapping up a year-long mission. He will be accompanied by his ISS Russian crewmates, Anton Shkaplerov and Pyotr Dubrov.

"Despite the challenges here on Earth—and they are substantial—NASA is committed to . . . the working relationship with all our international partners to ensure [the crew's] safety and the ongoing safety of the ISS," NASA Administrator Bill Nelson told the NASA Advisory Council (NAC) on March 1.

"We as a team are operating just like we were operating three weeks ago," NASA Associate Administrator for Space Operations Kathy Lueders told reporters on Feb. 28, four days after the invasion. "Obviously, we understand the global situation, but these joint teams are operating together."

On Feb. 25, Russia boosted the space station's orbit, one of its primary roles for the last 20 years. A U.S. cargo ship owned and operated by Northrop Grumman, which is docked at the station, is scheduled to conduct an orbit-raising burn in April, a maneuver planned well before global tensions escalated.

Having more options for ISS station-keeping is the kind of contingency planning NASA develops on an ongoing basis. "We always look for how [to] get more operational flexibility," said Lueders, adding that it would be very difficult for the U.S to operate the station without Russia.

"The ISS was created as an international partnership with joint dependencies, which is what makes it such an amazing program," she said.

Nevertheless, in light of deteriorating relationships with Russia, NASA should consider assembling a tiger team to prepare contingency plans, says Wayne Hale, a former NASA flight director and manager who now oversees the NAC's Human Exploration and Operations committee. "It seems prudent," Hale says.



NASA

NASA astronaut Mark Vande Hei, pictured inside the station's cupola module, is due to return to Earth on March 30 aboard the Russian Soyuz MS-19 capsule that is visible through the cupola window.

Another concern is whether Russia and the ISS partners will agree to extend funding for it beyond 2024, when current commitments end. The Biden administration said in December it wanted the ISS to remain in orbit until 2030.

"One has to question [whether,] if the ISS survives today . . . it will survive post-2024," says NanoRacks founder and CEO Jeff Manber. "We're in a very grave situation for cooperation. There is precious little time," to make decisions about extending the ISS, he adds. "If you're talking about [ending the ISS] in 2024, it becomes very difficult to think of new investments."

NanoRacks is among three companies working with NASA to develop research platforms for the post-ISS era, though they are not expected to launch before 2027-28. Should the station end before then, NASA could make use of its crew and cargo transports and other spacecraft for free-flying missions until the new commercial outposts are available. "It's not ideal, but research could continue," Manber says.

Aside from the ISS, civilian space programs already are being affected. Russian Soyuz flights from the European Space Agency's (ESA) spaceport in French Guiana have been suspended. The joint ESA-Russian ExoMars rover mission, slated to launch aboard a Russian Proton rocket from the Baikonur Cosmodrome in September, will "very likely" miss its launch date, ESA said on Feb. 28.

The first of four Russian Antonov aircraft carrying ExoMars equipment from Europe to Baikonur was scheduled to depart on March 16, to be followed by the rover's flight to Baikonur aboard a Russian Ilyushin on April 3.

"We deplore the human casualties and tragic consequences of the war in Ukraine," ESA said in a statement. "We are giving absolute priority to taking proper decisions, not only for the sake of our workforce involved in the programs, but in full respect of our European values, which have always fundamentally shaped our approach to international cooperation."

ESA's words echo the wider European response to the Russian aggression. "To see the Europeans taking the lead here—and not just in space—has to be very disconcerting to the Russian decision-makers in our community," Manber says.

"Historically, Europe has been the bridge as the Russian-American willingness to work together in space ebbs and flows," he says. "Clearly for the Europeans, this is a reordering of the post-World War II norms. It is not a policy decision playing out. We're seeing almost raw emotional reactions."



The E175-E2's first flight occurred in 2019, but flight tests have now been suspended for three years.

EMBRAER IMAGES

Embraer's Complicated Conundrum

> AIRFRAMER PUTS E175-E2 PROGRAM ON ICE

> TURBOPROP LAUNCH DECISION IS PENDING

> REGIONAL JET MONOPOLY LIKELY TO REMAIN STABLE FOR NOW

Jens Flottau Singapore and Frankfurt

The decision to shelve further E175-E2 flight-test and certification efforts for the time being—and maybe for good—must not have been too difficult for Embraer. The single-aisle jet has no orders and no short-term prospects of market interest significant enough to justify spending more money on it, and U.S. scope clauses are not moving. Embraer is also facing a more complicated question: Should it really build a new large turboprop aircraft, and if so, when is the right time to launch it?

Both projects require large—and in the case of the turboprop, very large—capital expenditure despite a very uncertain market environment. There is no certainty about when or even if scope clauses in the U.S. might be relaxed to the extent needed to ensure that the E175-E2 could be compliant. Similarly, the turboprop market would be far larger if sales to U.S. carriers were realistic. Timing is also a crucial, complex factor: The later the E175-E2 and the turboprop enter service, the more likely it is that operators will have next-generation hybrid or hydrogen-powered options available to them, possibly from the mid-2030s or even sooner. On the other hand, the longer Embraer waits to launch a new turboprop, the more new technology it could incorporate; but if it moves too quickly, fewer propulsion benefits will be possible.

As with virtually all aircraft manufacturers, Embraer is emerging from the novel coronavirus pandemic severely bruised. Any business plan formulated before the crisis unfolded has long been overtaken by events. Even so, the strategic positioning of Embraer's commercial aircraft business is unique: While damaged in the short and probably medium term, it also has a temporary monopoly in the traditional regional jet market, now that production of Bombardier's CRJ series has ceased and the Mitsubishi SpaceJet has been delayed indefinitely.

Last year made evident how difficult the current business climate is. Embraer delivered 48 commercial aircraft. Among them were just two E190-E2s and 19 E195-E2s. The first-generation E175 made up the majority of deliveries, with 27 units being handed over to U.S. regional airlines. The numbers reflect a slight uptick from 2020, when 44 aircraft were handed over (32 E175s, one E190, four E190-E2s and seven E195-E2s). But in 2019, its customers took delivery of 89 aircraft, 67 of which were E175s.

Embraer's firm-order backlog for commercial jets consisted of 325 aircraft at the end of 2021. While that provides stability, the backlog is uncomfortably tilted toward a small number of customers. There are 147 E175s to be delivered, but 100 of them are going to one airline, Republic Airways.

The E175-E2 is not the only model in the second-generation E-Jet family in trouble. There are only five more E190-E2s left to be delivered. Of the 170 E195-E2s on firm order, 72 are for lessors AerCap, Aircastle and Azorra. Another 81 aircraft are allocated to just two airlines—Azul and Porter.

The Brazilian manufacturer launched the E175-E2 assuming that scope clauses limiting the use of large regional aircraft in the U.S. would have changed in time for the arrival of the aircraft, and airlines would have found the prospect of flying the latest version of the E175 so economically attractive that they would have been willing to negotiate new agreements with pilot unions. However, the unions did not show any willingness to relax scope clauses, nor was the item as high on the airlines' agenda as Embraer had hoped. Surprisingly for Embraer, U.S. carriers have simply continued to order the E175-E1 in large quantities.

Typically, regional airlines operating on behalf of U.S. major carriers cannot fly aircraft that have more than 76 seats or weigh more than 86,000 lb. The E175-E2 has space for up to 90 passengers in a single-class layout or 80 in three classes. More important, its maximum takeoff weight

(MTOW) is 98,120 lb., around 10% higher than scope clauses permit. Making it compliant would require a massive weight reduction that company insiders say would be unlikely to be achievable. Instead, further improvements to the E175-E1 are being considered.

For now, the second-generation version has been put on ice for three years. The manufacturer said in a regulatory filing that "as in previous years, the reprogramming of activities is associated with the ongoing U.S. mainline scope clause discussions with the pilot unions regarding the maximum takeoff weight limitation for aircraft with up to 76 seats, together with current global market conditions for commercial aviation and the continuing interest in the current E175 jet in the U.S. market." Embraer "expects to resume the program development activities following the aforementioned period, which will result in a reprogramming of the aircraft's entry into service between 2027 and 2028."

Embraer initially had a firm order from SkyWest Airlines for 100 E175-E2s that it had to remove from its backlog in 2018, as no scope clause movement was in sight. Following that cancellation, no orders were left. The E175-E2 nonetheless made its first flight on Dec. 12, 2019, and has been in a slow-moving flight-test campaign since. Embraer already has delayed entry into service once, from 2021 to 2024, given the lack of market interest and the impact of the novel coronavirus pandemic.

Whether or not the E175-E2 project will be resumed will largely depend on scope clause relaxation in the U.S. The longer the process takes, the less likely any resumption becomes. The ongoing pilot shortage could ultimately entice regional carriers to move scope up even higher to include larger E2 versions. Any order from an airline outside of North America would likely not be large enough to justify the investment needed to finish flight testing and certification.

And then there is the turboprop project addressing shorter-range markets that would call for a similarly sized aircraft with 70-90 seats requiring significant capital expenditure in the coming years. Embraer has been talking about the possibility of launching that aircraft since around 2018, well before anyone knew the industry was heading into its deepest crisis. The company initially tied the project to regulatory approval for the planned takeover by Boeing of its commercial aircraft division at a time when the European Commission was dragging its feet on making a decision.

Of course, the lobbying turned out to be pointless when Boeing pulled out of the deal in 2020. The project survived nonetheless, and in spite of earlier claims that it could not proceed without major corporate support, Embraer last year changed direction by adopting a substantially different design—moving the engines to the rear.



Embraer is in talks with engine manufacturers about its planned new turboprop.

That decision remains in place. Now Embraer's preparations for the possible launch are focusing almost entirely on the selection of an engine manufacturer and determining how much new technology the powerplant will include. The answer could have substantial ramifications, both in terms of the aircraft's efficiency and its timeline.

Embraer Commercial Aviation CEO Arjan Meijer said at the recent Singapore Airshow that the company is engaged in talks with all three major engine manufacturers about the project. But each of them has differing interests: Protecting its position in the turboprop market (Pratt & Whitney Canada) or the option of entering it at all (General Electric and Rolls-Royce). For all three, the level of innovation needed is going to be pivotal and, according to Meijer, all have different ideas about what a future turboprop engine could look like.

Should Embraer go for an engine largely based on existing technology, a launch decision must still be made by the end of this year for service entry in 2027. A more advanced powerplant could take longer, and a possible delay of some years would mean any new turboprop engine would lose some of the timing advantage it has over more revolutionary projects such as Airbus' ZEROe aircraft, currently targeted to enter service by 2035.

Embraer is looking at a two-aircraft family, with the smaller version seating around 70 and the larger up to 90 passengers in a single-class layout. The OEM plans to use what is essentially an E-Jet fuselage.

Moving the engines to the rear was favored by U.S. airlines, which argue that move would gain better passenger acceptance and cabin comfort. Embraer says U.S. airlines have shown an interest in operating the smaller version in a 50-seat, three-class layout, replacing aging 50-seat regional jets. The manufacturer estimates the 50-seater replacement market in the U.S. alone is around 500 aircraft.

Moving the engines to the back of the aircraft would also enable easier integration of a future hydrogen propulsion system, if and when that technology becomes ready. While the aircraft is to be designed for a maximum range of 800 nm, most sectors would be 250-300 nm.

FAA Faces Challenging Transition After Dickson's Departure

> HIS SUCCESSOR MUST JUGGLE SEVERAL HIGH-PROFILE ISSUES

> DICKSON'S TECHNICAL EXPERTISE WILL BE SORELY MISSED

Sean Broderick Washington

FAA Administrator Steve Dickson's unexpected decision to leave the agency at the end of March saddles his successor with several high-profile safety issues that are facing critical near-term milestones.

Dickson announced on Feb. 16 that he will leave effective March 31, roughly halfway through his five-year term, to "devote his full time and attention" to family. That brief window gives senior leadership some time to make necessary personnel adjustments and prepare his replacement to take over.

Ensuring that 5G C-band services safely coexist with aircraft radio altimeters is even more important to the industry. A handshake deal between the FAA and wireless providers AT&T and Verizon Wireless to limit deployments around some airports expires in July (*AW&ST* Jan. 24-Feb. 6, p. 30). As a result, the FAA's new top official will play a role in determining what happens next—especially if additional concessions are needed to avoid disruptive flight operations bans.

Another relatively new priority that Dickson's successor will inherit: making sure that requirements in new aircraft certification legislation passed by Congress at the end of 2020 are met.



Steve Dickson has led the FAA through the pandemic and helped reset its relationship with Boeing.

MIKE SIEGEL-POOL/GETTY IMAGES

Deliveries of Boeing 787s remain on hold while the agency and company hash out protocols for inspecting and repairing each aircraft (*AW&ST* Dec. 6-19, 2021, p. 14). Barring rapid progress in the next several weeks, Dickson's immediate successor may have to sign off on staff recommendations that deliveries be allowed to resume. The new administrator also will be tasked with seeing that the additional attention being paid to Boeing is not pulling too many resources from other regulatory priorities.

Dickson will leave office before the 787 and 5G sagas are over, but his work during the last 30 months has helped the FAA regain some of the footing it lost during the 737 MAX grounding. He took office in August 2019, five months after Ethiopian Airlines Flight 302 went down—the second fatal 737-8 accident in less than five months. Dickson immediately began reorienting Boeing's focus away from reassuring customers and Wall Street that progress was being made on winning regulatory approval for required changes to the 737 MAX, urging the company instead to focus on actually making progress. Sign-off on the aircraft modifications and pilot training would not come for another 15 months, following extensive deliberations with—and criticism from—international regulators and other industry stakeholders (*AW&ST* Nov. 23-Dec. 6, 2020, p. 16).

Dickson backed staff who questioned Boeing's 787 quality control, ultimately leading the company to halt deliveries, reduce production and redouble efforts to solve its production issues. The situation has left 787 deliveries on hold for nearly a year, and neither Boeing nor the FAA will predict when that will change.

The FAA announced on Feb. 15 that when deliveries restart, its inspectors will be going over and signing off on every aircraft, an action often delegated to a manufacturer. The agency made a similar move when 737 MAX deliveries resumed in December 2020—a task that it has not handed back to Boeing.

Unless there is a change in protocol, Dickson's seat will be filled by Deputy Administrator Brad Mims, who will occupy the role while a successor nominated by President Joe Biden is vetted and confirmed by the U.S. Senate. Mims has held his position as the FAA's deputy administrator since February 2021. His 40-year career includes serving as head of government relations for the FAA during the Clinton administration, working as a Capitol Hill staffer and stints at several transportation-focused consultancies.

Mims lacks the technical background that Dickson, a former U.S. Air Force pilot and long-time Delta Air Lines captain and executive, brought to the job. But his Capitol Hill experience and ties to the Biden administration could prove beneficial for an agency still struggling to convince some that it is applying lessons learned from recent failings—notably the 737 MAX certification and oversight crisis.

Rep. Pete DeFazio (D-Ore.) is one of several lawmakers who say the FAA has not done enough to hold anyone accountable for the 737 MAX and 787 problems nor moved fast enough with certification and oversight reforms put in place as a result of the MAX problems. Nevertheless,

he credited Dickson's leadership.

"While Administrator Dickson and I didn't always see eye-to-eye, I thank him for his dedicated service to our country during such a challenging time for aviation," DeFazio says.

Representatives from both sides of the political aisle and around the industry agree on one thing: The Biden administration should act quickly to fill the impending void atop the FAA with a capable leader who carries on Dickson's penchant for collaboration.

"My airline labor colleagues and I agree that Administrator Dickson has been the most accessible FAA administrator we have encountered," Allied Pilots Association (APA) President Eric Ferguson says. "The willingness to engage all stakeholders has been especially welcome."

The APA suggested three possible nominees to the Biden administration. Like Dickson, each is a pilot. The APA's short list consists of former Ohio congressman and state representative John Boccieri, a United Airlines pilot and member of the U.S. Air Force Reserve; Teamsters Airline Division Director David Bourne; and current Air Line Pilots Association President Joe DePete.

"While Administrator Dickson and I didn't always see eye-to-eye, I thank him for his dedicated service to our country"

"Each one of these highly qualified individuals has affirmed their willingness to serve in this vital, safety-sensitive capacity," Ferguson says.

Losing Dickson's technical expertise comes at a particularly vulnerable time for the FAA. Some top agency officials' participation in an interagency 5G working group has led to temporary changes in responsibilities, with several senior staffers taking on acting roles. Elevating the agency's second-highest official to the top job, even temporarily, and the related ramifications could place more strain on its senior executives.

Dickson's departure also will come just months after Billy Nolen started as associate administrator for aviation safety. The former U.S. Army aviator, airline captain and industry executive brings welcome technical expertise to the agency's top career safety position. However, Dickson's departure gives Nolen one fewer colleague to help him navigate the political and bureaucratic aspects of his new role.

The FAA's Air Traffic Organization, its operations arm and largest component, is navigating its own leadership changes. Chief Operating Officer Teri Bristol announced her retirement effective March 1, and Pamela Whitley, assistant administrator for NextGen, retired at the end of January.

—With Bill Carey in Washington

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Earth Observation Emerges as New-Space Growth Area

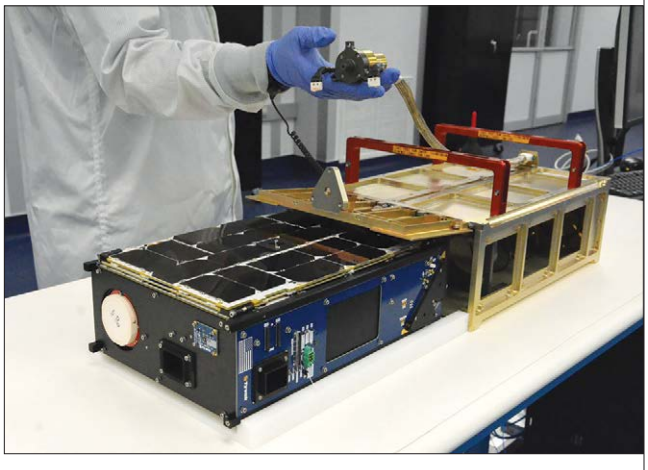
> STARTUPS EYE INCREASING DEFENSE AND CLIMATE-MONITORING DEMAND

> MARKET IS FORECAST TO GROW INTO THE BILLIONS OF DOLLARS THIS DECADE

Michael Bruno Washington

After years of startup space-launch companies rocketing to fame and possible fortune and the communication satellite market increasingly dominated by big brands, entrepreneur and investor attention is turning to other new-space segments. Chief among them is satellite-based Earth observation.

While venture capitalists, analysts and consultants predict a dropoff in the number of rocket companies, Earth-observation satellite businesses remain on an upswing. That is thanks to continued investor interest, a fragmented and exploitable marketplace and rising government and commercial demand for satellite-based services for everything from climate change response to national security.



TERRAN ORBITAL

"[Earth observation] is a big market, and it's getting bigger," Terran Orbital CEO Marc Bell told a public investor briefing Feb. 17, ahead of his startup's planned reverse merger in March with a special-purpose acquisition company (SPAC).

"This market is expected to have exponential growth owing to the surge in the demand for satellite imagery data throughout various industries," echoed a MarketsandMarkets report.

According to Quilty Analytics' latest Earth observation and geospatial quarterly briefing, the total Earth-observation business ecosystem will grow to a $26.3 billion enterprise by 2025 from almost $20 billion in 2020. The consulting firm parses the market into three segments—infrastructure, data processing and distribution, and downstream geointelligence (geoint) and analytics. It forecasts compound annual growth rates (CAGR) for each: Infrastructure will grow at a CAGR of 2.5% to $9.1 billion, data processing at 11.3% to $3.5 billion and geoint at 6.8% to $13.6 billion.

Other forecasts vary by approach, but all point upward. Euroconsult said in its latest Earth-Observation Satellite Systems Market report that manufacturing revenue for Earth observation should grow to $76.1 billion by 2030, bolstered by existing government programs, new entrants and diversified commercial constellations. That compared with $65.8 billion in 2011-20.

As many as 90 constellations accounting for 78% of Earth-observation satellites by the end of the decade will be built and launched. While most of the 2,600 satellites to be launched will be for commercial applications, the bulk of manufacturing revenue remains driven by civil and military government programs, as the latter accounted for 80% of satellite value during the last decade, according to Euroconsult.

Earth observation has so much potential that small-satellite manufacturer Terran Orbital will offer it as its only in-house payload capability for customers. Just the commercial-focused Earth-observation market alone, including use of space-based synthetic aperture radar (SAR), could be worth $35 billion combined through 2026, according to company documents. But managers at Terran's SPAC, Tailwind Two Acquisition, say that when combined with the classified government Earth-observation market, the total addressable market could be three times that.

New-space author and researcher Laura Forczyk tells Aviation Week that one reason Earth observation is taking off is that there are both technological and business model iterations to exploit. Size, weight and power advances in satellites, coupled with lower launch costs and improvements in imagery such as SAR, leave room for niches to open up and be claimed. Meanwhile, as is happening across the new-space sector, Earth-observation startups can expand service offerings upstream and downstream. "What is the hot area now is not necessarily getting the data but processing the data," she says.

Terran Orbital's Tyvak subsidiary was the hardware provider for the Community Initiative for Continuous Earth Remote Observation (Cicero), a constellation of 6U nanosatellites in low Earth orbit that collect climate and weather data for commercial companies and governments.

While Earth observation has been around for decades, it was largely a cottage industry of traditional defense prime contractors providing just the large, "exquisite" geoint imagery satellites under billion-dollar government acquisition awards. The U.S. intelligence community in the early 2000s started using commercial purchase practices, stirring some change among those competitors. But in recent years, numerous factors have been combining to drive an unprecedented overhaul and expansion of the marketplace. According to Quilty Analytics, these include:

- Broader awareness of the potential value of space-based geointelligence.
- Increasing demand in defense and an expanding range of commercial applications.
- New, lower-cost satellite systems and emerging sensor types.
- An influx of new and valuable, albeit lower-cost, Earth-observation data that triggers new uses.
- Downstream technologies including cloud, artificial intelligence (AI) and machine learning to harness Earth-observation data.



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How Earth-Observation Spacecraft Manufacturers Align



Note: This list excludes companies with merchant supplier offerings. Some of the companies listed are not fully vertically integrated.

Source: Quilty Analytics

Consultants see a positive feedback loop spiraling higher. "In addition to the impact of cloud, the satellite data services industry finds itself at the junction of two revolutions, one being the big data/AI and the other being the commercialization of space through its main drivers, small and microsatellites," the MarketsandMarkets report said.

For Earth observation, both government and private-sector markets also are experiencing internal changes that help drive demand. "Really traditional purposes include spy satellites for national security, and obviously that continues to be important," Raphael Roettgen, managing partner of E2MC Ventures, told a Constellations Podcast. "But it reaches as far as climate tech. I mean, a lot of the things, data that we know about climate is basically coming from remote-sensing satellites."

Steve Isakowitz, CEO of Aerospace Corp., agreed about climate change driving business potential across the board, as well as the feedback loop of new technology. "Another area is with companies that are exploring new wavelengths in the electromagnetic spectrum," he told the SpaceDotBiz Podcast. "It's not just visible, its radio frequency, SAR, and these others that until recently I think weren't really thought of as having commercial markets."

Not surprisingly, numerous startups are emerging. "We've leaned into that," Orbital Sidekick CEO and co-founder Dan Katz told Aviation Week in February. "We definitely think of ourselves as a dual-use company."

Orbital Sidekick is hoping that its new investor In-Q-Tel, which has funded technology for the national security sector since 1999, will "elevate its support of national security for the U.S. and its allies," a Feb. 17 announcement states. Katz further said the San Francisco startup, which is looking to double its staff to 66 workers this year, could announce another venture capital round this quarter. The company raised $16 million in Series A last year and then landed a $16 million U.S. Air Force SBIR Phase 2 award.

Orbital Sidekick plans to launch a Global Hyperspectral Earth-Observation Constellation of six 100-kg ESPA-class satellites in the second half of this year via a SpaceX Falcon 9. Each satellite will capture 512 spectral bands at high resolution with a daily revisit rate for mostly North American locations.

Like many new-space entrepreneurs, Katz describes a journey for his six-year-old startup that started with expecting to serve a large, albeit purely commercial marketplace, but gradually embracing the Pentagon's growing interest in tapping Silicon Valley. The startup eyed mining and energy sector operations, such as pipeline monitoring, but now also provides raw data streams to the Pentagon. Both public and private sector customers increasingly are interested in environmental monitoring. While he sees an inflection point in the next decade where government revenue will not be necessary, it remains critical this decade, both for income and the imprimatur.

"With the space economy, if someone comes to you and says, 'we're a pure commercial player and don't take any money from the government,' that is probably not [possible]," Katz said. "The space economy is not mature enough to probably handle a pure commercial play right now. And also, you're reducing your market opportunity."

Others agree. "The commercial market is not there yet guys," Terran Chief Financial Officer Gary Hobart told his investor-day audience. "We are very focused on our defense and intelligence customers."

Terran is not the only Earth-observation player to go public. Twelve-year-old Satellogic, an Earth-observation satellite systems and analytics company, became publicly traded in late January after its own SPAC deal. It took an 11th-hour investment boost from former Trump administration Treasury Secretary Steve Mnuchin to help the deal close. But executives and investors walked away as confident about the company's prospects as ever.

"It is hard to overstate the importance of up-to-date, high-resolution Earth imagery as an aid to decision-making across a broad variety of contexts," Mnuchin said in the announcement.

Meanwhile, several other companies continue to raise funds in the venture capital and private markets. Satellite-

Earth-Observation Market Downstream Is Fragmented



Source: Quilty Analytics

powered hyperspectral imagery and analytics startup HySpecIQ is aiming to raise more funds and grow its small staff ahead of an expected September 2023 launch of its first of 12 orbital assets, a new executive tells Aviation Week.

The Herndon, Virginia-based company, which is scaling up after a high-profile infusion of $20 million from technology investor Peter Thiel, plans to launch another satellite each in 2024 and 2025, said Tim Abbott, who joined last fall as senior vice president of product and sales. HySpecIQ hopes to have its full constellation in orbit by 2028. "We are raising money, and once we launch we don't think we'll need additional capital because we think we'll be in a good place with two satellites up," he said.

The latest venture capital trends reported in Space Capital's fourth-quarter 2021 briefing indicated strong investor interest. EO and communication satellite startups are taking over the attention of early-stage funders who were once focused on small-rocket startups. Increasingly, they are looking to companies focused on SAR, RF and hyperspectral applications as well as Internet of Things connectivity, according to Space Capital. At the same time, annual investments in startups offering Earth-observation-based applications doubled in 2021, reaching $560 million.

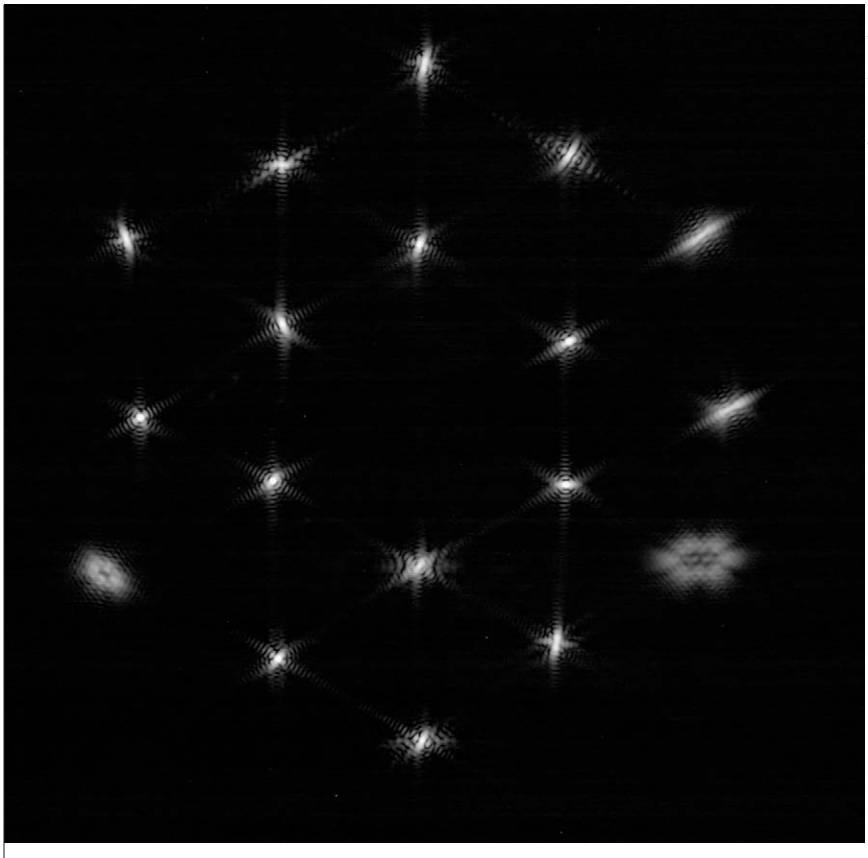
Satellites as a whole have accounted for the most deal activity since 2021, accounting for 52% of total round share, said Space Capital. Within satellites, manufacturing and components and Earth-observation sectors account for a combined 77% of total funding-round activity.



Coming Into Focus

- WEBB TELESCOPE MIRROR SEGMENTS FIND TARGET STAR
- SCIENCE PROGRAM IS SLATED TO BEGIN IN JUNE

Irene Klotz Cape Canaveral



NASA/STSCI/J. DEPASQUALE

Alignment of the James Webb Space Telescope's primary mirror began with each of its 18 segments taking an image of the bright, isolated star HD 84406, located in the constellation Ursa Major. Over the next several weeks, the 18 segments will be adjusted so that they generate a single image.

At first blush, there is nothing particularly noteworthy about HD 84406, a bright, isolated star located near the bowl of the Big Dipper in the constellation Ursa Major. But as the first target imaged by the newly launched James Webb Space Telescope, the star now holds an honored place in the annals of astronomy.

Blurry images of HD 84406 began reaching anxious engineers at the Space Telescope Science Institute control room in Baltimore shortly before 2:30 a.m. EST on Feb. 2. Though meaningless for science, the pictures showed that the 18 segments comprising the James Webb Space Telescope (JWST) primary mirror had remained optimally positioned despite launch vibrations, exposure to zero gravity, panel deployments and an extreme temperature shift. Each segment returned a distinctive image of the star, providing positioning data for an ongoing mirror alignment.

"It's a real testament to the care and precision with which the observatory was put together on the ground and to how smoothly the ride to space and all those deployments went," Marshall Perrin, JWST's deputy telescope scientist, told reporters on Feb. 11. "That has put us in a great starting point to begin aligning those mirrors to act as one."

Engineers had expected the mirror segments to be misaligned by up to 1 mm, which would have made the hunt for HD 84406 elusive. "Those 18 spots of light could potentially [have been] spread over the sky," Perrin noted.

To begin, JWST took images with its Near Infrared Camera (NIRCam) of a swath of sky about as big as the full Moon to ensure all 18 mirror segments would be able to find the target star. JWST was repositioned 156 times and collected more than 1,500 images for that effort.

"As we watched the data come down . . . we started seeing those bright spots of light that we were looking for. We were able to find all 18 segment images within the first 10% of the search area," Perrin said. "There was one particular moment that first evening when one set of images came in, and in the next set . . . we could see maybe eight more segments all clustered close together and even more in the next image right after that. That was a real 'wow' moment."

Imaging HD 84406 also provided the Webb team its first opportunity for integrated telescope operations. For example, the mirror and NIRCam gathered light, software scripts controlled the observatory's pointing and took images, and ground teams ran observation planning software and collected processed images. "All these systems acted together in the way they will for science observations," Perrin said. "It went very smoothly."

So far, the pointing of the telescope relative to the spacecraft and the individual pointing of the 18 primary mirror segments have matched predictions, Lee Feinberg, JWST's optical telescope element manager, told reporters. "At this point . . . we don't see anything of concern."

The next step is to align the mirror segments so that images of the target star appear on top of each other, a process known as image stacking. "It is a bit of a long process because we have to take images, analyze them using software . . . and get those images on top of each other," Feinberg said.

Mirror movements are controlled by tiny actuators located on the back of the segments. Each segment has six actuators, paired in groups of three into hexapods to control tip, tilt and roll. A seventh actuator, located in the center of each segment, controls radius curvature.

"The actuators themselves are actually an amazing achievement," Feinberg said during an interview on NASA TV. "They were designed by Ball Aerospace using these special little gear motors that can move

the mirrors in steps that are just a fraction of a human hair. The smallest step that we can move is about 20,000 times smaller than the width of human hair."

Once the target star image is stacked, the mirror segments will be positioned to operate as a single monolithic mirror through a process known as phasing.

Imagine you have surfers in the ocean each riding a different wave, Feinberg tells Aviation Week. "What we need is for all of those surfers to be on the same wave. We need all of the mirrors to be essentially on the same wave of light . . . otherwise we will get images that are kind of confusing," he adds.

The work is divided into coarse and fine phasing, the latter of which is based on algorithms developed to diagnose and correct the spherical aberration discovered on the primary mirror of the Hubble Space Telescope shortly after it reached orbit in 1990. "Just from the images that Hubble could send down, they had to come up with a way to determine the prescription," Feinberg says.

The technique that was used, known as phase retrieval, involved moving Hubble's secondary mirror to take images that were out of focus. From those, engineers applied an algorithm to determine the shape of the primary mirror and calculate the prescription for corrective optics, which were installed during the first Hubble servicing mission in December 1993.

"Phase retrieval allows you to figure out the wavefront of light from these out-of-focus images," Feinberg says.

When work began on what was originally known as the Next-Generation Space Telescope, renamed later as Webb, teams began looking at how to align a segmented mirror in space. Ground telescopes typically use a Shack-Hartmann (or Hartmann-Shack) wavefront sensor, which is an optical instrument for characterizing an imaging system.

"That would have meant a whole dedicated instrument requiring hundreds of kilograms and dedicated volume," Feinberg says. "The team was really looking for a way to just use JWST's main science camera—NIRCam—to do the entire wavefront sensing control process, which is the process of aligning the telescope, and most critically, the fine alignment, which is the last step."

Engineers realized they could essentially use the same technique that measured Hubble's flawed mirror to do the final shaping of the JWST primary mirror, which will align the segments to about 0.005 of the width of a human hair.

"The one big difference is that we don't tend to like to move secondary mirrors frequently," Feinberg says. "There's always the risk over time that something gets stuck or whatever. So the idea was to put little lenses inside of the filter wheel of NIRCam to create these out-of-focus images . . . and then apply these algorithms.

"You need more than one out-of-focus image to do this properly," he adds. "You can't just look at one image, and the images need to be out of focus to use the phase-retrieval algorithm."

The algorithm used for Hubble was further developed to include mirror segment motions for JWST. "What you're really trying to solve for are the positions of the mirrors—how do the mirrors need to tip, tilt and move so that you align it?" Feinberg says.

"The Webb primary mirror could have corrected the Hubble spherical aberration pretty well just using the actuators that we have," he adds.

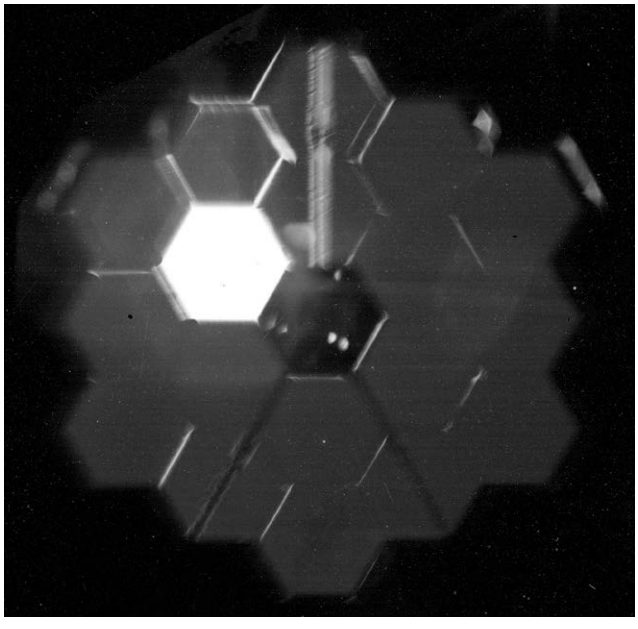
JWST will not be the last telescope to benefit from the heritage Hubble technology. Phase retrieval is being used for coronagraphs, which are high-contrast imaging tools, and the technology will play a key role in several systems being developed for the Nancy Grace Roman Space Telescope, which will search for dark energy and dark matter. The phase-retrieval algorithm also is expected to be part of a proposed optical ultraviolet observatory that will succeed Webb.

"We're starting to think about what's going to happen after Webb," Feinberg says. "We definitely think we'll be using these algorithms again because it's very likely we'll have more segmented telescopes. In the future, there's the thought that we can do more computational capability onboard, as they are starting to do with coronagraphs. That's probably where things will migrate."

Once Webb's primary mirror is aligned, the secondary mirror will be adjusted so that light can reach all four JWST science instruments. The observatory was launched on Dec. 25 and reached its operational orbit about 1 million mi. from Earth on Jan. 24.

Science operations are expected to begin in late June. In the first year, more than 300 observation programs are planned, covering four broad themes: first-generation galaxies, which formed more than 13.5 billion years ago; how galaxies evolved over the history of the universe; how stars and their planets form; and planetary systems, both in the Solar System and beyond.

NASA



This "selfie" was created using a specialized pupil imaging lens inside of the James Webb Space Telescope's NIRCam instrument. The lens is designed to take images of the primary mirror segments instead of images of space, a configuration solely used for engineering and alignment purposes. In this image, one of the telescope's 18 mirror segments was pointed at a bright star.

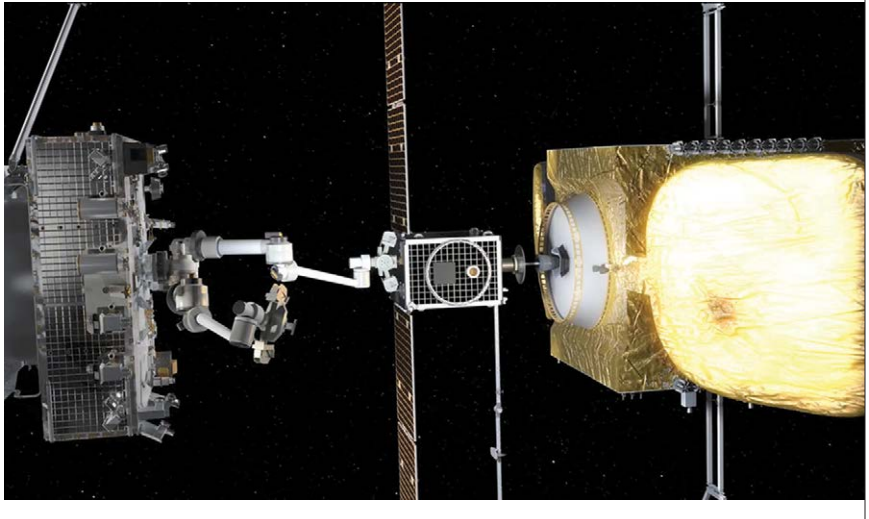
Satellite-Servicing Mission Lands Customer and Launch Agreement

- SPACEX TO LAUNCH ROBOTIC MISSION IN 2024
- DARPA'S RSGS PAYLOAD AIMS TO DEMO PERSISTENT ROBOTIC SERVICING

Jen DiMascio Washington

Northrop Grumman is taking the next step in its space-servicing business, SpaceLogistics, with the sale of its first Mission Extension Pod and a launch agreement with SpaceX for a Mission Robotic Vehicle.

Optus, Australia's largest satellite owner and operator, has an agreement with Northrop's SpaceLogistics for the installation of one Mission Extension Pod (MEP) on a D3, K_u-band communications satellite in 2025.



NORTHROP GRUMMAN

These two milestones come on the heels of the company's successful launch and operation of two Mission Extension Vehicles (MEV). The MEV is a 2,500-kg (5,512-lb.) spacecraft that docks to a satellite to control its orbit and attitude.

MEV-1 docked with Intelsat 901 in February 2020, adjusted the satellite's inclination by 1.6 deg and relocated it in geostationary orbit. On April 2, Intelsat then transitioned about 30 of its commercial and government customers to IS-901. A year later, in April 2021, Northrop repeated the feat when MEV-2 successfully docked with the Intelsat 10-02 satellite at 1 deg. W. Long. that was running out of fuel. The docking was to enable the satellite to remain in service for up to five more years.

Compared with the MEV, the MEP is a smaller, customer-owned and -controlled device that extends the lives of satellites by six years and performs orbit control; the Mission Robotic Vehicle (MRV) is a servicing vehicle with two robotic arms that install the pods.

"The payload is so much more than just the robotic arms," says Ana Saplan, program manager for Robotic Servicing of Geosynchronous Satellites (RSGS) at DARPA, which is working through a public-private partnership with Northrop. "[The payload] includes all the components necessary to accomplish the missions—tools that would be stored on the vehicle [and] then used at the end of the arms, and the cameras both on the back of the vehicle as well as at the end of the arms in order for you to do inspection. There [are] lights, all the software and the avionics to control the payload."

Those systems include light-detection and ranging sensors: one for dual, fault-tolerant rendezvous proximity operations used by the MEV with a chemical propulsion system that can be refueled, as well as an electric propulsion system for orbital maneuvering.

The MRV and MEP completed their respective preliminary design reviews in the fall of 2021. They remain on schedule for critical design reviews in 2022 and are set for launch in 2024. The MRV's primary mission is to test the ability of its robotic arms to install MEPs on commercial satellites. The MRV will launch three MEPs in all, as well as enable robotic inspection, relocation and repair of satellites.

This mission will be the first robotic-capable spacecraft for "persistent robotic servicing capabilities" in geostationary orbit, Northrop says.

That will begin, according to DARPA, by testing the spacecraft's robotic capabilities just after launch, during its orbit raise. "We're hoping that we will be able to demonstrate how the tools work," Saplan says. "We will be able to turn on the lights and do inspection as we initialize the payload and show that all the components are working. Although it's not a servicing mission with another spacecraft, we will be able to prove out some of the robotic capabilities during checkout."

Later, the MRV will use its robotics to conduct on-orbit augmentation capabilities, including the installation of the MEP on another satellite, says Northrop spokesman Paul Swiergosz.

The Mission Robotic Vehicle uses robotics to attach Mission Extension Pods, augment propulsion and extend the lives of commercial satellites running out of fuel.

"The exchange for us is that we own the robotics in exchange for demonstrating those capabilities in space," Swiergosz says. "So fulfilling one of DARPA's demonstrations will include installing an MEP on the Optus satellite."

Extending the life of a satellite goes beyond what China recently accomplished when its SJ-21, which China has described as a space-debris mitigation satellite, moved an inoperable satellite into graveyard orbit. The MRV will be able to install on-orbit augmentation capabilities, such as an MEP, and perform repairs and relocations, he adds.

"Satellite owners are demonstrating enthusiasm and confidence for our life-extension solutions and the potential cost savings they could provide," says Joseph Anderson, SpaceLogistics vice president of business development. "Our Optus contract represents our third service contract with commercial satellite providers. And with several signed term sheets in queue, our installation manifest for MEPs is already full for 2025 and nearly full for 2026."

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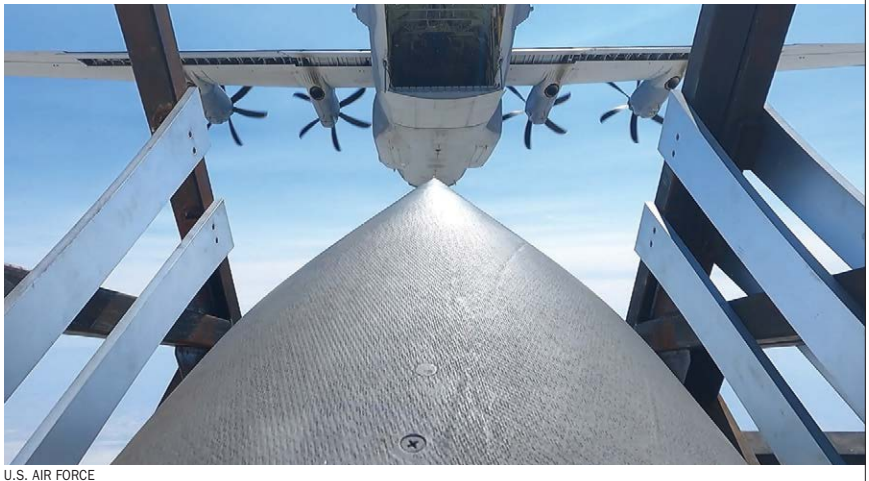
> ITS MISSION HAS CHANGED, BUT ITS FUNDING HAS NOT

> FLOATPLANE DEMO IS ON TRACK FOR 2022

Steve Trimble Fort Walton Beach, Florida

An inconvenient fact is not lost on the head of U.S. Air Force Special Operations Command as the organization prepares to demonstrate a new amphibious capability for the Lockheed Martin C-130J later this year.

The nearly 70-year-old C-130 has proven to be one of the most adaptable designs in aviation history, but attempts to convert the tactical airlifter into a seafaring floatplane have eluded several operators over the decades. U.S. Air Force Lt. Gen. Jim Slife, who earned aerospace engineering degrees from Auburn University and Embry-Riddle Aeronautical University, understands the challenge.



U.S. AIR FORCE

"It's been a long time since I studied aerospace engineering, but I know if you were going to build an amphibious airplane you probably wouldn't start with a C-130," Slife told an audience at the Special Air Warfare Symposium on Feb. 23.

Nonetheless, a concept to install two massive floats to the fuselage of a C-130J is moving forward. The floatplane modification has passed the preliminary design review, and a flight demonstration remains on track for the end of 2022, Slife said.

Despite the C-130J's inherent weaknesses as an amphibious aircraft, the heavy floatplane concept is at the heart of a strategic pivot by Air Force Special Operations Command (AFSOC) to a new era of special air warfare after spending the last two decades focused on fighting violent extremist groups. In a strategic competition with China, exotic new capabilities are being contemplated such as a C-130 that can pick up special forces or cargo dropped off by submarines on the surface of an ocean.

"If you convert the entire South China Sea into a landing strip, can you think of the dilemmas that you can create for China?" Slife asked the symposium audience. "Are there things you would want to put into the water or things that you might want to extract from the water that could create a lot of consternation for China? Absolutely."

But the C-130 floatplane concept also highlights the major constraint facing AFSOC's attempt to pivot to strategic competition with China: a lack of funding.

A failed attempt to rescue hostages in Iran in 1980 prompted an influx of funding to build up AFSOC as a global crisis response force. Twenty years later, the aftermath of the terrorist attacks on Sept. 11, 2001, expanded AFSOC's mission. For the next two decades, AFSOC led the airpower response to wars against insurgents and terrorists. The second transformation drove funding to expand its fleet of gunships and acquire dozens of airborne intelligence, surveillance and reconnaissance aircraft to provide targeting support.

"We haven't had the catastrophe that motivates us to open the checkbook to buy that force that we need," Slife said.

As a result, AFSOC plans to transform by adapting a heavy, fixed-wing fleet now composed of special derivatives of C-130Js rather than investing in an optimal, purpose-built platform for a new set of missions.

Another example of AFSOC's new strategy is the conversion of the C-130J fleet into long-range strike platforms. In October, AFSOC demonstrated the Rapid Dragon capability, which fired a Lockheed AGM-158B Joint Air-to-Surface Standoff Missile—Extended Range (JASSM-ER) from a pallet released from the cargo hold of an EC-130SJ. AFSOC may never even use such a capability, but the strategic-competition philosophy demands that China take the threat of such a capability seriously, Slife said.

A long-range cruise missile launched from an EC-130SJ highlights a new direction for Special Operations Forces.

"You don't have to plan to shoot cruise missiles out of C-130s," he said. "But as your adversaries have to honor every cargo airplane as a potential high-volume, precision-fires platform, it creates different kinds of problems for them. This is how we contribute to deterrence."

As the fleet adapts, so too must the mindset of AFSOC personnel, Slife said. For two decades, AFSOC's sole mission has been supporting special forces troops on the ground. That mission will continue, but the latest pivot means AFSOC wants to support the conventional air warfare capabilities too. Slife cited multiple examples of such a role from distant history, including dropping spies behind enemy lines during World War II from the weapons bays of B-24 bombers. That example prompted Slife to raise a provocative thought about how AFSOC could leverage the future Northrop Grumman B-21.

"Do we have anybody [who is] thinking about what it's going take to jump out of the belly of a B-21?" Slife asked the audience. "I hope so. Because that's who we are now."

How One U.S. Air Force Unit Is Standing Up KC-46 Operations

- NEW KC-46 UNITS ARE DEALING WITH LOW STAFFING AND LIMITED FLIGHT OPERATIONS
- AIR FORCE IS SLOWLY INCREASING MISSIONS THE TANKER CAN FLY

Brian Everstine Singapore

In mid-February, a U.S. Air Force Boeing KC-46A out of North Carolina linked up with two F-35As to fuel the fighters on the long flight from the F-35As' base in Guam to Singapore, where the new U.S. Air Force aircraft would be on public display at one of the world's major air shows.

The flight marked the first "coronet" mission for the new tanker from the 916th Air Refueling Wing out of Seymour-Johnson AFB, North Carolina, a term for a sortie that involves flying with receiver aircraft as they deploy to a location outside the U.S. The 77th Air Refueling Sqdn. (ARS), an Air Force Reserve squadron, one of the newest Pegasus units in the service, is standing up its operations as it awaits additional aircraft. The unit's pilots and boom operators are figuring out how to fly the new refueler whose reputation has been shaped by problems in its development.

"The [KC-46] is going to have a lot capabilities that no one really talks about move attribution here," says Maj. Mike Orzeck, an instructor pilot with the 77th ARS. "You only talk about the hard things we get through. [But] that's with any new aircraft, right? You're going to have a learning curve."

The 916th Air Refueling Wing, a former KC-135 unit, began receiving the first of 12 KC-46s in June 2020 and is waiting for its last three tankers. One was expected to be delivered in February, though that delivery has been delayed.

The unit is working on increasing its staffing levels, faced with a lingering shortage of maintainers and boom operators. To train its pilots, the wing is flying its tankers at a pace of two per day, practicing refueling F-15Es from the same base, C-17s from nearby Joint Base Charleston, South Carolina, and with KC-46s refueling each other. Mission planners also jump at any opportunity to refuel other nearby aircraft, which includes F-22s, F-16s and C-5Ms, says Master Sgt. Kristian Kankelfritz, an instructor boom operator with the unit.

["I get whoever I can,] just to break things up. I can do C-17s every day, all day out of Charleston, but everybody gets tired of that," he says.

The Air Force's Air Mobility Command has rolled out an "interim capability release plan" allowing KC-46s to be tasked by U.S. Transportation Command for operational missions for certain receiver aircraft even though the KC-46 is not yet fully operational. So far, about 70% of the Air Force fleet has been cleared for these operational mission tasks.

The 916th Airlift Wing is eagerly awaiting its turn to be activated to perform these duties. Kankelfritz says the wing expects to be approved in early April, after it has received all its tankers and more personnel have been trained to maintain and operate the KC-46.

The wing's shortfall in maintenance personnel and boom operators is continuing to have an impact, as the training pipeline has slowed, with not enough training spots for airmen who are not coming from existing positions working on KC-10s and KC-135s. The Seymour-Johnson squadron, when it previously operated KC-135s, had an associated active-duty unit that shared maintenance on the aircraft with the 77th ARS. The new active-duty KC-46 unit at the base is expected to be formed in the fall.

And with U.S. airlines hiring at a rapid pace, some pilots are being drawn away from military service. "Manning all around could use a bump-up, but maintenance is really where



The flight to the Singapore Airshow, where this Boeing KC-46A from the 916th Airlift Wing was on display, was the wing's first long-distance mission. The tanker refueled F-35As on the way.

DAVID CHUA/D3DPHOTOGRAPHY

we're seeing it the most," Orzeck says.

When asked about the new aircraft, KC-46 pilots typically are quick to boast of the tanker's increased survivability and situational awareness. This includes the use of the Link 16 data link, radar-warning receivers and other new technologies that make it more defensible and connected to other aircraft, compared to the older KC-135s and KC-10s.

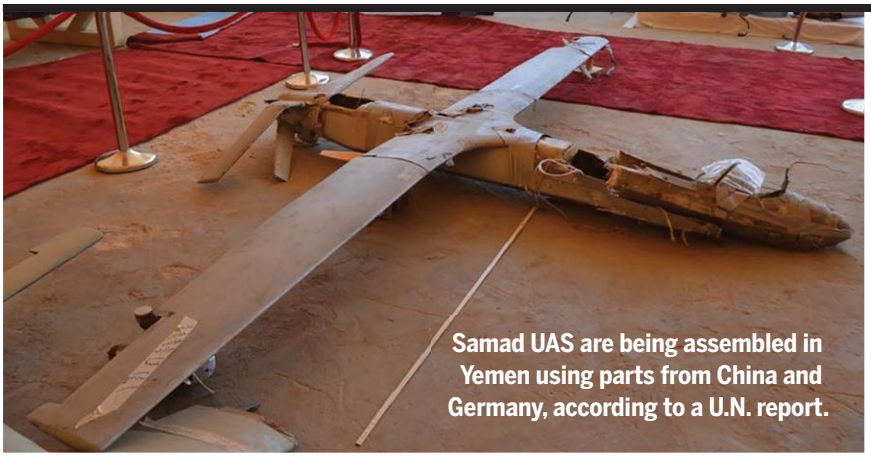
The adoption of the new technology has been exciting and a bit challenging, Orzeck says. Crews with the 77th ARS have faced some difficulty in working through the systems on their own without much training beforehand.

"There's a learning curve here, and we're still all trying to figure out the systems themselves. But [the new aircraft] definitely increases [situational awareness] as far as who's in the battle, who needs fuel, who's going where, and you can send messages back and forth without ever going over [radio communications]," Orzeck says. "And then you incorporate the threat-detection stuff onto that, it just increases [situational awareness] tremendously.

"As far as training though, we're just kind of figuring it out ourselves," he adds.

The modernized Boeing 767-based aircraft has displays from the 787 cockpit, along with an advanced autopilot that is effective when the aircraft flies its refueling "track"—a course set during refueling to help it remain steady as it offloads gas. For those used to flying the aging tankers this modification has been a help, freeing up operators to pay

UNITED NATIONS SECURITY COUNCIL REPORT



Samad UAS are being assembled in Yemen using parts from China and Germany, according to a U.N. report.

Without Conventional Airpower, Yemen's Houthis Turn to UAS

> UPGRADED UNMANNED AERIAL SYSTEMS CAN FLY UP TO 3,000 KM

> LOW-TECH UAS AND MISSILE STRIKES ARE IMPOSING A HEAVY COST ON SAUDI-LED COALITION

David Hambling London

The Pentagon's decision to send fifth-generation fighters to bolster the United Arab Emirates' defenses highlights the dramatic success of the Houthis' asymmetric campaign of air strikes using unmanned aerial systems (UAS). Poorly equipped insurgent forces with no airpower in Yemen have been regularly hitting targets a thousand and more kilometers away in what may become a template for future conflicts.

While they can deliver only limited amounts of ordnance, the Houthis' UAS have caused disruption in remote capitals, creating headlines and changing the political climate. The range of these strikes has progressively increased through the seven-year conflict as UAS technology has matured, a trend that may continue.

During the first phase of the conflict with the Saudi Arabian coalition in 2015-18, the Houthis turned to Qasef-1 kamikaze UAS or loitering munitions. The Qasef is an export version of the Iranian Ababil with a maximum range of 150 km (93 mi.). Since then, the Houthis have employed a series of UAS designated Samad (or Sammad), essentially scaled-up Qasefs. A 2020 study by Conflict Armament Research and a report by the United Nations Panel of Experts on Yemen both confirm that Samads are assembled locally, using commercial parts acquired on the international market. Engines, for example, have been sourced from Germany and China.

The latest U.N. panel report considers a recently captured Samad-3 UAS that appears similar to the vehicle described in its 2019 report, with similar dimensions—2.3 m (7.5 ft.) in length with a 4.5-m wingspan—but with a fuel-tank increased from 21 liters (5.5 gal.) to 44. The panel estimates that the original had a range of 1,200-1,500 km, indicating the upgraded version has a reach of 2,500-3,000 km. This compares to perhaps 1,200 km for the Houthis' longest-range missile, the Burkan-2.

The range estimate matches claims made by the Houthis. In early 2022, Yemeni Brig. Gen. Abdallah Al-Jafari said in a TV interview that their drones can hit targets over 2,500 km away.

Such capability was considered implausible when the Houthis claimed responsibility for an Abu Dhabi International Airport attack in July 2018. United Arab Emirates (UAE) authorities said the airport disruption had been caused by an incident with a supply vehicle. A Bellingcat study at the time concluded that "it is highly likely that a Houthi-led drone attack did not take place in Abu Dhabi." However, subsequent evidence, including leaked CCTV video, appears to confirm the Houthi attack.

The long-range attacks have since stepped up, with airports being frequent targets. People have been injured and civil aircraft on the ground damaged twice at Abha International Airport in Saudi Arabia, with casualties also reported at the country's

attention to other tasks such as monitoring data links and maintaining situational awareness. At times it, has also meant flying has been too easy, Orzeck says.

"It's so easy to get complacent because we're not managing fuel panels anymore. It does everything for you," he says. "In that respect, we all talk about [the need to not] get lazy here. We've got autothrottles and all this, let's make sure we're still engaged. Have the cameras up, make sure we know what's going on behind us. But yeah, without having to manage the fuel panel—as co-pilot that used to be like your entire job. . . . Now it just does it all for you; it's beautiful."

The most notable issue with the KC-46 has been its remote-vision system—the collection of cameras and sensors that the boom operator uses to operate the refueling boom to offload fuel. The system has been plagued by camera quality issues, prompting a full redesign that has been stalled amid debates between the Air Force and Boeing on the extent of the fixes (*AW&ST* Jan. 24-Feb. 6, p. 14). The full fix is not expected to be rolled out until 2024, after which the KC-46 could finally become fully operational.

Meanwhile, the Air Force has approved the rollout of an interim "enhanced" software update for the system, which will sharpen the quality of the display and address some other issues. While the rollout started in December at the training base, the 77th Air Refueling Sqdn. does not know when it will be their turn for the update.

Jizan Regional Airport. Abu Dhabi International Airport in the UAE has been attacked on multiple occasions.

While the most dramatic UAS assault was one on the Saudi Abqaiq oil processing facility in 2019 involving around 20 UAS plus ballistic missiles that caused significant damage, many others have been carried out, including one that started a fire at the Ras Tanura oil export terminal in Saudi Arabia and attacks on pipelines and facilities at Qatar's Al Shaibeh Establishment. There have also been attacks on shipping.

Over the course of a four-year campaign, such actions have gone from being deniable to reaching a more concerning level for which foreign assistance has been sought to prevent them.

While the Samad-3 examined by the U.N. panel was equipped with an 18-kg fragmentation weapon, Houthi displays of UAS also show both Qasef and Samad models with what appear to be explosively formed penetrator (EFP) warheads. EFPs resemble shaped charges, but they produce a high-speed slug of metal rather than a narrow jet. These are less effective against heavy armor but have longer range and produce a larger hole, making them suitable for attacks on oil and gas storage facilities, ships and similar targets. The Houthis likely acquired EFP technology from Iran and have used it in roadside bombs.

While the majority of Houthi UAS launched toward Saudi Arabia and the UAE are intercepted, either by aircraft or by surface-to-air missiles, a percentage get through. The cost of interception highlights the asymmetric nature of the conflict. Saudi Arabia recently requested a new batch of 280 Raytheon AIM-120 Advanced Medium-Range Air-to-Air Missiles to replace missiles expended against Houthi drones—at a cost of some $650 million. While each garage-built drone costing a few thousand dollars draws a missile costing over $2 million, the Houthis will be motivated to continue the campaign, even if the chance of striking a target is low. Moreover, even unsuccessful drone attacks have an effect on morale.

A Dutch study indicates that the Samad series flies at low altitude and at a speed of no more than 100 kt. The Houthis say the Samad-3 is equipped with technology that makes it difficult to detect, but no evidence of this has been found. However, when several are flown and attacks are launched in conjunction with ballistic missiles—and sometimes with smaller UAS launched closer to the target area—a small but significant success rate is achieved.

The porousness of their counter-drone defenses has prompted the Saudi-led coalition to launch a new campaign to target UAS storage and manufacturing sites with air strikes. Similar offensives were announced in 2019 and 2020 but had little impact on the UAS offensive. Such strikes also bring the risk of civilian casualties and adverse consequences.

Unlike larger aircraft, small UAS do not require dedicated facilities. They can be built in garages and workshops and launched from a road or, if rocket-assisted, the back of a truck. This leaves few meaningful targets, and even these may easily be confused with civilian facilities.

In parallel, the Saudi-led coalition is attempting to prevent UAS parts from reaching the Houthis, but as the U.N. panel notes: "Despite a number of high-profile seizures . . . the Houthi supply networks appear to be sufficiently intact to ensure that the frequency of attacks can be sustained."

At the start of this year, Saudi Arabia and the UAE found themselves on the defensive against an aggressive UAS campaign. Attacks in January started a fire at Abu Dhabi International Airport and killed three migrant workers when a tank exploded at a nearby oil storage facility. Now the U.S. and France are offering military assistance, which may help the coalition intercept incoming UAS and locate their points of origin, but this is far from guaranteed.

The Houthis may also further extend the range of their UAS, enabling them to attack via indirect routes and from unexpected directions or strike targets well beyond the current zone of operations. The Houthis unveiled a Samad-4 with a 25-kg bomb load and extended range in 2021. But this has not been used and may still be in development.

A few reports of delta-wing loitering munitions have surfaced. These may be what the Houthis term Wa'aed, which in turn may be derived from the Iranian Hazem series. No specifications have been revealed, but three were used to attack the tanker Mercer Street in August 2021 at a location implying a range of hundreds of kilometers.

The continuing UAS campaign and the failure of attempts to neutralize it suggest that comparatively cheap, low-tech weapons continue to be a major threat in this conflict. As with other insurgent tactics, the occasional lucky hit on an oil facility, tanker, airport or military building may justify the entire effort. After four years, long-range insurgent airpower is here to stay.

GREEN SHOOTS

- AIRBUS ORDERS INCREASED BY 40% IN 2021 OVER 2020
- HILL HELICOPTERS HAS ORDERS FOR AROUND 450 HX50/HC50s
- MAJOR SEARCH-AND-RESCUE CONTRACTS EXPECTED BY YEAR-END

Tony Osborne London



An uptick in orders is giving the helicopter industry confidence that it is emerging from the doldrums of the COVID-19 pandemic.

While several OEMs have yet to officially announce their order tallies, the mood at companies such as Airbus, Bell and Leonardo as well as at engine providers is that the industry has turned a corner, even though the market is still someway off pre-COVID-19 conditions.

Airbus logged almost 420 orders in 2021, an increase of 40% compared with the year earlier, and deliveries were also up, with 338 compared with 300 in 2020. At Bell, deliveries of its commercial line were up around 11%, to 156 helicopters in 2021.

Bruno Even, CEO of Airbus Helicopters, calls 2020 a "low point" from which the industry will recover progressively, although he warns that it could still take 2-3 years for orders to recover to pre-COVID-19 levels.

Leonardo Helicopters has a similar perspective. The company tells Aviation Week that the "civil market is reacting after the 2020 pandemic plunge better than expected," although Leonardo Helicopters does not project a full recovery until 2025.

Much of the improvement is in the light helicopter market, mainly for light singles and twins. Airbus tallied 195 orders for H125 and H130 single-engine aircraft in 2021, compared with 122 a year earlier, while Bell sold slightly larger numbers of its Model 505 and 407 platforms. Airbus' new five-blade H145 secured some 93 new orders, with high demand for emergency medical services, law enforcement and military use after additional payload capabilities were added.

Part of the civil helicopter market upturn is due to increased demand for passenger transport. Just as high-net-worth travelers have sought the sanctuary and COVID-19 security of business jets during the pandemic, private helicopters are increasingly sought after, too. This market trend may also explain the apparent success of UK startup Hill Helicopters, which, since kick-starting its sales drive for the HX50/HC50 turbine helicopters during the pandemic, says it has secured orders for nearly 450 machines, even though the company has not yet produced a single aircraft. The HX50/HC50's competitors, the Robinson R66 and Bell 505, are expected to make their first flights by year-end.

Sales of super-medium and heavier helicopters have stayed stubbornly stagnant, however. A long-signaled replacement wave from the now much-consolidated oil and gas industry has yet to arrive, even though energy prices skyrocketed during the past year. Oil and gas operators have hinted, though, that after many years of helicopter supply outstripping offshore demand, they anticipate that offshore oil and gas activity will pick up.

Chris Bradshaw, the CEO of Bristow Group, told investors in February that he expects "significant increases" in spending by oil and gas companies on offshore activity beginning this year. "We expect that to be a multi-year growth cycle," he said. Whether that will translate into orders for new

Turkey's indigenous helicopters **p. 54**



LEONARDO HELICOPTERS

medium and super-medium platforms remains to be seen.

Offshore operators are continuing to try to get the most from their assets, flying fleets of helicopters longer than they would have previously. Airbus' Even says he expects the sector to take more time to recover and that he is waiting for a "change of habit" from oil and gas operators.

Sales of larger helicopters could be helped by new search-and-rescue (SAR) contracts as governments move away from the military provision of SAR toward the private sector, a process led by the UK during the 2010s. In January, Bristow was selected to provide helicopter services for the Netherlands Coastguard using a pair of Leonardo AW189s. Both the UK Maritime and Coastguard Agency and the Irish Coast Guard are expected to announce contract awards for SAR helicopter services toward the end of this year.

Increased firefighting missions, meanwhile, have created an unexpected market for Sikorsky's Black Hawk. Recent sales of helicopters configured for firefighting have prompted the OEM to secure an FAA certification for its S-70M model aircraft. The restricted category certificate enables the rotorcraft to conduct agricultural operations, carry external cargo and dispense liquids from the air.

Light helicopter types such as Leonardo's AW109 Trekker have benefited from the uptick in commercial orders.

Less certain is the future of Sikorsky's S-76 and S-92 platforms. The company has not communicated about the S-92 since April 2020.

While the industry has been buoyed by the signs of recovery, not all companies have managed to survive the pandemic. For example, severe financial difficulties forced Michigan-based Enstrom Helicopter to close its doors in January, after 60 years in business and production of 1,300 helicopters. But there may be light at the end of the tunnel for the company. Enstrom's president, Matt Francour, says multiple groups have expressed an interest in buying the company's assets and restarting production. "I don't know how and I don't know when, but I have a feeling we'll be back," Francour says.

Sustainable Aviation Fuels Tapped To Achieve Decarbonization Targets

> MOST HELICOPTERS ARE COMPATIBLE WITH 50% SAF BLENDS

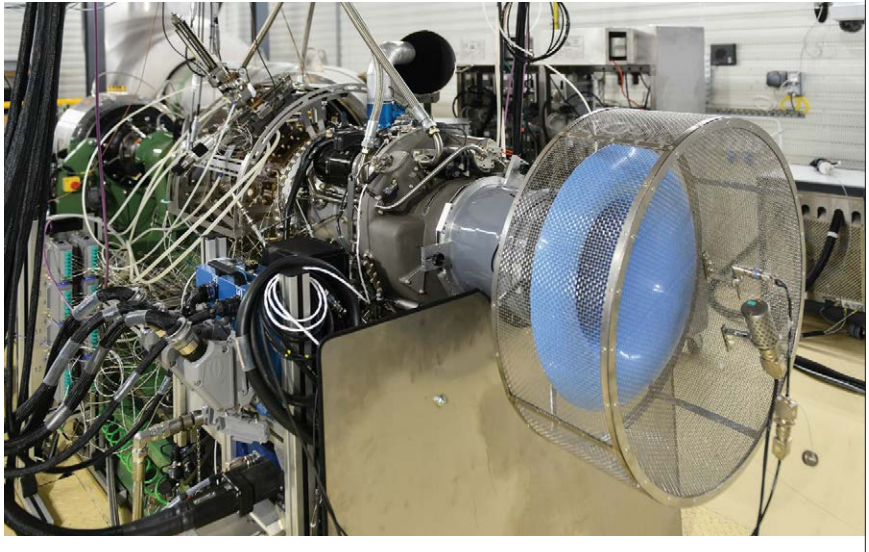
> INDUSTRY IS INVESTIGATING THE IMPACT OF 100% SAF ON ENGINES AND FUEL SYSTEMS

Tony Osborne London

Like the commercial airliner business, the helicopter industry has been trying to make itself greener for decades.

Engines that are more fuel-efficient as well as improvements in aerodynamics and blade design have resulted in more capable platforms that produce fewer emissions than previous generations.

SAFRAN HELICOPTER ENGINES



In terms of global aviation fuel usage, the rotorcraft sector is hardly a major factor, accounting for only about 1% of annual consumption. Nevertheless there is a growing acknowledgement across the industry that the move toward greener rotorcraft operations needs to pick up pace.

"Since the beginning of the 2010s, industry has been developing low-carbon solutions, but there was no real market interest in them," Franck Saudo, CEO of Safran Helicopter Engines, says. "This has clearly now changed. "The COVID crisis has accelerated some societal trends, one of which is the focus on the environmental transition."

Several helicopter OEMs have announced major strides in the electric realm with the development of battery-driven vertical-takeoff-and-landing aircraft. These are not being developed to replace existing commercial rotorcraft but are largely representative of a new market to serve urban and regional air mobility needs. Current electric vertical-takeoff-and-landing technology lacks scalability, limiting it to small air vehicles that would be impractical for many of the missions performed by conventional rotorcraft.

Hybrid technologies, in which electrical power supplements that produced by the turboshaft, could enable the so-called "right-sizing" of helicopter engines, an optimization that the industry says could deliver 10-15% reductions in fuel consumption and provide some safety benefits.

But while improvements in engine technology could offer important incremental changes, industry leaders say sustainable aviation fuel (SAF) may be the only way of truly reducing the rotorcraft sector's carbon emissions until technology enables cleaner hydrogen-powered flight.

Currently, most modern rotorcraft and their engines and associated system are certified to use up to a 50% blend of SAF in combination with Jet A1 fuel, but the industry is now targeting the use of 100% SAF by the end of the decade.

"This [SAF] is a low-hanging fruit that we need to adopt. . . . With this we can start to achieve bigger impacts," Regis Magnac, Airbus Helicopters' head of energy, leasing and global accounts, tells Aviation Week.

Magnac runs Airbus Helicopters' SAF User Group of OEMs, operators and suppliers that are making moves to decarbonize their operations and better understand the challenges around SAF production, logistics and implications.

"With current [SAF] production rates, the possibility to use blends of up to 50% gives us a lot of room," says Emanuele Bufano, head of airworthiness for Leonardo Helicopters. Customers are looking to fly with SAF blends of around 5-8% now, he notes.

Since Safran teamed up with Germany-based emergency medical service operator ADAC Luftrettung (Air Rescue) to fly missions using a 40%

Safran is testing one of its Makila engines with 100% SAF on its Bearcat test bench, measuring emissions and the impact of the fuel on key components.

SAF blend last summer, both have been quickly joined by offshore operator CHC, flying one of its Sikorsky S-92s on a 35% SAF blend on a flight in Norway. Leonardo Helicopters used SAF during a trial flight on its AW149 demonstrator aircraft in the UK in November. Bell has also been an early adopter, using a 35% blend SAF on its demonstration and training fleet of helicopters and conducting flight tests of its Model 525 super-medium using SAF since mid-2021.

The principle behind SAF as an emissions reducer is that the carbon dioxide absorbed by plants during the growth of the biomass used to create the fuel is roughly equivalent to the amount of carbon dioxide produced when the fuel is burned in an engine.

However, SAF can never be entirely carbon-neutral, as emissions are generated during their production, refining and transport. When a helicopter uses 100% SAF, it can be said that carbon emissions are reduced by around 80%, but this figure very much depends on the feedstock and the


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Seconds count when lives are on the line. It's why every feature of the Airbus H145 has been designed for safe, effective, and fast operations. With easy patient loading, state-of-the-art avionics to reduce pilot workload and a safer working area on the ground, the H145 ensures people get the medical care they need as fast as possible. All of this has made the H145 one of the emergency medical services market leaders around the globe – helping people every single day and making sure the world remains a beautiful place.
AIRBUS

process used to produce the fuel. So-called second-generation SAF use waste materials and have no impact on agricultural food production.

The industry is also looking ahead to the development of e-fuels or power-to-liquid synthetic fuels that are produced using electricity from renewable sources such as solar or wind. The process, similar to the electrolysis process used for the extraction of hydrogen, generates fuel from water and CO_2 extracted from the air.



CHC and Sikorsky flew an S-92 in Norway on a 35% SAF blend last September. Norway has mandated 0.5% biofuel blends in aviation fuel and aims to increase that to 30% by 2030.

Using SAF blends of more than 50% or achieving sole-use of SAF is a multifaceted challenge. Widespread use of SAF is not yet possible, as supplies are extremely limited, and its current cost can be up to four times that of conventional aviation fuel, but as energy companies raise production levels, costs are expected to fall. Mandates, particularly in Europe, could drive costs down further.

On the certification front, there are two approaches, says Safran's Saudo: using technology to modify the components of the helicopters to accommodate the different fuels, or modifying the chemistry of the different fuels so they work with aircraft fuel systems. Safran is exploring both avenues in its work toward 100% SAF compatibility for its engines, with efforts focused on 100% SAF mixed with and without aromatics, the petrochemicals that are a base component of fuels and provide viscosity and lubrication.

The expectation is that the wider aerospace industry will push for the use of aromatics in 100% SAF so that it works in a way similar to Jet A1, essentially becoming an alternative-drop-in fuel.

Jean-Baptiste Jarin, Safran Helicopter Engines' SAF expert, says the rotorcraft industry's views must receive notice, particularly as some characteristics of helicopter fuel systems differ from those of fixed-wing aircraft.

He cites the extensive use of nitrile polymers in helicopter seals and fuel-tank linings to improve the crashworthiness of the fuel system, which may face issues when used in combination blends over 50%. Other considerations are the way SAF vapors and how a helicopter's fuel pumps move those vapors around the fuel system. In most fixed-wing aircraft, fuel is stored above the engine, but in helicopters the fuel is stored below, often underneath the cabin of the helicopter, and then pumped into the engine above the cabin.

Bell says it is in discussion with "fuel suppliers and engine suppliers, along with providers of other portions of the fuel system to be able to work through what level of blends we can go to," says Michael Thacker, Bell's executive vice president for innovation and commercial business. Meanwhile, UK rotary-wing manufacturing startup Hill Helicopters says its in-house-developed GT50 turbine engine for its HX/HC50 family of light helicopters will also be able to use SAF.

"This is not just an engine issue," says Airbus' Magnac. "The chemical characteristics of SAF are different, so we need to check that seals and fuel pumps will have the same behavior."

Limited experience with the SAF tested so far suggests they are far more energetic and produce less coking on the engines, which could lead to reduced maintenance intervals and less smoke.

Understanding the potential benefits of blended SAF is a key part of Safran's partnership with ADAC, Jarin says. Current plans call for one of ADAC's Airbus H135s based in Cologne, Germany, to make regular use of a 35% SAF blend over the next 1,000 hr. of operation (*AW&ST* June 28-July 11, 2021, p. 68).

"The helicopter has been flying daily with SAF since January," Jarin says. "The objective is to assess the quality and benefit in terms of local emissions and in terms of maintenance."

Safran is also working with Airbus to perform flight tests of an H225 heavy helicopter, with one of its two Makila engines powered by 100% SAF. Components from a first flight performed in November using a SAF derived from waste cooking oil provided by French energy company TotalEnergies, are being examined by engineers before the next phase of flight tests begins. Safran is also bench-running a Makila using its Bearcat test rig to measure the emissions and the fuel's impact on various components.

Despite the efforts being focused on SAF, it is not the only way to reduce carbon emissions. Further gains can be made by adopting more efficient flight profiles, particularly in cruise. Leonardo is working with Shell Aircraft to develop use of flight-test data along with information about temperature, altitude and weight of the aircraft to fly more efficiently, just as airlines have set out to perform so-called perfect flights with continuous ascents and descents. "We believe there is a very good return on investment on this," says Leonardo's Bufano, with fuel savings of around 1-2% per flight expected.

Larger savings could emerge from hybridization, enabling rotorcraft that would generally be powered by two engines to operate on just one, with the electrical system providing additional power during takeoff, landing and in hover mode.

Airbus is testing an electrical back-

up system on its H130 FlightLab platform that can provide additional power in the event of engine failure. A second phase of the test will increase the power output, potentially improving the payload of the aircraft (*AW&ST* Feb. 8-21, 2021, p. 60). A similar approach has been adopted by Bell in the design of its Future Attack Reconnaissance Aircraft candidate: The helicopter's supplemental power unit can provide additional power and could be an enabler for a single-engine, medium-size rotorcraft (*AW&ST* Nov. 9-22, 2020, p. 56).

Bell's Bounce-Back

> 505 UPGRADES EXPECTED TO BROADEN UTILITY ROLES

> 525 ENTERING FINAL TESTS FOR BASELINE CERTIFICATION

Guy Norris Fort Worth, Texas

Boosted by higher production numbers in 2021 and signs of progress toward certification of the Bell 525 super-medium model, the helicopter-maker is optimistic of a continuing rebound in fortunes for its commercial rotorcraft sector through 2022.

"Despite the continuing challenges in 2021, it was a bit of a bounce-back year for Bell commercial," says Michael Thacker, executive vice president for innovation and commercial business. "Demand returned across our business, particularly in North America. New aircraft sales and aftermarket demand both improved substantially over 2020 levels."

Describing 2021 as "a very positive step in the recovery from 2020," he adds that "thus far in 2022, we appear to be getting off on a good track as well from a business perspective." Part of this is driven by brighter prospects for the Bell 505 light helicopter in the training and para-public sectors, with the easing of COVID-19 pandemic restrictions particularly benefiting recovery of the former.

The 505, which entered service in 2017, accounted for 63 of the 156 civil helicopters delivered by the Textron subsidiary last year. The program enjoyed a "big milestone year" in 2021, with the delivery of the 300th 505 and the 60th in Europe, says Thacker. As well as expanding its global dealership network last year, Bell has focused on developing additional capabilities targeting broader para-public applications. These include the added option of a recently approved Garmin GFC 600H autopilot system, an updated helicopter emergency medical services (HEMS) configuration and European certification of a 2,000-lb.-capable cargo hook.

Production of the 407/429 light and 412 intermediate/medium helicopters also continues to constitute a valuable slice of Bell's business, with the 407 accounting for 56 of the combined 93 aircraft delivered across these families in 2021. An element of this includes the 407GXi—the industry's first single-engine helicopter certified for instrument flight rules (IFR) operations. "We've had reasonable uptake on the IFR, and in terms of a safety benefit to single-engine operators, this is a critical step forward—not just for us but for the industry," says Thacker. Deliveries in 2022 will include the bulk of 12 407GXis ordered in 2021 by HEMS operator Life Flight Network.

But a decade after its launch, the Bell 525 super-medium continues to be the focus for the company's longer-term growth ambitions. Making its first flight in July 2015, the Bell 525 is the first commercial helicopter to incorporate a fly-by-wire flight control system. However, the program has had a protracted development, in part because of certification complications related to the flight control system as well as the loss of the first prototype in July 2016, prompting flight tests to be halted for a full year.

Now, as part of efforts to broaden the operational utility of the Bell 525 super-medium helicopter at service entry, the manufacturer is set to begin a dedicated icing certification program in parallel with the aircraft's long-running baseline type certification (TC) effort.



Dedicated Bell 525 icing certification tests will build on earlier cold-weather trials conducted in Michigan in 2019.

BELL

The icing work, due to begin in early March in Marquette, Michigan, will use AC14, the first production-representative Bell 525 to join the certification test fleet in 2018. "We want to do it in parallel because we want the aircraft to be in a more sellable configuration to our customers at first delivery," Program Director Derek Mookhoek says. "And so, rather than having a basic TC at entry into service and then do a follow-up amended TC around icing, we want to work that in parallel."

Although some sorties have been made with artificial ice shapes on another test airframe (AC3) as part of preliminary safety-of-flight check flights, the program in Michigan will

be a more extensive effort involving a build-up approach using AC14. In addition to testing with ice shapes on the empennage and nose, this aircraft is also configured with the suite of optional full icing-protection system kits available on the Bell 525, including heated blades and a heated cockpit windshield.

Following test flights in dry air to check handling with ice shapes, the program will involve flights behind a specially modified Boeing CH-47D configured with a Helicopter Icing Spray System (HISS). The tests will culminate with flights in natural icing conditions. Operated by the U.S. Army Redstone Test Center, the HISS is designed to generate artificial icing conditions using a spray bar suspended beneath the CH-47D.

Bell is also working through the final few type inspection authorization (TIA) flight tests toward baseline certification—a process that has been slowed by the impact of the pandemic, Mookhoek says. "We do have a few TIA flights remaining, and we have certification reports and certification artifacts that continue to go over to the FAA," he notes. "But we are getting closer and closer to that finish line. And the engagement with the FAA right now has been going up."

Joshua O'Neil, Bell 525 chief engineer, says working through the certification of the fly-by-wire system and other advances continues to pace the program. "You are going to have to go through the process of establishing your certification basis many times in things that are new to everyone," he says. "That kind of thing takes time, and we certainly expected it to take time, but in terms of the continued work that we have, it really is getting through those wickets. It is also understanding the basis of certification and how to document that and how to demonstrate those kinds of things."

Having previously forecast the completion of certification testing in 2020 and 2021, Bell is unwilling to put a revised estimate on when deliveries of the long-delayed helicopter are likely to begin. However, Doug May, flight operations leader, stresses that the initiative to pursue the amended type certificate for icing will not hamper or otherwise further delay the baseline certification effort. "It will not pace us from a certification or delivery to a customer perspective," he adds.

Airbus Closes In On Crucial FAA Approvals for the H160

> LACK OF FAA APPROVAL HAS HELD BACK SERVICE ENTRY

> JUST ONE H160 HAS BEEN DELIVERED FROM 90-STRONG BACKLOG

Tony Osborne Marignane, France

Orders for Airbus' newest helicopter, the H160, may be flowing in, but despite production beginning to surge, deliveries of the new-generation twin-engine medium rotorcraft are not keeping pace.

With orders for around 90 helicopters now recorded, including 52 in 2021 alone, just one of the helicopters has been delivered since the company gained European Union Aviation Safety Agency (EASA) certification in the summer of 2020.

The launch customer for the aircraft should have been a private entity in the U.S., but a setback in securing FAA certification for the helicopter has meant that U.S. customers and the airframer have been left in a holding pattern.

Airbus managers had assumed that the FAA approvals would simply follow those of EASA, as the two regulators have Technical Implementation Procedures in place to confer validity equivalent to the certification made by the other. Historically, FAA certification has soon followed approvals from EASA, and vice versa.

Instead, the U.S. regulator opened "a lot more topics than what was expected," Gilles Armstrong, head of the Airbus H160 program, told journalists here on Feb. 17. These inquiries have "pushed back" service entry in the U.S., he said. Meanwhile, the OEM delivered the first H160 to All Nippon Helicopters of Japan in December, after Japanese regulators signed off on certification in May 2021.



AIRBUS HELICOPTERS

Gulf of Mexico oil and gas helicopter service operator PHI will take delivery of the first of four H160s soon.

The FAA's certification process has been further hampered by travel restrictions due to the COVID-19 pandemic, which prevented FAA personnel from traveling to France for technical discussions. Much of the process has been carried out through remote conferencing, which Armstrong described as "relatively painful."

Among the topics reopened was the subject of noise profiles and the alignment of requirements around the use of lithium batteries.

"We have to remain humble on exact dates at this point, but we have now closed a lot of those topics," Armstrong said.

He also said he could not comment on the reasons for the delays, but several aircraft and rotorcraft programs have been held up as the FAA reforms its certification processes in the

aftermath of the Boeing 737 MAX accidents in 2018 and 2019.

"It is a painstaking line-by-line process, and we are confident we are reaching the end of that convergence process, so now we have to see exactly when [certification] happens," Armstrong added.

FAA approval is seen as particularly crucial for the H160, as customers in the U.S. account for a large proportion of the commercial orders. The company is also seeking approvals from both Chinese and Russian regulators.

But in addition to addressing the FAA's questions, the OEM has also had to address EASA concerns about the H160's landing gear electric-braking system. Airbus has since opted to use a hydraulic system that needs to be retrofitted to several early-build aircraft.

Now, with FAA sign-off finally in sight, Airbus is hoping to get back on track with the delivery of the first of four H160s destined for oil and gas operator Petroleum Helicopters Inc. (PHI) in the coming weeks (*AW&ST* March 22-April 4, 2021, p. 50).

Their operation, which serves oil and gas platforms in the Gulf of Mexico, will be a test case for what is hoped to be one of the biggest and most lucrative markets for the platform. Airbus is positioning the H160 in anticipation of a wave of orders to replace older types currently in use such as Airbus H155s, Bell 412s, Sikorsky S-76s and early-model Leonardo AW139s. Customers cite benefits including the aircraft's reduced environmental impact in terms of noise levels and fuel burn as well as reduced operating costs and higher productivity due to the greater ease of maintenance.

The delays in service entry have allowed the company to continue to advance the development of mission kits for the aircraft. One of the prototypes has been sent to the Moroccan desert to test inlet-barrier filters for the rotorcraft's Safran Arrano engines.

Airbus has also been testing rescue hoists and electro-optical cameras that will equip public service aircraft such as the six commercial model H160s that will be used by the French Navy for search-and-rescue missions.

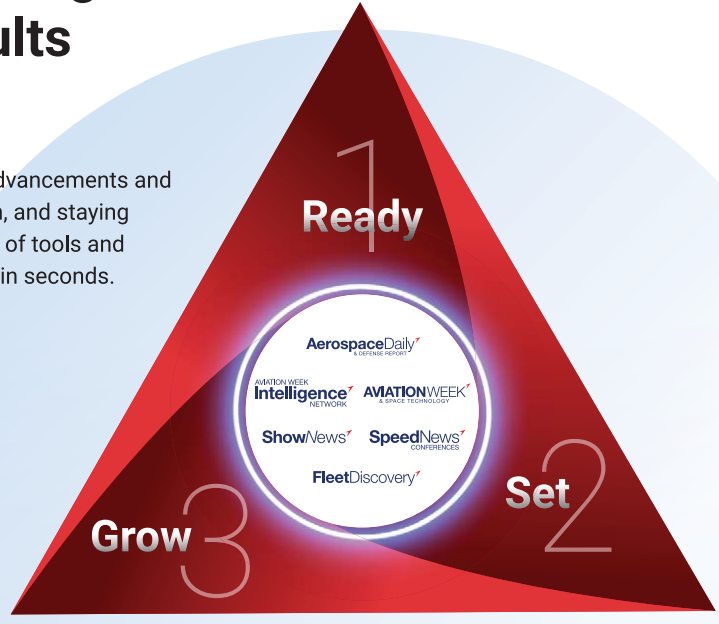
These aircraft, the first of which has just begun flying in its French Navy livery, are being provided through a consortium of Airbus Helicopters, Babcock and Safran Helicopter Engines as an intermediate step before the delivery of militarized H160Ms, which are being developed through France's €10 billion ($11.2 billion) HIL (Joint Light Helicopter) program, formally contracted by the government in December. French armed forces are buying 169 H160Ms, to be known as Guepard (Cheetah). The first 30 of these were included in Airbus' tally of orders for 2021.

With commercial orders building and deliveries of military H160Ms expected to start in 2027, Airbus is planning a production rate of 35 H160s a year. It is also mulling the use of a second so-called flex line that could accommodate production of both the H160 and the H175 super-medium platforms, possibly boosting output to 10 more H160s per year.

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AVIATION WEEK NETWORK

Turkey's Indigenous Helicopters Advance Toward Market Entry

- T625 EXPECTED TO REPLACE 200 SINGLE-ENGINE ROTORCRAFT IN DOMESTIC USE
- FOURTH PROTOTYPE JOINING FLIGHT-TEST PROGRAM SHORTLY

Tony Osborne London

Turkey looks set to join the short list of countries able to offer an indigenous commercial helicopter, as Turkish Aerospace Industries targets bringing its T625 platform to the international market by the middle of the decade.

The 6-metric-ton (13,230-lb.), twin-engine medium rotorcraft has already secured domestic interest for use by the military and government agencies, but the company is also eyeing the sale of at least 300 aircraft on the international market.

TURKISH AEROSPACE



Three prototypes, including P1 (pictured), will support the flight-test program, and a third aircraft is due to fly soon.

Born from a domestic program launched in 2017 to replace aging helicopter types such as the Bell UH-1 Iroquois, the T625 looks set to enter a highly contested market for medium-size rotorcraft currently dominated by types such as Leonardo's AW139, Bell's 412 and Airbus' H160.

Christened with the name Gokbey, the T625 is the first entirely indigenous rotorcraft to emerge from the Turkish Aerospace Industries (TAI) stable. Taking lessons from the company's work with Leonardo on the T129 attack helicopter, the T625 makes use of a largely local supply chain. TAI has developed the rotorcraft's dynamic system, its landing gear, the four-axis autopilot and the digital flight control system in-house, while defense electronics firm Aselsan is providing its Modular Avionics Touchscreen Environment glass cockpit and avionics suite.

Since the first hops of an adapted ground-test vehicle known as P0 in September 2018, two more prototypes have started flying in support of the flight-test program. P1 and P2 are currently being used to expand the T625's flight envelope, with P1 being used for low-speed trials. Nearly 250 hr. of flying have been completed across the flight-test fleet so far, program officials tell Aviation Week.

The third complete prototype, P3, will begin flying in the coming weeks and will be used to "perform flight performance and autopilot testing," program engineers say.

Although development and certification timelines have slipped, the company is confident about the program's progress. TAI has begun low-rate production of the aircraft, targeting delivery of the first military versions by year-end to the country's military police, the Jandarma.

Current plans call for around 200 Gokbeys to replace single-engine platforms in government use, and TAI says several foreign customers are interested in the platform. Initial discussions with export customers have started, but no contracts have been signed, officials say.

The aircraft is likely to be able to take on a wide mission set, including passenger transport, offshore oil and gas support, emergency medical services and search and rescue.

Commercial models will be certified by Turkey's Directorate General of Civil Aviation and the European Union Aviation Safety Agency, meeting the latter's CS-29 requirements for large rotorcraft.

Flight-testing activities for type certification are slated to be completed by the end of 2025, with full-scale production beginning around the same time.

TAI has not openly discussed the pricing of the helicopter, but program officials say they will implement an "aggressive price policy for the international market."

The T625 will be the first commercial rotorcraft to use the Honeywell/Rolls-Royce-developed LHTEC T800 engine originally designed for the Boeing/Sikorsky RAH-66 Comanche.

For Turkish military customers, the T625 will enable engine commonality with the T129. However, as TAI eyes military sales of the platform, Turkish industry is working on a domestically produced alternative engine—the TS1400 produced by TUSAS Engine Industries, the engine offshoot of TAI. The goal of producing an indigenous engine is to ensure that U.S. International Traffic in Arms Regulations do not hold up sales. Ankara has already struggled with sales of the T129 due to problems securing approvals for the transfer of engines, which led to the cancellation of a deal with Pakistan.

Work on the locally developed 1,400-shp turboshaft is already at an advanced stage, and TAI plans to be able to offer both engine options to customers. The TS1400 is expected to fly on the T625 after 2024.

Other locally developed systems include the platform's health and usage monitoring system (HUMS), which will monitor the vibration levels of the dynamic systems and perform rotor track and balance functions—processing raw data from the onboard sensors as with other HUMS systems. Data from the HUMS will be collected using a USB device. Out of the box, TAI program officials say the aircraft will be ready for both visual and instrument flight rules operations with a single pilot and will be capable of flight in known icing conditions. TAI has ambitions beyond the T625, however, with lessons learned from the program feeding into plans for a 10-ton transport helicopter and an attack helicopter of similar weight.

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FREIGHTER FUTU

Helen Massy-Beresford Paris, **Guy Norris** and **Jens Flottau** Singapore and **Thierry Dubois** Lyon

Riding a wave of strong demand for freighters and surging business from the e-commerce sector, among other factors, Airbus and Boeing have both committed to major new freighter programs in recent months. But how sustainable is the demand? Looking further ahead, will the manufacturers need to introduce more freighter models to meet the needs of the growing sector as it is driven by a post-COVID-19 capacity squeeze.



While high levels of air cargo demand are obviously good news for operators in the short term, they also represent a challenge. Air cargo demand increased by 6.9% in 2021 worldwide, compared with pre-COVID-19 levels of 2019, and by 18.7% over 2020 figures, according to International Air Transport Association (IATA) data released on Jan. 25. But capacity measured in available cargo ton-kilometers was 10.9% below 2019.

That is due in large part to the still depleted long-haul networks of many airlines, set against rising export orders and increasing manufacturing output in many major markets. Although a recovery in narrowbody passenger activity is in general making greater strides, many widebody jets around the globe remain parked two years into the COVID-19 pandemic—1,176 aircraft at the end of 2021, according to Aviation Week Fleet Discovery data (see table on page 58).

Whether these aircraft are destined to be future feedstock for conversions or merely passenger aircraft on standby, the return to service—or not—of those widebodies will be one factor affecting the balance between the need for new freighters and the risk of a glut in the coming years.

It is not yet clear what long-term effect Russia's invasion of Ukraine will have on the recovery of passenger carriers or on cargo operators around the world. But the impact of sanctions and flight bans on major freight operators such as AirBridgeCargo Airlines—part of the Volga-Dnepr Group—not to mention the operational disruptions carriers outside of Russia are experiencing, will certainly put further upward pressure on capacity and freight rates in the short term.

According to Fleet Discovery's latest commercial forecast, 498 of those widebody aircraft should return to service in 2022; 223 will do so next year, and slightly fewer than 90 will roll back out in 2024. But the 1,176 total includes some aircraft that will never return to fleets and some that will be converted into full freighters as well as others that do not currently have a passenger-to-freighter (P2F) conversion programs.

IATA predicts worldwide passenger traffic will return to pre-COVID-19 levels by 2024, but air cargo demand is set to remain high in the interim and beyond.

One big driver of that trend is online shopping. Digital research company eMarketer predicts that worldwide retail and retail e-commerce spending will stabilize in 2022 but notes that "even in a slower-growth environment, total new spending will be enormous."

Retail e-commerce spending is expected to exceed $6 trillion in 2023, up from $4.9 trillion in 2021 and $5.5 trillion in 2022, eMarketer data shows. "This year, worldwide e-commerce sales will exceed $5 trillion for the first time, accounting for more than a fifth of overall retail sales," eMarketer said in a global e-commerce outlook report released on Feb. 2. "Despite slowing growth, total spending will surge past $7 trillion by 2025."

Even if passenger traffic has recovered more strongly on narrowbody routes, bringing belly capacity back with it, there is still room for more freighters, thanks to e-commerce.

The arrival of new Airbus A320neo-family aircraft and A220s in fleets should continue to free up older

EFW

RE

> NEW PROGRAMS AND ORDERS HIGHLIGHT CARGO BOOM

> GLOBAL 2021 AIR CARGO DEMAND ROSE 6.9% OVER PRE-COVID-19 LEVELS

> 2021 CAPACITY WAS DOWN 10.9% FROM 2019



EFW is targeting 30 Airbus conversions annually within two years.

aircraft as conversion candidates. Similarly, the resolution of the Boeing 737 MAX issues and a ramp-up in deliveries of the type to Boeing operators will mean more older 737 models become available for conversion.

Turboprop manufacturer ATR is also experiencing strong demand for its freighters, both new and converted. FedEx received the first ATR 72-600F, with a payload of 9 metric tons, in December 2020. It has firm orders for 30 aircraft and options for 20 more. In addition to orders for new aircraft, 17 ATR cargo conversions were performed last year globally, according to the Toulouse-based airframer. The 10 secondhand aircraft it delivered were mostly for cargo operations, says Fabrice Vautier, senior vice president of commercial operations.

If COVID-19 has led to profound changes in consumer spending and travel habits, it has also had a significant effect on the air cargo sector.

"Prior to COVID, we had, as an industry, the standard reference point that the split between cargo moved in main deck capacity versus belly capacity was roughly 50-50, give or take for different trade lanes," says Glyn Hughes, director general of The International Air Cargo Association. "That overall situation has been dramatically affected by the COVID situation, and looking at the industry numbers, it's now around 75-25. I don't think we're going to return to 50-50 even after we get a full resumption of passenger networks because structural changes have occurred."

Those developments include stronger demand for air cargo than in the years before the pandemic as well as a significant increase in forwarder-procured charter flights for cargo operations—a phenomenon that may ease but not disappear, Hughes adds.

"Structurally, going forward it probably won't be 50-50 main deck versus belly," Hughes says. "It might be 60-40 or possibly 65-35. That means that the freighter fleet will need to be larger." The connectivity of the passenger networks as well as the capacity provided by the so-called preighter aircraft, or passenger jets used to transport cargo during the crisis, will need to be replaced somehow.

It's clear from the flurry of high-profile freighter activity in recent months among manufacturers that Airbus and Boeing also believe the demand is sustainable.

With that in mind, Boeing launched the long-awaited 777-8F in January, scooping up a 34-strong firm order from launch customer Qatar Airways. Shortly thereafter, the Singapore Airshow in February proved to be a good showcase for Airbus' A350F, which launched in November, as Singapore Airlines firmed up its order for seven of the freighters, and Etihad Airways signed a letter of intent for seven. Air France-KLM is also a future customer.

Even before production on the new freighter models begins, the manufacturers are looking ahead to what will come next to complement those high-profile new freighters.

For Boeing, looking beyond the 777-8F, the manufacturer is considering a 787 freighter, Boeing Commercial Airplanes President and CEO Stan Deal said in February on the eve of the Singapore Airshow.

"A 787 [freighter] makes a lot of sense," Deal said, noting, however, that no announcements had been made.

Launching another new freighter in addition to the 777-8F would be a costly undertaking. Although a 787-based freighter would provide an efficient solution to the 767 replacement question and would meet new international emissions standards that are currently due to sunset the long-running twinjet program in the late 2020s, it would stretch the company in ways it can ill afford.

Similarly, a freighter version of the A330neo would certainly benefit from fuel-efficiency gains. But many passenger A330s are ripe for retirement and the initial outlay for conversion is much cheaper, so the economics may not stack up.

"I think the portfolio now for both manufacturers, for the foreseeable years and the post-COVID return, looks like it has a nice balance," Hughes says.

In the meantime, the ongoing surge in new freighter orders is likely to continue with additional deals in 2022—particularly for the ever-popular 767. The midsize freighter received another boost in late December when express cargo carrier UPS ordered 19 aircraft.

The UPS deal took gross orders for production Boeing freighters to 85 for 2021, 38 of which were 767-300Fs. The balance consisted of 42 777Fs and five 747-8Fs, the last of which is due to be

EFW



EFW announced new P2F orders at the Singapore Airshow.

delivered this year. The UPS agreement followed a flurry of 767-300F orders over the past two years from other cargo operators, an order rate that will ensure that production remains at three aircraft per month—currently the highest for any Boeing widebody.

Although the 787 freighter may be in the cards one day, Boeing is eager to exploit the cheaper option of extending production of the commercial 767 model as long as possible. The line is supported by the Boeing KC-46A tanker version of the 767, production of which is currently set to continue through 2029.

To that end, Boeing is also studying whether to seek a potential exemption from International Civil Aviation Organization (ICAO) environmental emissions regulations that will effectively ban the production of Boeing's current models of the 777F and 767-300F by 2028.

"When you look at the utilization [of the 767-300F] as opposed to the next model of aircraft that may be compliant beyond that, it actually has a lower carbon footprint than that," Deal says. "The ICAO rules allow for an exemption, and you may see an exemption granted for that airplane or you may not. We are preparing for either eventuality."

The company's freight sector forecast has predicted air cargo traffic will double in the next two decades, triggering demand for more than 2,400 new-production and converted freighters. Among the influx of aircraft, it expects 500 will be new-build medium widebodies, 400 medium and large widebody conversions and 850 new-build large widebody freighters. The balance will be converted single-aisles.

As operators look to plug the belly-hold gap left by still-depleted long-haul passenger networks, P2F conversions are in strong demand.

For Thomas Centner, director of sales and technical marketing at Airbus conversion specialist Elbe Flugzeugwerke (EFW), that demand goes beyond a COVID-19 effect.

"The long-term trend of express growth, driven by online shopping, has been accelerated by COVID, but this trend is not reversible," Centner says. "So there will be a greater need for freighters to avoid the risk of being reliant on belly freight."

In recent developments for EFW, wet-lease and cargo operator SmartLynx ordered six A321 P2F conversions, while lessor CDB Aviation secured conversion slots for 12 additional A330 aircraft.

With orderbooks full well into the future, Centner said that he had been expecting interest in conversion slots to begin to tail off. However, that has not happened so far.

"On the A320, the A321 and the A330, we certified with little availability of conversion candidates," Centner says. "COVID obviously changed this. And now with feedstock available at reasonable prices, we've got the capacity, we've got the aircraft, the market recognition is there, and that is driving us."

Centner says the underlying trends support ongoing growth for the freighter sector, while COVID-19 has sparked a renewed realization that freighters are necessary.

"At the moment, we are targeting 30 conversions annually on the A320 family and 30 on the A330," Centner says. "We are not there yet, but we will achieve this within the next two years.

"Today, we are producing in Singapore, in Dresden, [Germany,] in San Antonio and in Guangzhou, [China,] on the A321," he says. "We are expanding the A330 conversion into China as well. We have a conversion site in Shanghai, and we are expanding into the U.S. with the A330 in Mobile, Alabama, in the middle of this year."

Widebodies in Storage

December 2021

AIRBUS		
A300	A300B4-100F/-200F	1
	A300B4-600	2
	A300B4-600R	4
	A310-300	9
A330	A330-200	170
	A330-300	140
	A330-900	13
	A340-200	2
	A340-300	16
	A340-500	1
	A340-600	30
A350	A350-1000	14
	A350-900	55
A380	A380-800	153
BOEING		
747	747-300 SCD	1
	747-400	23
	747-8	6
767	767-200	1
	767-200ER	4
	767-300	7
	767-300ER	55
	767-400ER	6
777	777-200	33
	777-200ER	146
	777-200LR	13
	777-300	38
	777-300ER	79
	777-9	12
787	787-10	18
	787-8	39
	787-9	81
ILYUSHIN		
IL96	IL-96-300	4
TOTAL		1,176

Note: Not all aircraft have current passenger-to-freighter programs.

Source: Aviation Week Network Commercial Fleet Discovery

Aviation Week forecasts that about 500 stored widebody passenger aircraft will return to service in 2022, 223 in 2023 and nearly 90 in 2024.

ASK THE EDITORS

When Are You Going To Blow the Whistle on SAF?

Sustainable aviation fuels (SAF) are a great demonstration project, but will they be a pipe dream if "100% sustainable" is to be taken seriously? The global fuel consumption by airlines in 2019 was 95 billion gal. a year; in early 2020, before COVID-19, it ran at 98 billion gal. Do you think there is the remotest chance of finding that much cooking oil?

Executive Editor for Technology Graham Warwick responds: Used cooking oil is the first feedstock available in any quantity for the first SAF produced in any quantity, which is HEFA (hydroprocessed esters and fatty acids). HEFA can be produced from any animal fat or vegetable oil, collectively known as FOGs (fats, oils and greases).

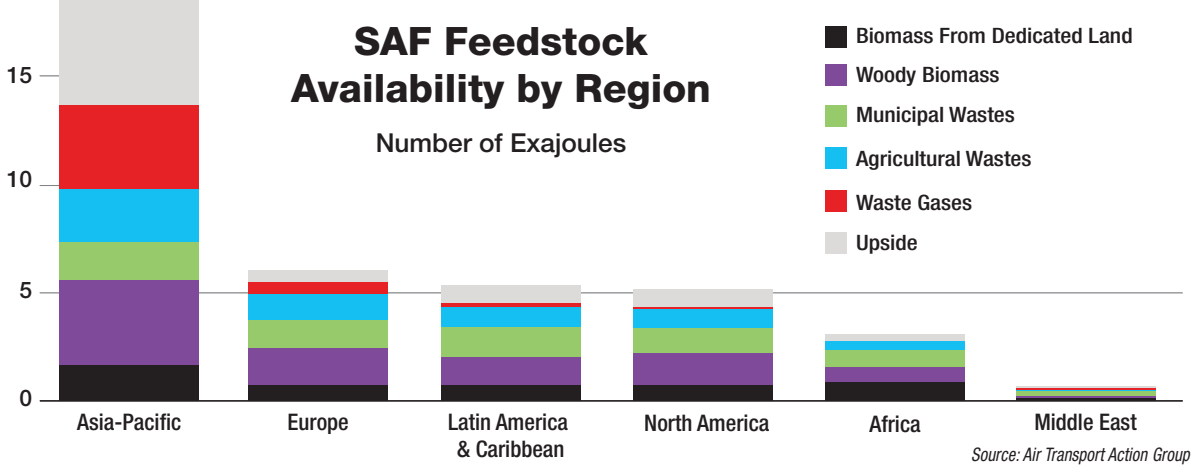
Cooking oil was used first because there was already a commercial collection industry, and when SAF got started, it was cheap. But it is universally acknowledged that the supply is limited, and prices have gone up.

SAF production facilities are coming online, however, that produce fuel from:

- Wood waste and agriculture and forestry residues.
- Municipal solid waste.
- Industrial waste gases.
- Energy crops and rotational crops.
- Hydrogen and captured CO_2.
- And many other feedstocks.

The point of SAF, and the strategy of organizations such as the Commercial Aviation Alternative Fuels Initiative, is that there will never be a single feedstock; many pathways will be approved that will allow the use of a wide range of feedstocks, some of them highly local. Multiple studies have suggested that when combined there is sufficient supply of feedstock available.

That said, Europe—which does not have the biomass potential of the U.S.— is pushing hard for e-fuel SAF produced using renewable energy and captured carbon. These are much more expensive than biofuels, at least until hydrogen electrolysis and direct carbon-capture costs come down substantially, but they have no major supply limits.



Source: Air Transport Action Group



TECH TAKE

By **Graham Warwick**

For the latest, go to **AVIATIONWEEK.COM**

Israel Certifies Elbit StarLiner UAS

Elbit Systems' StarLiner medium-altitude, long-endurance unmanned aircraft system (UAS) has received type certification from the Civil Aviation Authority of Israel (CAAI), approving the aircraft to fly in civil airspace.

The 17-m-span (55.8-ft.), 1,600-kg-gross-weight (3,530-lb.) StarLiner is a derivative of the Hermes 900 military UAS adapted to be capable of operating in civilian airspace, and the approval follows a six-year certification process that included extensive ground and flight tests, Elbit says.

ELBIT SYSTEMS



Elbit's Hermes StarLiner UAS has received type certification in Israel.

Changes to the UAS to enable civil certification include redundant avionics, sensors and satellite data links, integration of a terrain-awareness warning system, automatic takeoff-and-landing capability in reduced visibility as well as adverse-weather capability and lightning-strike protection.

The restricted-category type certification was granted under NATO's AEP-4671 airworthiness requirements for UAS, which are based on the European Aviation Safety Agency's CS-23 certification regulations (equivalent to FAA Part 23) with adaptations and additions for UAS.

Powered by a Continental Aerospace Technologies TAE 125 turbo-diesel engine, the StarLiner is capable of flying for up to 36 hr. at altitudes up to 25,000 ft. and speeds up to 120 kt. carrying up to 450 kg of electro-optical, thermal, radar or other payloads. The restricted-category certification is for aerial survey operations.

Elbit says it is under contract to supply the StarLiner UAS to the Swiss Federal Department of Defense and Civil Protection and to Transport Canada. Airworthiness approval enables the UAS to fly in unsegregated civilian airspace and above populated areas. This will allow the StarLiner to be used for border patrol, event security, search-and-rescue and environmental inspection missions as well as precision agriculture.

The Hermes StarLiner is not the first UAS to achieve civil type certification, but it is the largest so far. In 2015, the FAA granted restricted-category certification to the 15.5-lb. AeroVironment Puma AE and 44-lb. Insitu ScanEagle small military UAS to enable operations in civilian airspace over Alaska.

The U.S. agency in 2020 proposed airworthiness criteria for Part 21-17b special-class type certification of 10 small commercial delivery and inspection drones. Final certification criteria for the first of these UAS, Amazon Logistics' 89-lb. MK27-2 delivery drone, were published by the FAA on Jan. 27.

MagniX To Power Desaer's Hybrid Transport

Brazilian startup Desaer has partnered with electric-propulsion developer MagniX to develop a hybrid-electric version of its planned ATL-100 regional utility transport.

Development of the hybrid ATL-100H will follow that of the baseline twin-turboprop ATL-100, which was launched in 2020 with plans to enter the market in 2026.

The ATL-100H is to be powered by two turboprop engines and two 350-kW (470-hp) Magni350 electric-propulsion units that would be powered by batteries. According to Desaer, the ATL-100H is expected to reduce fuel consumption and CO_2 emissions by 25-40% over the baseline aircraft, depending on range.

With a gross weight of 19,000 lb., the ATL-100 is an unpressurized, ramp-equipped aircraft designed to carry 19 passengers, three LD3 cargo pallets or 12 fully equipped paratroops. Powered by 1,000-shp-class turboprops, the aircraft has a long-range cruise speed of 231 kt. and maximum range of 2,000 nm.

The ATL-100 is designed to replace existing 19-seat utility aircraft such as the Embraer EMB-110 Bandeirante and De Havilland Canada DHC-6 Twin Otter. Founded in 2017, Desaer is also planning to develop a follow-on pressurized 40-seat regional turboprop, the ATL-300.

DESAER



Desaer's ATL-100H would combine turboprop and battery-electric propulsion.

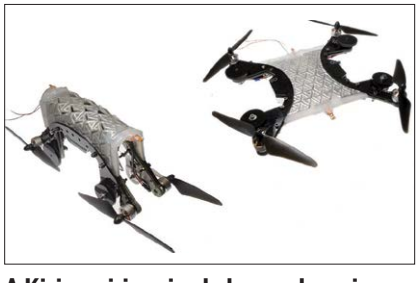
Shape-Changing Material Enables Morphing Drone

A soft robot that morphs from a ground to an air vehicle using a new shape-changing material has been demonstrated by researchers at Virginia Tech under a project funded by DARPA.

"We wanted a material that could do three things: change shape, hold that shape and then return to the original configuration, and do this over many cycles," says Michael Bartlett, assistant professor of mechanical engineering at Virginia Tech.

"One of the challenges was to create a material that was soft enough to dramatically change shape yet rigid enough to create adaptable machines that can perform different functions," he says.

VIRGINIA TECH



A Kirigami-inspired shape-changing structure allows the robot to morph from a ground to an air vehicle.

The team turned to kirigami—the art of making shapes out of paper by cutting—to create a rubber material with a repeating geometric pattern. To enable the material to hold a shape but allow that shape to be erased on demand, they introduced an endoskeleton of low-melting-point alloy embedded in the rubber skin.

When stretched, the metal bends, allowing the composite to hold a desired

shape and become a load-bearing structure. To return the material back to its original shape, the team incorporated soft, tendril-like heaters adjacent to the metal mesh. The heaters melt the alloy at 60C (140F) and the elastomer contains the liquid metal and pulls the material back into its original shape. When the metal cools, it solidifies and helps hold the structure's shape.

"These composites have a metal endoskeleton embedded into a rubber material with soft heaters, where the kirigami-inspired cuts define an array of metal beams," says graduate student and team member Dohgyu Hwang. "These cuts, combined with the unique properties of the materials, were really important to morph, fix into shape rapidly, then return to original shape."

The Virginia Tech researchers combined the shape-changing material with onboard power, control, motors, and both wheels and propellers to create a small drone that can rapidly morph from a ground vehicle to an air vehicle and back again.

Micro-Weather Forecasts for Safer Drone Deliveries

Small unmanned aircraft equipped with meteorological instruments have flown simulated urban and suburban delivery routes on the Daytona Beach, Florida, campus of Embry-Riddle Aeronautical University (ERAU) to help develop hyperlocal weather-prediction tools needed for autonomous flights in populated areas.

In urban environments, tall buildings can create unpredictable winds that affect small drones and air taxis. These conditions can vary significantly within a small area, so micro-weather forecasting is needed to determine if a route is safe to fly.

Under a two-year NASA-funded project launched in August 2020, ERAU is developing the General Urban Area Microclimate Predictions (GUMP) tool. GUMP uses both machine-learning (ML) mode and computational fluid dynamics (CFD) simulations to convert wind-flow fields into risk maps for operators.

The ML model is trained to ingest mesoscale weather forecasts from the National Oceanic and Atmospheric Administration and output refined forecasts for a specific location. A weather



EMBRY-RIDDLE AERONAUTICAL UNIVERSITY

Drones collected wind data at different altitudes along simulated delivery routes across the campus.

station serves as a source of ground-truth data during training of the model.

CFD simulations of wind flows over three-dimensional structures are used to extend the refined forecast to other points within the area of interest around the specific location, the researchers say. These simulations are performed over a range of conditions to generate a set of resulting wind-flow fields.

During deployment, GUMP retrieves the wind-flow field that is most consistent with the ML model's forecast. The wind-flow field is then converted into an intuitive risk map for operators, the researchers say, by applying appropriate thresholds for wind velocities.

Multisensor Module Monitors Structures in Flight

An EU-funded research project to develop a module capable of detecting and monitoring aircraft structural damage in flight by combining four different sensing methods has wrapped up after delays caused by the COVID-19 pandemic.

The objective of the DIMES project (for Development of Integrated Measurement Systems) was to eliminate the need for aircraft to be inspected for cracks and damage at regular intervals. Today, aircraft must undergo a D check every 6-10 years, a process that takes months and involves stripping and disassembly.



EMPA

The DIMES system combines four different methods of detecting and monitoring structural damage.

Using components that were as robust and inexpensive as possible, the project developed a system that could monitor metallic and composite structures in flight and avoid the need to take aircraft out of service for periodic heavy maintenance.

Led by Empa, the Swiss Laboratories for Materials Science and Technology, the project included Airbus, the University of Liverpool, the UK's Strain Solutions and Germany's Dantec Dynamics.

"The sensors were to answer several questions at the same time: Is there any damage? Where is the damage? What is the nature of the damage? How serious? And how long will the component last?" says Erwin Hack, DIMES project manager at Empa.

The module developed under the project combines four monitoring methods—resistance strain gauges, fiber-optic Bragg gratings, and visual and infrared cameras—to detect cracks as small as 1 mm (0.04 in.) in metals and damage indications in composites down to 6 mm in diameter.

In 2019, Airbus provided a 7-m-long (23-ft.) section of a wing from an A320 that had been damaged in a crash in 1988. The wing section was fitted with a prototype measuring system and installed in a test bench at Empa in Dubendorf. The structure was subjected to 70,000 bending cycles while researchers collected data. As expected, the tests enlarged the fractures in the wing that had resulted from the crash and caused new cracks to form. The next step was to test the DIMES system on a carbon-fiber structure. This test used A350 fuselage panels that had been stressed primarily by repeated pressurization cycles.

Launched in 2018, DIMES was intended as a two-year project, but the COVID-19 pandemic interfered and the A320 wing and A350 panel tests were not completed until May 2021.

The DIMES system has also been installed on a wing that is undergoing structural testing at the Airbus Wing Integration Center in Filton, England, a cockpit section at Airbus in Toulouse as well as an aircraft at the National Research Council of Canada's Aerospace Research Centre in Ottawa. The goal is to automate damage detection so that structural tests can run continuously, thereby saving time.

VIEWPOINT

Ukraine's Nuclear Threat Is Nonexistent

By **Steven Pifer**

Trying to justify Russia's unjustifiable invasion of Ukraine, Russian President Vladimir Putin claimed that Kyiv sought to develop nuclear weapons. That is a glaring untruth, as he well knows.

Thirty years ago, Ukraine had on its territory the world's third-largest nuclear arsenal. Kyiv gave those weapons up—in large part because Russia said it would respect Ukraine's territorial integrity and not use force against it. The country has never sought to reacquire nuclear arms.

A months-long crisis became a war on Feb. 24, when the Russian military launched attacks into Ukraine from multiple directions. Russian officials have strained to come up with reasons.

Speaking to a Russian security council meeting on Feb. 21, Defense Minister Sergey Shoigu suggested that Ukraine could develop tactical nuclear weapons. Putin picked up this theme, saying: "We also know that statements have already been made that Ukraine intends to develop its own nuclear weapons. We cannot leave this real danger without reaction."

In his Feb. 24 announcement of a "special military operation"—the Kremlin's euphemism for its brutal new assault on Ukraine—Putin stated that those in Kyiv "also claim to possess nuclear weapons." On March 1, Foreign Minister Sergey Lavrov told the United Nations Conference on Disarmament that Ukraine sought nuclear arms.

None of that is true.

When the Soviet Union collapsed in 1991, Ukraine had some 4,500 nuclear weapons within its territory. With minimal consultation, the Russian military spirited out the tactical nuclear weapons in early 1992.

That left 1,900 strategic nuclear warheads, more than the combined arsenals of Britain, France and China. As for delivery systems, Ukraine inherited 176 SS-19 and SS-24 ICBMs and 45 strategic Blackjack and Bear bombers. Beginning in the spring of 1992, Ukrainian military personnel maintained the nuclear storage facilities and had sole custody of the spare ballistic missile warheads and nuclear weapons for the air-launched cruise missiles to arm the Blackjack and Bear bombers.

Ukraine lacked the infrastructure to sustain an independent nuclear force, but it very likely had the scientific talent to figure out how to make some weapons operational. The Ukrainian government chose not to do so. It instead agreed to transfer the nuclear warheads to Russia for elimination and to destroy the ICBM silos, ICBMs and bombers.

A major factor prompting Ukraine's agreement to get rid of the nuclear arms and accede to the Non-Proliferation Treaty as a non-nuclear-weapons state was the Budapest Memorandum of Security Assurances. The memorandum, signed in December 1994 by then-U.S. President Bill Clinton, then-Russian President Boris Yeltsin, then-Ukrainian President Leonid Kuchma and then-British Prime Minister John Major, committed the U.S., Russia and Britain to respect Ukraine's territorial integrity and sovereignty and not to use force or threaten to use force against Ukraine.

Ukraine completed shipping the 1,900 strategic nuclear warheads to Russia by June 1, 1996. It finished eliminating the missile silos, ICBMs and heavy bombers several years later.

Unfortunately, Russia shredded the commitments it had made in the memorandum. In March 2014, the Russian military seized Crimea, and Moscow illegally annexed the peninsula. Several weeks later, Russian security and military officers launched a supposed "separatist" conflict in the eastern Ukrainian region of Donbas. Over eight years, that conflict has claimed some 14,000 lives.

On Feb. 21, 2022, Russia recognized the so-called Donetsk and Luhansk "people's republics" as independent states. Three days later, the Russian invasion began.

Understandably, many Ukrainians now regret the decision to get rid of nuclear arms. On Feb. 22, Ukraine's minister of foreign affairs, Dmytro Kuleba, sidestepped a question about whether Ukraine had made a mistake in 1994. He then noted that "a smarter decision could have been found." However, on Feb. 23, he stated: "In 1994, we gave up nuclear weapons, from the third-largest nuclear arsenal in the world. We are not going to get nuclear weapons again. Today we expect the world to keep us safe."

"THE COUNTRY LACKS THE INFRASTRUCTURE TO BUILD AND MAINTAIN NUCLEAR WEAPONS."

Russia attacked his country the next day, beginning the largest war in Europe since 1945.

Had Ukraine attempted to keep nuclear weapons in the 1990s, it would not have been able to establish close ties with the U.S. and Europe, including with key institutions such as NATO and the European Union.

However, Kyiv did not try to keep nuclear arms, and today it lacks the infrastructure necessary to build and maintain nuclear weapons. It has no facilities for enriching uranium or reprocessing used nuclear fuel to extract plutonium. No evidence suggests the country ever tried to build that infrastructure. Had it done so, the Russians would have almost certainly found out and could cite specifics. Putin, however, has zero evidence, just as he has no proof for his false assertions of genocide in eastern Ukraine or of drug addicts and neo-Nazis running the government in Kyiv.

His decision to invade Ukraine will leave a stain on Russia's reputation for decades to come. Unfortunately, the example of what the Kremlin has done to Ukraine also will discourage states considering getting nuclear arms from giving up those nuclear aspirations.

Steven Pifer is a William J. Perry Fellow at Stanford. A retired Foreign Service officer, he served as U.S. ambassador to Ukraine and helped negotiate the Budapest Memorandum.

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Aerospace Calendar

To submit Aerospace Calendar Listings
email: aero.calendar@aviationweek.com

March 7-25—RTCA Plenary Sessions/Committee Meetings. Virtual or various locations. See rtca.org/content/upcoming-committee-meetings

March 8-9—McAleese and Associates 13th Annual Defense Programs Conference (DPC22). Ronald Reagan Building and International Trade Center. Washington. See mcaleese.com

March 14-16—NBAA International Operators Conference (IOC2022). The Westin Bonaventure. Los Angeles.
See nbaa.org/events/2022-international-operators-conference-ioc2022

March 15-17—AeroTech. Hybrid event: Online + Pasadena, California. Pasadena Convention Center. See sae.org/attend/aerotech

March 15-17—Deployed Medical and Healthcare Delivery. Copthorne Tara Hotel London Kensington. London. See defenceiq.com/events-deployedmedicalforum

March 16-17—DSI (Defense Strategies Institute) Unmanned Systems & Robotics Summit. The Sunset Room. National Harbor, Maryland. See unmannedsystems.dsigroup.org

March 17-19—International Women in Aviation Conference. Nashville, Tennessee. Gaylord Opryland Resort & Convention Center.
See wai.org/events/33rd-annual-international-women-aviation-conference

March 21-23—ISDEF 2022. International Convention Center. Tel-Aviv.
See isdefexpo.com/category/isdef-2022

March 28-31—Defence Services Asia/Natsec Asia 2022. Malaysia International Trade and Exhibition Center. Kuala Lumpur. See dsaexhibition.com

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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.

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The Power of Unity

Russia's Feb. 24 invasion of Ukraine changed the world in ways almost no one—including Russian President Vladimir Putin, a former spy with czarist tendencies—would have predicted. The first invasion on European soil since World War II has jolted the European Union out of indecision and division. Though perhaps fueled by raw emotion, the world's democracies responded with concrete consequences—an unprecedented set of economic sanctions that have cut Russia off from the global economy and banking system.

Even nonaligned Finland, Sweden, Switzerland and Singapore quickly joined in. Putin has achieved something that years of U.S. harping could not: Germany will increase its defense spending to the NATO goal of 2% of GDP and modernize its aging military aircraft fleets. In response, Putin threatened to put his nuclear forces on alert. So far, Europe and the West have stood firm.

What happens next is anybody's guess. In the short term, Russian tanks are clogging Ukrainian roadways, and Russian aerospace forces have so far failed to control the Ukrainian skies. That has left defense analysts puzzled about the Russian military's failure to employ the full force of its airpower, electronic-warfare expertise and cyberoffenses. With the war turning to a grisly artillery bombardment of civilians, Western military strategists are calling for the manufacture of stockpiles of precision-guided munitions to shore up NATO's defenses.

Russia's exile will have an effect on the global economy and with it the aerospace industry. But any disruptions pale in comparison to the damage the world would face if Russia's invasion of its neighbor escalated into a wider—or even nuclear—conflict.

Russia is a major supplier of critical metals, particularly titanium. Cutoffs to the supply, though, would take a long time to be felt, as major OEMs such as Airbus and Boeing have large stockpiles of reserves and time to turn to alternate sources of supply. The bigger worry for now is that raw material prices could soar.

Western lessors that own several hundred aircraft operated by Russian airlines certainly face exposure, but the decoupling of Russia from the commercial aviation market would not be a huge blow for most Western companies. With an economy smaller than California's, Russia is a relatively minor customer for commercial aircraft and produces few critical components (landing gear forgings for the Boeing 787 being a notable exception).

More worrisome are oil price spikes of more than $100 a barrel. This will hit airline bottom lines, and militaries will feel the bite, too: The U.S. Defense Department is the largest institutional customer for oil in the world.

"THERE IS POWER IN INTERNATIONAL ALLIANCES AND LIMITATIONS IN DISPLAYS OF BRUTE FORCE."



ARTISTICPHOTO/SHUTTERSTOCK

Civil space operations have been a diplomatic sanctuary for the U.S., Russia and Europe since the Cold War. Although this arena could help rebuild international relations after the crisis, fissures are appearing.

Space is a far more complicated place than it was in the 1990s, with commercial companies operating alongside and for multiple government customers. While operations on the International Space Station continue, all is not well. In a sign of Europe's disappointment, the European Space Agency canceled a media briefing with German astronaut Mathias Maurer.

And in response to sanctions, Dmitry Rogozin, the head of the Russian Space Agency, threatened to let the space station fall into an uncontrolled de-orbit and crash. SpaceX CEO Elon Musk then offered a Dragon capsule to keep it aloft; NASA is considering contingency plans. In addition, the board of OneWeb suspended launches from the Baikonur Cosmodrome in Kazakhstan after Rogozin ordered the UK to divest its stake in the company. Russia is also bringing its employees back from Kourou, French Guiana, where Arianespace operated Russian Soyuz launchers.

But in this confrontation on the European continent, there is a larger question looming, says Tong Zhao, a senior fellow at the Carnegie Endowment: Will this conflict encourage China to improve its ties to the U.S. and Western democracies? Or will it deepen its ties with Moscow and, following Russia's lead, become an invader of a democracy?

Should Beijing decide to attack Taiwan and similar sanctions were applied to China, it would be much more painful for the aerospace industry. With its massive domestic market, Beijing is a major buyer of commercial airplanes, engines and related components and a source of critical raw materials. It is much more integrated into the global aerospace ecosystem than Russia is.

But among the lessons to be learned from this war in Ukraine is that there is power in international alliances and limitations in displays of brute force.



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