STARTS AFTER **PAGE 36**

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March 9-22, 2020 · Volume 182 · Number 5

FEATURES

DEPARTMENTS

26 | *Boeing's FARA design includes a tandem cockpit, hingeless high-solidity main rotor, canted tail rotor and pusher propulsor.*

ON THE COVER

Boeing has unveiled its design for the U.S. Army's Future Attack Reconnaissance Aircraft—the last of five competing teams to do so—in its bid to win one of two contracts to be awarded at the end of March. Our report by Pentagon Editor Lee Hudson and Graham Warwick, executive editor for technology, on Boeing's clean-sheet design begins on page 26. Boeing concept.

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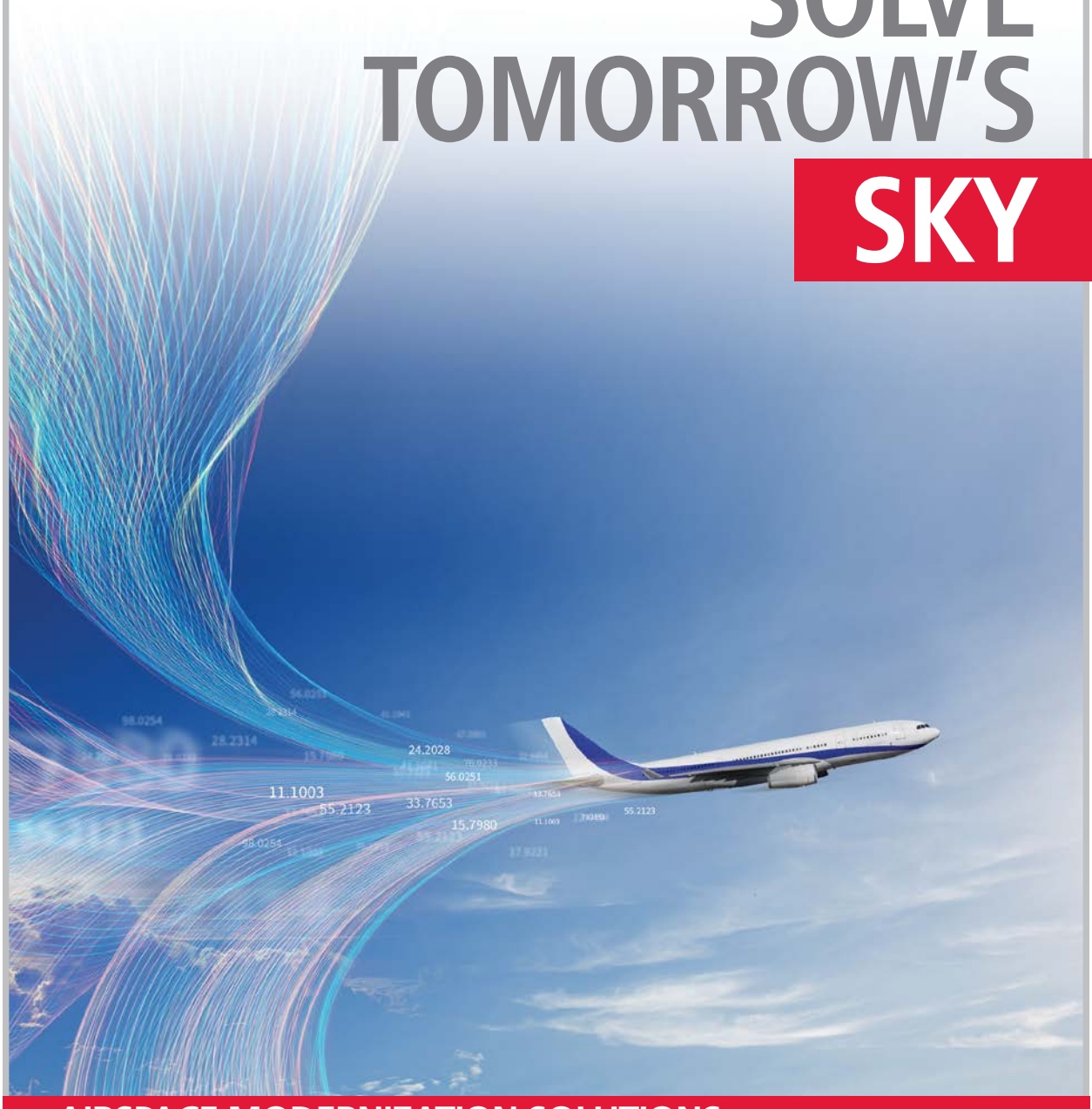
SOLVE TOMORROW'S SKY



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FEEDBACK

AIRBUS

SAFE SURFING?

The proposal for commercial aircraft to engage in air-wake surfing described in "Cooperative Benefit" *(Feb. 24-March 8, p. 36)* is a "bad idea whose time has come."

After decades of vertical and longitudinal separation to protect aircraft from the sometimes disastrous effects of wake turbulence, we are now proposing to allow large aircraft with potentially hundreds of paying customers to approach within 1 nm of one another and to allow the "software" to monitor whether they are "surfing" or not.

Your article states that the movement of the "surfable" wake is unpredictable. What happens when aircraft this close to one another stray from the correct flight path and enter the wake vortices of the leading aircraft? Are we blithely talking about aircraft upset with the potential for large numbers of injured passengers? Will the pilots of the trailing aircraft be able to know when they are in danger? What's the phrase that has been repeated by pilots in articles on aircraft computerization—"What's it doing now?"

Today's pilots don't seem to have the experience to know what's happening to their aircraft in all flight regimes. The Air France 447 pilots didn't know the aircraft had stalled! This whole idea will be driven by economics, not by safety or common sense.

Fred Furtek, Baldwinsville, New York

PUT PRODUCT QUALITY FIRST

After reading "Years of Pain" and "Unsafe Decisions" *(Jan. 27-Feb. 9, pp. 18 and 20, respectively)*, it seems to me that the best Boeing CEO David Calhoun can do is to focus on the "seven habits of highly effective people," as explained to us by the late Steven Covey in his book of the same title.

Boeing should become proactive again and not reactive, as it was to Bombardier and Airbus. It should put product quality first, not overly focus on the shareholders but better seek win-win results for all stakeholders, listen better to its customers and its employees and support the Boeing workforce by showing appreciation and giving them time to chill out.

I am sure if Mr. Calhoun and his successor were to do those things, Boeing would become great again.

Marc Koetsier, Hoogeveen, The Netherlands

PLANNING, NOT HEROICS

While the near disaster of the Boeing CST-100 Starliner is alarming ("Starliner Gives Boeing a Hard Lesson in How Not To Verify Software" *[Feb. 24-March 8, p. 35]*), it is not an isolated case of immature flight software being released for flight.

Thankfully, the Starliner flight-test team diagnosed the problems and mitigated the consequences so that hardware wasn't lost, nobody was injured, and the mission resulted in partial success. I've also experienced the shocking discovery of major software faults during flight test. The insidious aerospace program pressures—schedule and budget—seem to override best practices.

The industry had better put a higher priority on software testing in the laboratory, where the consequences of an error are a failed experiment and software lockup. That way, nobody would get hurt, and expensive hardware at risk of catastrophic loss would, in the laboratory, be limited to a handful of boxes rather than the entire flight-test article.

Boeing leadership—and indeed the aerospace industry leadership—should take a lesson from this Starliner case.

Software lab testing is critical. It must be planned for and cannot be cut based on a desire to reach an arbitrary milestone. Don't rely on flight-test team heroics to save the day.

Gregory Casey, Lancaster, California

REMEMBERING THE 880

When I saw "60 Years Ago in Aviation Week" about the Convair 880 *(Feb. 10-23, p. 9)*, I had to text my sister, Jimmye Nan Ramsey, the article's photo. She gave me a Delta promotional poster of the 880 soon after she became a flight attendant for the airline. She is still flying oversea routes for Delta, and I still have the poster. She claims she is going to retire at the end of the year (we'll see).

She texted me back: "Oh my, that beautiful Convair 880. One of the first planes I flew. Very expensive to operate from what I remember. When a bin of first class glasses falls out of the galley onto the floor, when you land, it makes a lot of noise!!! Before the 880 was the Convair440 which was a prop and only 1 Stewardess. Flew that 2 times only."

The "Lisa Marie," Elvis Presley's Convair 880, is parked down the road from her house in Memphis.

I hope you enjoy this human interest story remembering the 880 as much as I enjoy reading your magazine.

Lee Guthrie, Humboldt, Tennessee

ONLINE, in response to "Gun-Armed, Close-Support Missiles Among DARPA's New Projects" *(Feb. 24-March 8, p. 14)*, *SKYWAYPARKBLUE writes:*

The Chinese pioneered UAV close support around 1350. Really. Rocket planes with rocket munitions. They were small. I imagine not very effective, but they might have scared the enemy half to death.

CORRECTIONS:

In "Death Claw Shows Path to Faster Development" *(Jan. 27-Feb. 9, p. 43)*, the word used for the gunsight predicted-impact-point marker should have been spelled "pipper."

"Correcting Little Mistakes" *(Feb. 24-March 8, p. 6)* should have stated that the measure of 26,400 gal. was correct but that the measure of liters in the original letter, "Who Does Better?" *(Feb. 10-23, p. 6)*, should have been 100,000 liters.

These items have been corrected online and in our digital archive.

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.


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WHO'S WHERE

Mark Matossian has been hired by Finland's *Iceye* as U.S. CEO. He will lead U.S. expansion for the satellite-based synthetic-aperture radar services provider. At Google, Matossian led development of the Terra Bella Earth-imaging constellation. He is a cofounder of Solstar Space, which partnered with Blue Origin and NASA to develop telecommunications services for spacecraft.

Passur Aerospace has hired **Brian Cook** as CEO; he also will remain on the board. Cook had been CEO/director at CyFIR, a cybersecurity software producer.

Training giant *CAE* has hired **Todd Probert** as group president of defense and security. He succeeds Gene Colabatistto, who has retired. Probert had headed Raytheon's command, control, space and intelligence business unit and led artificial intelligence development for the Defense Department.

Silicon Valley's *Stellar Solutions* has promoted **Richard Rogers** to executive vice president from vice president of civil programs. **Amy Chaput** has been hired to succeed him; she had been acting chief technology officer at a federal agency.

AeroVironment has hired **Kevin McDonnell** as chief financial officer (CFO) and senior vice president. He was CFO of JAMS and before that held various senior financial roles including at Teradata and Digital Insight.

Parker Aerospace has promoted: **Austin Major** to group vice president of business development and global support from vice president of customer support; **David Overholt** to vice president/general manager of fluid systems from vice president/general manager of military flight controls; **Patrick Scott** to vice president/general manager of gas turbine fuel systems from general manager; and **Gregg Robison** to director of environmental, health and safety from engineered materials quality manager.

Lockheed Martin has named **Greg Karol** senior vice president of human resources and corporate officer. With Lockheed for more than 33 years, he was vice president of human resources for its aeronautics sector.

Don Davis has been promoted to *Vertex Aerospace* senior vice president/general manager of aircraft integration and sustainment from senior vice president of business development and strategy. Davis, a former U.S. Marine Corps officer, also has worked for Boeing and DRS.

Aircraft Propeller Service has promoted **Mauricio Mazzini** to director of quality in the U.S. from quality assurance leader in Brazil. He was quality assurance manager for Aeross, UTC Aerospace Brazil and TAF Airlines, among others.

Sage-Popovich Inc. has promoted **Petar Todorovic** to vice president of operations from asset valuation manager. He succeeds owner **Nick Popovich**, who will serve as an advisor.

Zoe Berthiaume-Dutrisac has been hired by *Satellogic* as chief of engineering. At MDA-Maxar, she managed satellite communication subsystems and oversaw the design, development and manufacture of multiunit complex antenna systems.

Avcorp Industries has promoted **Michael Elvidge** to general manager of its Delta, British Columbia, facility from engineering and quality leader. He succeeds Cedric Savineau, who has left the company.

CDB Aviation, Irish subsidiary of China Development Bank Financial Leasing, has promoted **Peter Goodman** to chief marketing officer from head of commercial for Europe, the Middle East and Africa. It also has hired **Craig Segor** as chief investment officer. Goodman held prominent management positions at BOC Aviation, ORIX and GECAS, among others. Segor was CEO at Plane View Partners.

Cyient has hired **Denise Millard** as vice president of sales for its aerospace and defense unit. Millard was sales and marketing vice president at Esterline and before that worked for L3 Harris, Thales and Bombardier. She is a Royal Canadian Air Force veteran.

Honeywell Aerospace has hired **Laura Pogue** as a senior strategic planner for aerospace and defense business development. Pogue hold an MBA and is a licensed instrument-rated, commercial pilot.

Titan Aviation Fuels has promoted **Byron Gray** to national sales manager from Gulf Coast regional sales representative.

Greenwich AeroGroup's *Summit Aviation* has hired **John Gonsalves** as director of sales and marketing. He was Bombardier's director of aircraft sales for government programs in the U.S., Mexico and Central and South America.

Space Dynamics Lab has named U.S. Navy Rear Adm. (ret.) **Liz Young** to its board to advise on system engineering and program management for the space and intelligence industry, including NASA's Artemis program.

HONORS & ELECTIONS

The Aerospace Industries Association has named U.S. Rep. **Mac Thornberry** (R-Texas) as the inaugural recipient of *The Wright Stuff Award* for his contributions to national and economic security during 25 years in Congress. He served as chairman of the House Armed Services Committee from January 2015 to January 2019.

Jeanne Marie Koreltz Elliott has been presented with the *Albert Nelson Marquis Lifetime Achievement Award* for her leadership in aircraft cabin safety.

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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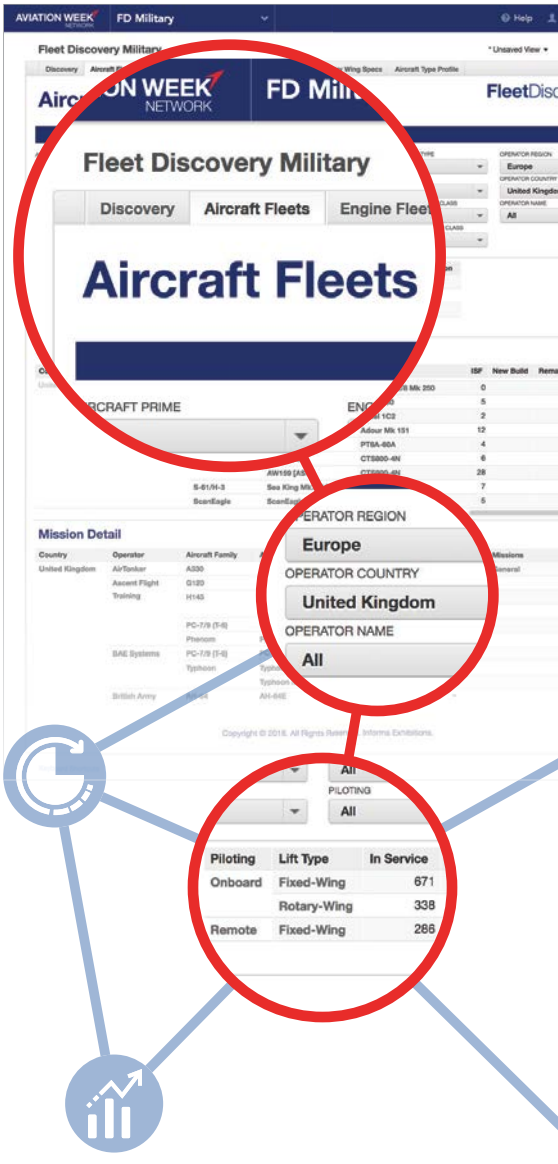

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FIRST TAKE

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DEFENSE

As the U.S. Army prepares to award two contracts for Future Attack Reconnaissance Aircraft prototypes ahead of a flyoff in 2023, Boeing has revealed it is offering a thrust-compounded helicopter (page 26).

Saab has teamed with IMP Aerospace & Defense, CAE, Peraton Canada and GE Aviation to propose the Gripen E for Canada's C$15-20 billion ($11-15 billion) Future Fighter Capability program.

Lockheed Martin has completed the critical design review for the AGM-183A Air-launched Rapid Response Weapon, a hypersonic strike missile planned to enter service on the B-52 in 2022.

Pakistan is considering purchasing China's CAIC Z-10 attack helicopter after U.S. sanctions stalled plans to purchase Bell's AH-1Z and the Turkish Aerospace T129 ATAK.

The French Air Force is exploring leasing a few Boeing CH-47 Chinooks for an evaluation that could lead to a heavy-lift helicopter fleet purchase.

Lockheed Martin will integrate the Sniper Advanced Targeting Pod on the United Arab Emirates' Dassault Mirage 2000-9s after being selected over traditional supplier Thales.

The U.S. Air Force's first two Lockheed Martin F-35 combat wings have reached "full warfighting capability" with a full complement of 78 aircraft, fully trained pilots and maintainers and all the required support equipment.

Korean Air is to design a full-scale technology demonstrator for the KUS-FC unmanned reconnaissance and attack aircraft program run by South Korea's Agency for Defense Development.

TECHNOLOGY

Spirit AeroSystems has signed an agreement with U.S. startup Airspace Experience Technologies to cooperate on development of electric vertical-take-off-and-landing (eVTOL) aircraft.

The U.S. Air Force has launched the Agility Prime program to accelerate the emerging advanced air mobility market and potentially become an early adopter of eVTOL vehicles (page 30).

Startup Joby Aviation will be the only eVTOL developer to provide a vehicle for flight testing in NASA's urban air mobility Grand Challenge development testing event this year.

FRAUNDORFER AERONAUTICS

German startup Fraundorfer Aeronautics has flown a technology demonstrator for its Tensor 600X compound gyrocopter, a two-seat personal air vehicle it plans to launch by year-end.

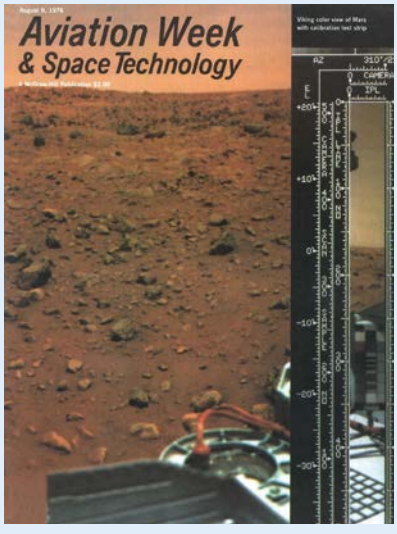
By the March 2 deadline, more than 50,800 respondents had commented on the FAA's draft regulation for remote identification of drones (page 50).

China's EHang has received an operational permit in Norway for long-term testing of its two-seat eVTOL autonomous air vehicle. It will fly samples and spares between the shore and oil and gas platforms.

German startup Lilium's first prototype eVTOL air taxi was damaged beyond repair on Feb. 27 by a fire during maintenance at Oberpfaffenhofen Airport, delaying first flight of the second prototype Lilium Jet.

45 YEARS AGO IN AVIATION WEEK

Our cover of March 3, 1975, showed NASA's Mars Viking 1 lander undergoing checkout in its aeroshell at Martin Marietta in Denver prior to being shipped to Cape Canaveral for launch. The Viking 1 orbiter/lander was launched on Aug. 20 of that year and became the first U.S. mission to land safely on Mars on July 20, 1976 (cover 2). Viking 2, an identical orbiter/lander, followed several weeks later. The Viking mission was designed to operate for 90 days after each of the landings, but both the orbiters and landers operated for far longer. Viking 1 made its final transmission to Earth on Nov. 11, 1982, more than two years after the Viking 2 lander's last communication.



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OBITUARIES

Katherine Johnson


NASA

NASA mathematician Katherine Johnson, whose contributions to the U.S. space program were chronicled in the 2016 film "Hidden Figures," died Feb. 24 at age 101. Joining NASA Langley's Flight Research Division in 1953, she first calculated aerodynamic forces on aircraft and later trajectories for human spaceflights including Freedom 7 and Apollo 11. "Johnson paved the way for other women and African-Americans to play important roles in space exploration," says the Space Foundation, adding: "Her courage, class and grace not only helped open the frontiers of early space flight, but showed us all how there is a place for every one of us in the space economy."

Jack Welch


BROOKS KRAFT LLC/CORBIS/GETTY IMAGES

To the business world, Jack Welch, the former General Electric CEO and chairman who died March 1 at age 84, will be remembered as a smart leader who ruthlessly cut costs to boost efficiency. But to the aviation community, Welch's lasting legacy will be his 1999 decision to back GE's huge bet to develop the higher-thrust GE90-115B as the sole-source engine for Boeing's longer-range 777-200LR/300ER. The risky venture, which reversed GE's decision of the year before to abandon further GE90 development, cemented a 20-year partnership with Boeing that continues with the GE9X on the 777X. Announcing the sole-source deal with Boeing in 1999, Welch said: "The GE90 is the most money I've spent on a new product, so let's hope it all works out." It did. The GE90-115B-powered 777 became the best-selling widebody twinjet family in history.

Matthew Zuccaro

Matthew Zuccaro, immediate past president and CEO of the Helicopter Association International (HAI), died Feb. 26 at age 70. He joined HAI in 2005, after a career as a pilot, operator and aviation executive. "He was a forceful champion for the rotorcraft community, where his professional career reflected a lifelong commitment to improved rotorcraft safety," says the General Aviation Manufacturers Association.

Jerry Grey

Jerry Grey, noted aerospace scientist and engineer, died Feb. 5 at age 93. A professor of aerospace engineering at Cornell University for 55 years, his research in rocket combustion instability was instrumental in assuring the reliability of the Redstone rocket that launched Alan Shepard, the first U.S. astronaut, and the F-1 engine that powered Apollo's Saturn V booster. He was also a pioneer in space nuclear power and propulsion.

COMMERCIAL AVIATION

The European Commission has rejected demands by the International Air Transport Association that slot rules at congested airports be suspended worldwide, allowing airlines to cut flights because of COVID-19 without jeopardizing future access when traffic recovers (page 20).

Plans for a third runway at London Heathrow Airport are in tatters after judges ruled the government's expansion permit had not taken into account the UK's climate-change commitments under the Paris Agreement.

Eurocontrol has signed a 10-year agreement with Aireon for space-based ADS-B data to help enhance traffic flows through European airspace (page 44).

Former Sukhoi subsidiary Sukhoi Civil Aircraft Co., which runs the Superjet SJ100 program, has merged with United Aircraft's Irkut Corp.

An Airbus A321 passenger-to-freighter conversion developed by ST Engineering, Airbus and Dresden, Germany-based Elbe Flugzeugwerke has secured European supplemental type certification.

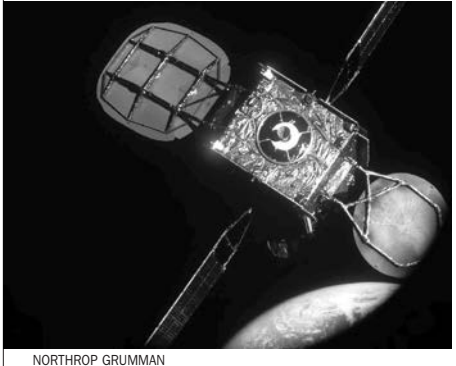
American Airlines and Qatar Airways are to reestablish codesharing after reaching a rapprochement following their long-running dispute over alleged government subsidies to the Gulf carrier.

U.S. regional Trans States Airlines is to cease operations by year-end, citing a pilot shortage and partner United Airlines' move to streamline and consolidate its regional flying with ExpressJet and SkyWest Airlines.

Canada is taking the lead in an international effort to improve airspace safety over and near conflict zones, the Safer Skies Strategy, following the fatal shootdown of a Ukraine International Airlines flight over Iran in January.

SPACE

DARPA's responsive-space Launch Challenge ended on March 2 without a single flight, after startup Astra scrubbed its final attempt at the first planned launch of its low-cost rocket from Kodiak, Alaska.


NORTHROP GRUMMAN

Northrop Grumman's MEV-1 servicing spacecraft docked with Intelsat 901 on Feb. 25, beginning a five-year mission to extend the communications satellite's operating life in geosynchronous orbit.

Virgin Galactic remains committed to becoming the first commercial human spaceflight provider this year, but says it could entail just lofting co-founder and entrepreneur Richard Branson.

UP FRONT

ELIZABETH MATHEWS

Lost in Translation

English proficiency and **aviation safety**

NEARLY 20 YEARS AFTER English language testing requirements for pilots and air traffic controllers were introduced by the International Civil Aviation Organization (ICAO), language continues to threaten global aviation safety.

"We are now at takeoff." That ambiguous communication preceded the 1977 runway collision at Tenerife, Spain, and focused industry attention on the importance of communications.

"We just running out of fuel" captures the failure of an English-as-a-foreign-language flight crew to communicate the urgency of their low-fuel status to busy native-English-speaking controllers at New York's John F. Kennedy International Airport in 1990.

Not every language-related accident involves air traffic control. Threat and error management require clear communication between all members of a flight crew. The crash of Helios Airways Flight 522 into a Greek mountainside illustrates how poor multilingual flight deck communications can have tragic consequences. Investigators described unsuccessful communications between the German-speaking captain, his Greek-speaking first officer and their British ground engineer. "Language difficulties prolonged resolution of the problem," they concluded. The crew could not effectively troubleshoot a warning horn and did not notice a pressurization switch set to manual instead of automatic, resulting in 121 lives lost.

The impact of English on safety in aviation is pervasive, and limited English proficiency is insidious and sometimes difficult to discern. As part of the team that developed the ICAO language proficiency requirements adopted in 2003, I believe the standards have been successful in increasing industry awareness of the risks to aviation safety from inadequate English proficiency. The ICAO language standards were a necessary and important first step.

But challenges remain. Global aviation is still struggling to comply with the ICAO language standards, which address only speaking and listening proficiency requirements for pilot and air traffic control radiotelephony communications. The standards do not address the more intensive oral communications required for multilingual flight deck communications or for flight training in English. There are no ICAO language standards for maintenance technicians, and there are no ICAO reading proficiency requirements for pilots, controllers or maintenance technicians.

Airplanes are increasingly complex machines. Pilots and technicians learn to operate, maintain and repair aircraft by reading complex manuals not written for an English-as-a-foreign-language audience. A recent industry focus on pilot training to better manage complex automation—and train for high-altitude upset recovery and other critical aspects of flying—should also account for aircraft piloted and maintained by people who use English as a foreign language.

IN PICTURES LTD./CORBIS/GETTY IMAGES

Today, more than 80% of all accidents can be attributed to human error. Experts acknowledge that improving the excellent safety record in aviation requires the more difficult task of improving human performance. Raising the English language proficiency level of pilots, air traffic controllers and maintenance technicians through global access to safety-focused aviation English curricula is the single most effective measure the industry can take.

Embry-Riddle Aeronautical University is addressing these issues through support for its Language as a Human Factor in Aviation initiative. We are focusing first on the development of English for Flight Training and English for Air Traffic Control curricula as well as an online assessment tool and research to improve industry understanding of language as a factor in aviation safety.

The next critical step to raise global levels of English language proficiency is industry-academic collaboration. Aviation-focused academic institutions like Embry-Riddle can bring state-of-the-art language teaching expertise to curriculum development, and businesses excel at agile response. Safety and fairness additionally require the objectivity and credibility that characterize not-for-profit academic institutions.

No industry has done more to make the world smaller than aviation. We share a single airspace. Language in aviation is a worldwide problem that can and should be solved through global collaboration.

Elizabeth Mathews is an assistant professor of aerospace and occupational safety at Embry-Riddle Aeronautical University and co-author, with Eric Friginal of Georgia State and Jennifer Roberts of Embry-Riddle, of English in Global Aviation: Context, Research, and Pedagogy.

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GOING CONCERNS
MICHAEL BRUNO

U.S. PRESIDENT DONALD TRUMP has been busy racking up detentes lately, from a "phase one" trade war truce with China to a bipartisan budget agreement with Democrats in Washington. While each of these is important for the aerospace and defense sector, another potential thaw is gaining attention for being possibly more than just a ceasefire.

For 16 years, Airbus, Boeing, Europe and the U.S. have been warring in the World Trade Organization (WTO) over government subsidies to the OEMs that make large airliners. Both sides have won in court, and last year Washington got the green light to collect up to $7.5 billion in penalties. But by May or June, the WTO will announce how much Europe can collect in return.

The Art of Making a Deal

Is **WTO** resolution possible?

AIRBUS

With that deadline looming, Boeing and the Trump administration recently offered both carrots and sticks to try to nudge Airbus and the EU toward a settlement. First, the administration announced on Feb. 14 that the tariffs applied to large commercial aircraft from Europe imported into the U.S. will rise from 10% to 15% on March 18.

Second, new legislation was introduced for consideration in Washington state that would dial back tax benefits to Boeing worth about $100 million a year. "Boeing applauds the actions today by Washington state leaders to introduce this legislation," the company said Feb. 19. "We fully support and have advocated for this action."

Boeing said the legislation, if enacted, would "resolve the sole finding against the United States," although the WTO would rule on that, and Airbus can dispute the ruling in a process that could take a year to play out.

Nonetheless, in order for the new legislation to matter, it ostensibly would have to become law first. Also, withdrawal of the tax benefit is not the same as making up for the harm the benefits might have done in the past. "It is unclear what impact the move will have," JP Morgan analysts say about the legislation.

Similarly, the tariff increase to 15% is not expected to have an immediate effect.

Still, the legislation affirms a relatively new desire by Boeing and the administration to try to craft some kind of a deal. Boeing used to favor seeing the WTO process fully carried out and had deflected long-running Airbus entreaties to talk about an agreement. But that was before a China trade war, let alone the 737 MAX crisis or the COVID-19 outbreak.

It also came before Boeing tried to acquire 80% of Embraer's commercial aircraft business—an acquisition that is being held up by EU antitrust regulators who live in the real world and read the same news about the WTO dispute and other EU-U.S. trade tiffs.

Of course, Airbus has good reasons to support a settlement. Analysts at Bloomberg have noted that even with tariffs on U.S. aircraft imports to Europe, Boeing still will be less harmed than Airbus by the whole dispute, as the latter's sales into the U.S. could be more important, comparatively.

"Without a deal to lift U.S. tariffs in 2020, Airbus will need to absorb costs on 49 aircraft or reduce deliveries, as we see it," Bloomberg analysts said Feb. 18. Airbus will soon be able to build six A320s a month in Mobile, Alabama, avoiding the U.S. levy on 72 deliveries this year, but that is all. Airbus is trying to backload its backlog with the hope that U.S. tariffs will eventually be lifted. If not, Airbus would lose up to about $300 million in pretax earnings this year, the company says.

"In a U.S.-Europe trade battle over airplanes, Airbus has more to lose, in our view," the Bloomberg analysts said. "All the fast-growing U.S. airlines purchase Airbus jets, including Frontier, Spirit, JetBlue, Allegiant and Delta.

"It's also unclear whether the UK would place tariffs on U.S. aircraft as it leaves the European Union," the Bloomberg analysts continued. International Airlines Group has a large letter of intent for Boeing 737s from last year's Paris Air Show, which has yet to be confirmed. Those deliveries might not be affected if the UK does not follow suit on tariffs.

To be sure, a potential settlement in the airliner dispute could be derailed by any number of things. It depends on how much the WTO allows to be collected in penalties, how the EU implements its levies, or other issues such as the Boeing-Embraer deal and how Trump reacts.

For now, hope springs eternal. "There is a possibility that this trade dispute could escalate before peace breaks out, but Boeing's recent moves on its Washington state tax breaks suggest that things are moving on the U.S. side," say analysts at Vertical Research Partners.

INSIDE BUSINESS AVIATION
WILLIAM GARVEY

New and Novel

Garmin's Autoland lands in **bureaucratic limbo**

THE CREW OF THE 23-YEAR-OLD Lear 35 radioed air traffic control as they climbed out of Orlando through to a 23,000-ft. altitude and then again to acknowledge their clearance to 39,000 ft. They were never heard from again. The jet continued climbing past its assigned altitude but then failed to turn west toward Dallas, its destination. U.S. Air Force pilots intercepted the silent aircraft, then at 46,000 ft., but got no response when they radioed the pilot. The Lear's cabin windows were dark and the cockpit windscreens frosted over.

Four hours after takeoff, the Lear began descending—its fuel exhausted. An F-16 pilot watched the jet make several aileron rolls and spiral into the ground near Aberdeen, South Dakota. The Oct. 25, 1999, crash killed all six onboard including pro golfer Payne Stewart. The National Transportation Safety Board determined the accident's cause was the pilots' incapacitation "as a result of their failure to receive supplemental oxygen following a loss of cabin pressurization, for undetermined reasons."

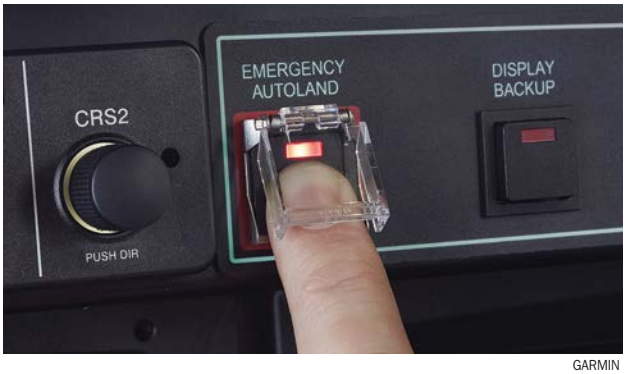
The crash struck a chord with many, including those working at Garmin International in Olathe, Kansas. Phil Straub, then a software engineer, remembers thinking: "Did that really have to happen?" At the time, Gary Burrell, the avionics company's cofounder (and the "Gar" in its name), was leading an engineering team working on the G1000 digital integrated flight instrumentation system. That, Straub recalls, pointed to an answer.

As additional digital systems were developed and the even more advanced G3000 took form, the idea of a wholly automated landing capability built on its digital foundation took hold. Discussions about the possibility began in the early 2000s, and management readily endorsed the undertaking. "It's the lifeblood of who we are," Straub says.

The first software was written and system requirements were initiated in 2011, the same year Straub, a veteran pilot, was appointed head of Garmin's aviation division. Flight tests began in 2014. In 2015, Straub's team members alerted the FAA to their goal and engaged various agency offices including flight test, certification and air traffic. After all, their technology fell under the "new and novel" category, and Garmin wanted as much of the regulator's input as possible. It did the same with the European Union Aviation Safety Agency.

The following February, the software, algorithms and autopilot control loops were deemed ready. And then came the day Chief Test Pilot Tom Carr took his hand off the sidestick controller (but not too far), pushed a button, and watched intently. The Cessna Corvalis he had been piloting turned toward the airport the system deemed most appropriate. It descended from altitude, lined up with the most suitable runway, lowered its flaps, slowed and flared just before touching down. The aircraft squeaked onto the pavement, rolled out on centerline and stopped. The system, christened "Autoland," worked (*AW&ST*, Nov. 11-24, 2019, p. 40).

All totaled, Garmin conducted 896 such flights. Piper and Cirrus, the first manufacturers to offer Autoland on the M600 turboprop and SF50 Vision Jet, respectively, have flown hundreds more. In February, Daher announced it is equipping the TBM 940 with Autoland as well. A notable Autoland feature comes into play in extreme circumstances. If the pilot fails to respond to prompts, the system will assume incapacitation and activate automatically—though it can be disengaged with the push of a button.



GARMIN

Straub thought all the ground and flight trials had been completed and necessary boxes checked as of November 2019. He anticipated the FAA certification award for Autoland by year-end. However, much to his frustration, that has not occurred yet; "new and novel," it seems, can stymie a bureaucracy. But "I think we're very close," he adds hopefully.

While pilots are familiar with automation, Autoland serves an additional population: the nonpilots onboard. The new system, Straub says, "gives them an actual say in the outcome of the flight" should something go wrong with the person at the controls.

Others agree. One member of the Malibu M-Class Owners & Pilots Association called Autoland "a game changer." Another commented: "Even though I never would expect to use it—God forbid something should happen to me while aloft—I will be glad it's there." Garmin Autoland is receiving the 2020 Aviation Week Business Aviation Laureate for Safety (*AW&ST* Jan. 13-26, p. 62).

But Straub suspects that once blessed by FAA and operating in the fleet, Autoland's first activation is likely to come from an alert pilot spooked by weather or operational demands beyond his or her capability. "And that's okay," he says. "It's better to explain after" than, like Payne Stewart, never have the chance.

William Garvey is Editor-in-Chief of Business & Commercial Aviation

PAST THE PEAK

> LEASING INDUSTRY CONTROLS MORE THAN 40% OF IN-SERVICE FLEET

> THE LARGE NUMBER OF LESSORS LEADS TO PRESSURE ON RATES

Jens Flottau Dublin and Singapore

Every year at the end of January it is difficult to get a table in a decent Dublin restaurant. For an entire week, the global aircraft leasing industry invades the city center between Trinity College and St. Stephen's Green. During the day, the venerable Shelbourne Hotel is the center of deal-making.

But as there are now far too many deals to be made, with far too few conference rooms available, the action spills to nearby cafes, bistros and even sidewalks. At night, talks continue at multiple receptions in the city's upmarket bars and restaurants.

Lessors have been around for a long time. The concept began to gain traction in air transport in the 1970s. Since that time, true powerhouses such as AerCap, GECAS, Air Lease Corp. (ALC) and Avolon have emerged. Their success has attracted more investors and money to the industry, with an abundance of available global capital seeking seemingly secure homes. The number of lessors with large portfolios of aircraft has doubled in a few years. In 2019, around 9,500 in-service Airbus and Boeing aircraft were owned by lessors, according to the Aviation Week Network Fleet Discovery database. There were a total of 23,000 aircraft with more than 100 seats in service at the beginning of 2019, making the lessor share roughly 41%.

Air Lease Corp.'s Steve Udvar-Hazy (left) and John Plueger (right) signed a deal with Airbus' Christian Scherer (center) at the 2019 Paris Air Show.

AIRBUS

The lessor-owned fleet has grown significantly, from 6,535 aircraft in 2009 and 7,781 in 2014 to the current number, according to Fleet Discovery. Lessors placed about 30% of direct Boeing orders at their peak in 2017, but the number has since declined. In addition to placing orders with the OEMs, lessors routinely buy large portfolios of aircraft in sale-and-leaseback deals with airlines, then trade those portfolios with each other.

BOEING

Ihssane Mounir, Boeing Commercial Airplanes head of sales

Lessors have proven to be an attractive sales channel for Airbus and Boeing, driving growth alongside emerging low-cost carriers such as Lion Air, AirAsia and IndiGo. For investors, aircraft seem to be really attractive assets. Unlike many other assets, they can be moved around worldwide if a placement proves unsuccessful. That perceived attractiveness has pulled in money, though not always smart money.

But the leasing sector is increasingly becoming the victim of its own success. A growing number of its leaders are saying it is time for an adjustment. Has the leasing concept gone too far?

There are some basic numbers on which the industry agrees: "Lessors make good money if the leasing share is below 30%; it becomes difficult above 40%," says Timothy Ross, BOC Aviation's head of investor relations. "We are in an oversupply situation," he says, due to many new lessors having aggressively entered the market over the last few years. "There were 6-8 lessors 10 years ago. Now there are twice that number," he adds.

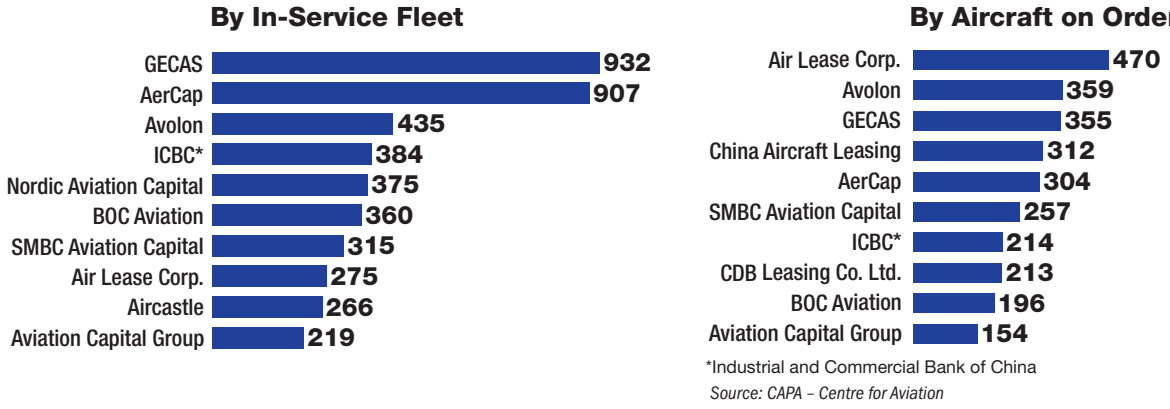
"Having around eight lessors controlling less than 30% of the fleet is a healthy level," says DAE Capital CEO Firoz Tarapore. "It is not healthy to have 20 lessors, many of which are first-time buyers and have no experience."

Eighteen lessors have placed direct orders for the Airbus A320neo family, not counting sale-and-leaseback deals for airline orders. Sixteen lessors bought the Boeing 737 MAX.

AerCap CEO Aengus Kelly says overexposure to the lessor channel has led to an influx of "incompetence" in the market. "[Aircraft manufacturers] have given the product to incompetent players," he contends. Inexperienced lessors are often unaware of the intricacies of even preparing for entry into service, such as ordering interiors on time, he notes. With too many lessors competing for airline deals, the small new players will often offer bargain rates too soon and destroy the market for everyone else.

"There are too many Chinese lessors that don't have to

10 Largest Lessors



*Industrial and Commercial Bank of China

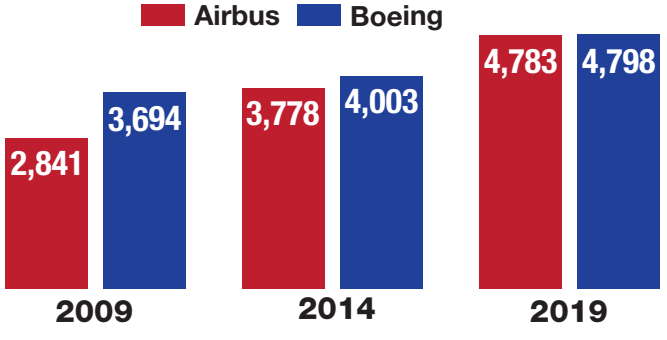
Source: CAPA – Centre for Aviation

make money," Avitas Senior Vice President Adam Pilarski says. "They are driven by the wrong considerations because they are government-owned. [Their] goal is to grow, not to make a profit."

"Airlines have been getting unbelievably attractive sale-and-leaseback deals," says Avolon CEO Domhnal Slattery. Of course, this was before the Boeing 737 MAX grounding. Since the aircraft is temporarily off the market, it is all but impossible to agree on any type of lease deals because its return-to-service timing is still unclear. At the same time, lessors with A320neo orders have been unable to benefit much from the grounding because they have few, if any, aircraft available to place in the short term—and Airbus production delays are not helping.

The situation is made even more complex by the recent COVID-19 outbreak that has left many lessors scrambling to place surplus aircraft from Asia-Pacific fleets with customers in other regions desperate for backup capacity available to fill gaps created by the MAX grounding. Financially strong lessors such as ALC or AerCap are sometimes prepared to assist airline customers by allowing them to temporarily defer lease payments.

Total Lessor In-Service Fleet



Source: Aviation Week Network Fleet Discovery Database

Even in normal times. the major players would prefer to face only each other. "Competing against grown-ups is better," Ross says. "Inexperienced lessors tend to panic quickly and talk about price first." But there are many other levers in lease contracts that are important, too—return conditions and currency hedges being just two that require the complex deal structuring of which many new players are simply incapable.

GECAS is the world's largest lessor by number of aircraft in service (932), followed by AerCap (907). Avolon, owned by HNA Group and Orix Aviation, is a distant third, at 435 aircraft. Ross' BOC Aviation ranks sixth. There are currently 11 lessors with more than 100 aircraft on order. ALC leads with 470 firm orders, followed by Avolon (359) and GECAS (355).

The MAX grounding is a double-edged sword for lessors. Some with big orderbooks, such as AerCap, have lost opportunities to grow and have made predelivery payments (PDP) that are not generating revenues. On the other hand, things could have been much worse without the grounding of the Boeing 737 MAX, which limited the available capacity in the narrowbody market. "There has been an overallocation of the MAX to the lessor channel," Ross says. "There could have been some really ugly lease rates if the MAX had been on schedule."

Pilarski agrees: "Airbus and Boeing have been overselling. We don't need all these planes." The industry "was saved by incompetence," he says, referencing mostly the MAX crisis but also the delivery delays for Airbus narrowbodies that still average six months for the A321neo and put airline network planning in disarray. "[Yet] even with 1,000 aircraft fewer, the market is fine," he contends. "Airlines make money because all of these aircraft are not there. We could have [had] huge overcapacity."

The MAX leasing market is a specific case, not only because of the current grounding, in effect since March 2019. There was a long delay in Chinese validation of the aircraft's type certificate, which meant Boeing was unable to place the MAX into the Chinese market until 2018. Even then, the market was only open for a brief period. Then came the China–U.S. trade war, followed by the grounding. While Boeing was still able to deliver aircraft, all the MAXs ordered by lessors and earmarked for Chinese operators had to be placed in other regions, leading to even more pressure on lessor yields. The influx only ended with the grounding.

In hindsight, Boeing actually agrees with the criticism, at least to an extent. "As an industry we have probably sold too many [aircraft to lessors]," concedes Ihssane Mounir, Boeing Commercial Airplanes head of sales. "Collectively, we have to rebalance the content to lessors. And we have been working very aggressively on this strategy over the past 12 months."

"The lessor content is north of 40%; Boeing is now aggressively managing it down to 30%," says Tarapore. "Boeing

The MAX grounding is making an already challenging situation even more complicated for affected lessors such as AerCap.

AERCAP

and Airbus should select capable people with experience. Lessors can help you."

Mounir contends that it was not Boeing alone, or even primarily, that took advantage of the situation. Boeing has simply caught up to Airbus over the past few years. Mounir also points at factors, not obvious at first glance, that helped create the issues facing the industry.

From an aircraft manufacturer's point of view, selling to a lessor has its advantages. Big volumes of identical aircraft offer opportunities to streamline production, though discounts are deep because of the larger volumes. Lessors are also more willing than airlines to buy further out. Boeing and Airbus find that attractive, as they can be sure to have production slots filled even several years along and plan capacity accordingly, not to speak of the highly welcome PDPs.

The risk is on the customer's side. Lessors will typically make speculative orders for narrowbodies, without having secured their own customers for the specific aircraft at the same time. They are more cautious in the widebody markets, where limited volumes and customization make trading harder. A lot more capital is bound by a single unit.

Avitas' Pilarski, a former McDonnell Douglas executive, recalls that "Douglas wanted the leasing share [of total orders] not [to go] above 20%." That clearly has not been the guidance at Airbus, which has used lessors more aggressively than other manufacturers as a way to build market share. "The salesperson would get the same credit [for a lessor order] as if it were an airline order," he notes.

So it is no surprise that Mounir contends "it is more them [Airbus] than us" when it comes to creating an oversupply. "All we have done is picking up over the past three years," he says, conceding that "you have to be careful to see who buys and who leases."

"I have yet to meet a leasing company that does not say there are too many other lessors and too much competition," says Airbus Chief Commercial Officer Christian Scherer. "But I would agree that there has been a bit of a frenzy in the leasing market fueled by easy access to capital. We, as an industry collectively, may have been a little too eager to pursue this, but I would not make that a superstrong statement."

Total Lessor Orders

Source: CAPA – Centre for Aviation

Scherer points out, "We don't want too much of the future production placed with lessors on a speculative basis." When the share of the lessor-owned in-service fleet goes above 30-35%, he says, "We are really watching it carefully." But, he adds: "It is not a commercial target for us to diminish the lessor backlog. Maybe we don't want to increase it further. The current equilibrium is not that bad."

Lessors have undoubtedly played an important role in Airbus' rise to market leadership. "We were the small guy, the outsider, and lessors offered airlines financing that would have been extremely onerous for small Airbus." At the same time, big lessors such as the International Lease Finance Corp. or GECAS had "a lot of financial depreciation appetite" that could be addressed by "big capital investment" in Airbus aircraft, among others, he says.

Not necessarily coincidentally, the leasing industry began to be established at about the same time as Airbus, in the 1970s.

Scherer says there are a number of proven lessors that are very professional. "[They] are not just speculating on asset value," he notes, "[because] there is more to it than financial speculation." On the other hand, aviation's growth in the past 10 years may have attracted some people without the necessary know-how. Given where the industry stands now, and influenced by the MAX grounding and the impact of the COVID-19 outbreak, Scherer says he "would not be surprised if there were some consolidation" in the sector.

Overall, Scherer is adamant that Airbus is following a sophisticated strategy in its dealings with the leasing industry that has proven to be highly successful. "The ideal scenario is a stable, competitive market," he says. "Allocation needs to be carefully managed so there is availability for customers, but not at the same time [as direct production slots for airlines]. Lessors are great because they are more flexible than we can be and react more short-term."

Airbus is also using the leasing industry to build up market presence for new models. For instance, it placed the Rolls-Royce-powered A330-900 with GECAS because the lessor owns a large fleet of General Electric-powered Boeing 767s that will come up for replacement over time. Similarly, Airbus recently signed a deal for 20 A220s with Nordic Aviation Capital (NAC), the largest lessor specializing in the regional sector. "There is a lot of science behind every deal," Scherer says.

For Airbus, the leasing deals are also somewhat of an insurance policy. "It is a real quid pro quo for manufacturers in a crisis," Scherer says. "In bad times, lessors can pay back; they are a financial shock absorber for OEMs." He points

out that after the Sept. 11, 2001, attacks lessors, unlike airlines, took delivery of all aircraft and helped Airbus keep its production stable.

Yet it is clear that neither of the two leading manufacturers have paid too much attention to protecting the residual values of their lessor (or airline) customers. Embraer, by contrast, has taken the opposite approach. When it launched the E2 family, the OEM decided to limit lessor deals to three companies: AerCap, Aircastle and the Industrial and Commercial Bank of China (ICBC). With 50 firm orders, AerCap is the E2's second-largest customer behind Azul. Aircastle bought 25 aircraft, ICBC 10. The leasing share of the E2 backlog is at 50%, broadly in line with market trends in terms of aircraft numbers, but many fewer players are involved than for the A320neo or 737 MAX.

There are signs that the market is slowly beginning to turn, triggered in part by the MAX debacle and Boeing's strategy shift.

Coming off their peak, lessors have placed very few additional orders in the past two years. In 2018, lessors placed 19% of all direct orders with Boeing; the share fell to just 3% last year. On the Airbus side, the share was 19% and 9.3%, respectively. Both added large orders to undisclosed customers in the past two years, some of which may have been from lessors.

AERCAP

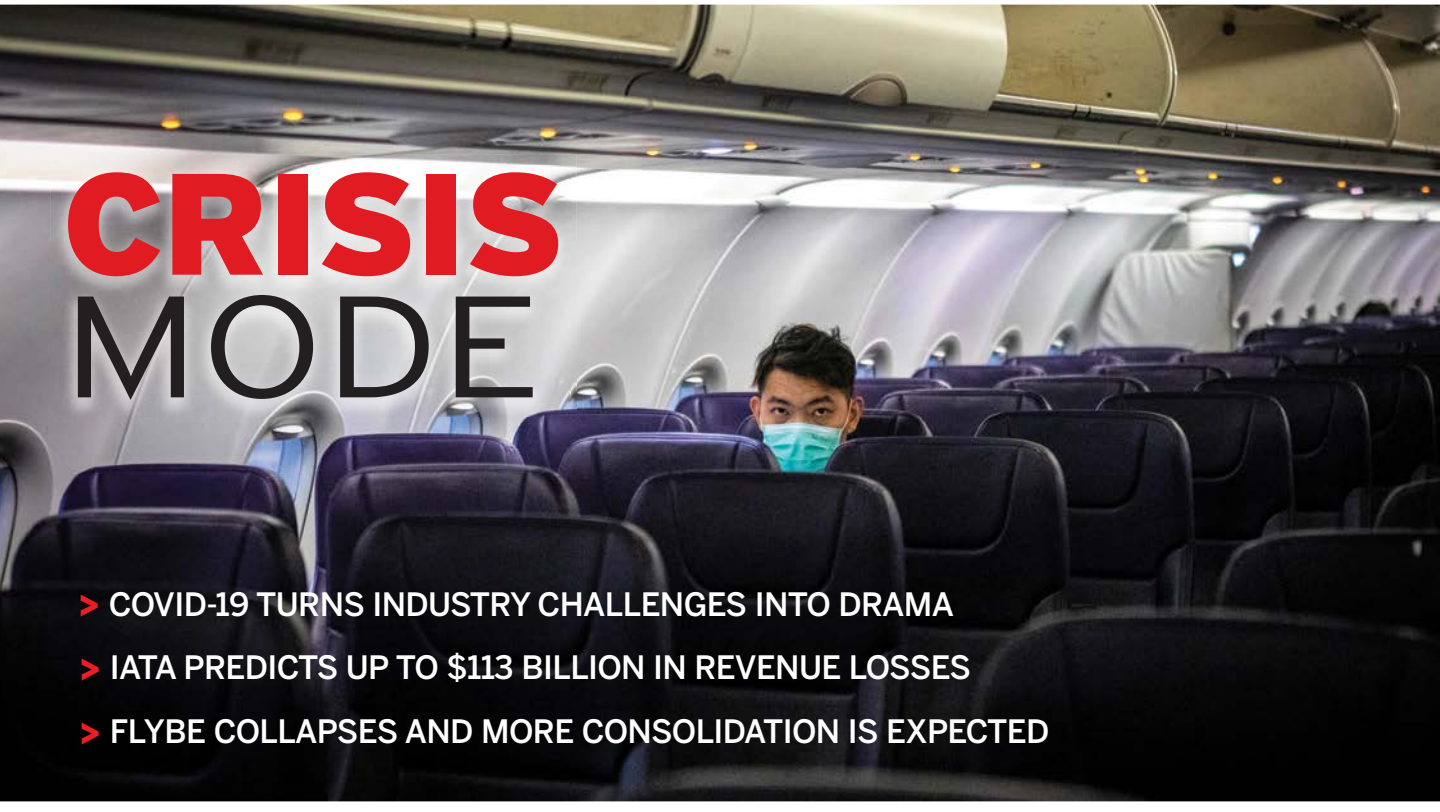
AerCap CEO Aengus Kelly says too many incompetent players populate the leasing market.

It does not seem as if many lessors will be back in the direct orders market anytime soon, given their large exposure and the huge market uncertainties. "[Last year] saw the lowest number of orders from lessors. 2020 will be the same," DAE's Tarapore says. DAE Capital has been looking at placing a large order with either Airbus or Boeing but has been put off by the manufacturers' expectations. "The prices are not justified by the rental levels," he says.

The initial pricing of the Neo and MAX were based on the cost savings achieved through lower fuel consumption. But with fuel prices easing, that advantage has become smaller. "It is not obvious that we needed all this new technology, [given the low fuel prices]," Pilarski contends. "All the money was kind of wasted. The investors don't get the premium they expected because the cost advantage is not as big as expected."

As a consequence, "we are beginning to see subscale ventures exiting," BOC Aviation's Ross observes. "[Some] feel the pain at the end of the first lease when investors find out that business plans have been based on the assumption of a gain on sales that turned out not to have been realistic."

"You are starting to see an exit of the smaller players," Slattery agrees.



CRISIS MODE

> COVID-19 TURNS INDUSTRY CHALLENGES INTO DRAMA

> IATA PREDICTS UP TO $113 BILLION IN REVENUE LOSSES

> FLYBE COLLAPSES AND MORE CONSOLIDATION IS EXPECTED

Jens Flottau Frankfurt, **Helen Massy-Beresford** Paris, **Adrian Schofield** Auckland, **Bradley Perrett** Sydney and **Ben Goldstein, Sean Broderick** and **Michael Bruno** Washington

Load factors are plunging for airlines worldwide as passengers avoid travel.

The aviation industry likes certainty, predictability and long-term planning visibility for the big investments it is based on. The COVID-19 crisis, which has now turned into a global phenomenon, guarantees it has none of it for the near future.

With the situation changing daily, it is not even accurate to assume that the situation is "unprecedented." It is not clear whether recovery will follow the pattern of the 2003 Severe Acute Respiratory Syndrome (SARS)—thereby having a precedent—or be much different and worse.

To date, there is no World Health Organization (WHO) warning not to travel to China, yet demand is imploding along the virus' path and beyond. Following the outbreak in Wuhan, China, the Asia-Pacific region was affected the worst first. Now there are similar developments in growing parts of Europe. And U.S. airlines are beginning to make substantial capacity reductions across the Atlantic and in the domestic system.

"The world economy is facing a sharp downturn in Q1 due to the impact of the coronavirus," writes Oxford Economics lead economist Adam Slater in a March 4 research briefing. "A dramatic slowdown in China plus the damage to demand as the virus spreads internationally point to world GDP contracting this quarter." Even if recovery is quick, Slater expects world GDP growth to contract to only around 2% for the year, "easily the slowest pace in the last decade," he notes.

The International Air Transport Association (IATA) projects the industry could lose up to $113 billion in revenues in 2020 if the virus spreads further. This would be 19% of forecast revenues and "on a scale equivalent to what the industry experienced in the global financial crisis," IATA states. A less dramatic scenario assumes a reduction of $63 billion or 11%. Both calculations assume that the recovery will be V-shaped.

"The turn of events as a result of COVID-19 is almost without precedent," IATA Director General and CEO Alexandre de Juniac says. "In a little over two months, the industry's prospects in much of the world have taken a dramatic turn for the worse."

De Juniac asserts that "as governments look to stimulus measures, the airline industry will need consideration for relief on taxes, charges and slot allocation," adding: "These are extraordinary times."

If COVID-19 spreads extensively, IATA forecasts Australia, China, Japan, Malaysia, Singapore, South Korea, Thailand and Vietnam will suffer a $49 billion revenue reduction and a 23% decline in passenger numbers. Canada and the U.S. would see 10% fewer passengers and $21 billion less in revenues. Europe would experience a $44 billion revenue shortfall. Nominal fuel costs (not counting those achieved by flight cuts) could fall by $28 billion, providing some relief, although hedging could delay the impact for many airlines.

The COVID-19 crisis makes the already complex situation with which the industry has been dealing overwhelmingly complicated. Some factors, such as the already existing weakness in the widebody market, are being made far worse. Others cancel

ALEX PLAVEVSKI/EPA-EFE/SHUTTERSTOCK

each other out partly but not everywhere: Airlines have been scrambling for additional narrowbody capacity in some markets as the Boeing 737 MAX grounding dragged on before the novel coronavirus outbreak. Now essentially everywhere in the world the last thing airlines need is more aircraft.

If traffic does not come back in the next few months, the MAX may hit the market at the worst possible time. Massive deferrals and cancellations are becoming possible for airlines following the one-year anniversary of the grounding this month. And why would they not make use of those options?

There is disruption everywhere in aerospace and air transport. Airbus' narrowbody production meltdown, which would be considered a major industrial crisis in normal times, has almost been forgotten. And while most observers are awestruck by the sharp drop in traffic as COVID-19 proliferates, it is important not to forget that there were more gradual declines last year, before the coronavirus emerged. Air transport had been on the verge of a substantial slowdown from its 10-year above-average growth phase as trade conflicts took their toll.

For Airbus, Boeing (and lessors, see p. 16), there is huge risk that airlines scheduled to take delivery of new aircraft this year will not be able to afford them or will defer deliveries as a measure of caution. Airbus is targeting around 880 deliveries in 2020, of which 338 (or close to 40% of production) are supposed to go to Asian operators (see graph). This is not counting aircraft to be delivered to lessors that are intended to be flown by airlines in the region.

While much of the focus has been on Airbus A330neo risk, only seven of the aircraft are scheduled to go to Asia-Pacific carriers this year, according to the Aviation Week Intelligence Network Fleet Discovery database. The A350 is much more exposed, with 37 total deliveries—including many to mainland Chinese carriers and Cathay Pacific Airways, based in Hong Kong.

Boeing's risk looks to be lower at first glance, with "only" 109 aircraft planned for Asia-Pacific airlines this year: 49 787s, six 777s and a notional 54 737s. But of course, the lower number is not voluntary and expresses the effects of the MAX grounding and China's refusal to order more 787s until its trade conflict with the U.S. is resolved.

"People don't buy aircraft to take delivery tomorrow," Boeing Commercial Aircraft head of sales Isshane Mounir says, noting that "China conversations are on standby right now [as] airlines are in cash-conservation mode." Mounir says he believes "this is a short-term issue for now."

Airbus CEO Guillaume Faury set a different tone at a March 4 hearing of the French senate's economic affairs committee, saying that industry-wide orders for long-haul aircraft could be affected in the current crisis. "When it comes to long-haul aircraft, between Airbus and Boeing we have a lot of supply and a market that is not quite as strong as was predicted a few years ago," Faury said.

Airbus is expecting a massive hit to the A330neo program. Air Asia X—by far the largest A330neo customer, with 78 on firm order—said late last month it will defer A330-900 deliveries.

"Civil manufacturers could be affected for several years but with a limited impact to 2020, though airlines especially in Asia are already reported to be talking to OEMs about deferrals," analysts at London-based Agency Partners write in a note to clients. "Comparisons with the impact of SARS are misleading and poorly judged: Asia accounted for only 10% of civil aircraft in 2000-2005 versus around 50% in 2010-2019." Agency Partners expects a "sharp and rapid impact" on the civil aftermarket, which could be short, "as a traffic recovery quickly drives a need to catch up with deferred maintenance."

Lessors are exposed, too. Early on, some larger lessors expressed optimism that they could shift capacity within their customer portfolio from affected operators to those in need of lift due to the MAX and other lingering issues, including A321 delivery delays and Rolls-Royce Trent 1000 engine problems that grounded some 787s. But the virus' spread into Europe and North America has tempered that. Facing cash-strapped carriers, lessors have little choice about being flexible.

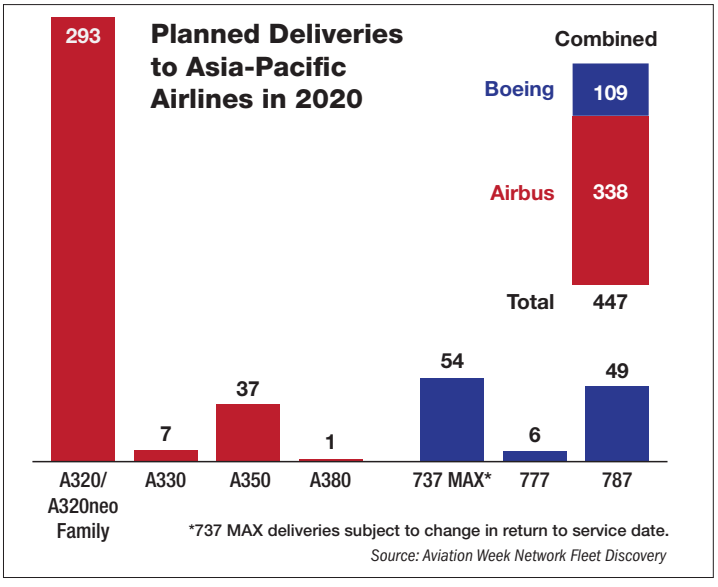
How bad things will get and for how long depends on how quickly air travel can recover. Different regions are in different phases of the crisis, and everything remains fluid.

China is preparing to go into recovery mode. The government will pay subsidies to support international air connections, as local airlines plan further restoration in domestic capacity. For the week of March 9, airlines are planning to run more than twice the domestic capacity they offered amid their period of maximum retrenchment in February.

Though more seats are being offered within China, aircraft appear to be flying less than half full. For international routes on which several airlines are operating, the government will pay a subsidy of 0.0176 yuan per available seat-kilometer (0.41 U.S. cents per available seat-mile), the finance ministry says. If only one airline serves a route, it will be paid three times as much, 0.0528 yuan. The support extends to foreign carriers.

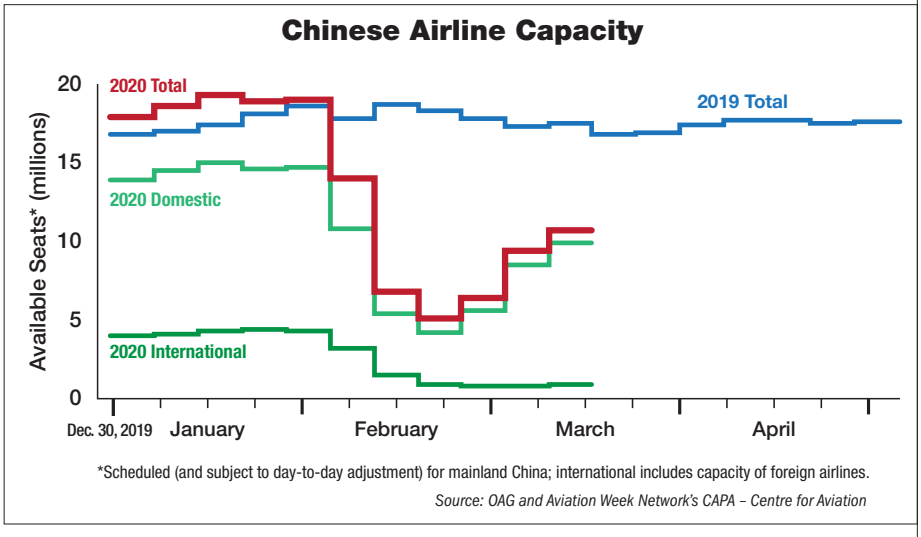
About 80% of China's international capacity, including that run by foreign airlines, had been shut down by mid-February, according to data from OAG and the Aviation Week Network's CAPA – Centre for Aviation. No trend improvement has appeared since then.

Chinese domestic capacity, by con-



trast, is rising from week to week, up from a mid-February trough of about 30% of the precrisis level. The government is demanding that the country get back to business: Factories and offices have been reopening. Airlines have likewise been putting aircraft back in the air. For the week beginning March 9, airlines are offering 9.9 million domestic seats, about two-thirds of the pre-epidemic volume.

Data on loads is not available, but on a typical day during the week of Feb. 24, Chinese airlines carried only 22% as many passengers on domestic and international services as they had a year ago, according to Chinese aviation data firm VariFlight. Comparing that with seat offerings in the same week suggests loads of less than 50%.



The crisis has overcome attempts by HNA Group to save itself. In talks for investment by the Hainan provincial government, the authorities are expressing interest in acquiring stakes of HNA Group's foreign aviation assets, though nationalization of Hainan Airlines remains the focus, say three sources familiar with the discussions. The foreign HNA aviation businesses in which the province could invest could include lessor Avolon, say sources associated with the group, the government and creditors.

Other markets in the Asia-Pacific region are also suffering massive declines in air service. South Korea has been particularly hard hit, reflecting the fact that it has the second-highest number of coronavirus cases behind China. International seat capacity in the South Korean market almost halved in the space of just six weeks, CAPA and OAG data indicate.

South Korea-based airlines such as Korean Air have cut back schedules dramatically: Korean Air has suspended more than 100 of its international flights, with frequency reductions on at least a dozen more.

Japan is another market severely affected. International seats were down 34% for the week of March 2 versus Jan. 27, CAPA and OAG data show. The decline initially hit only international traffic, but on March 4 All Nippon Airways announced domestic cuts, too.

The service reductions are a particularly tough blow for Japan, as the country's airlines and government were targeting a wave of traffic growth in 2020. The government created 50 new slots at congested Tokyo Haneda Airport for use from late March to boost international service.

Almost all Asia-Pacific governments have introduced travel restrictions, and new measures announced by India are among the most stringent, suspending visas for travelers from China, Iran, Italy, Japan and South Korea.

In Europe, Flybe became the first airline to collapse since traffic began to plunge. After years of distress, the continent's largest regional airline went into administration March 5 and stopped flying immediately.

Elsewhere in Europe, airlines have made deep, short-term capacity cuts. Ryanair, for example, is taking 25% of capacity out on a rolling basis to adjust to the new lower demand levels. Lufthansa Group is grounding the equivalent of 23 long-haul aircraft and 150 narrowbodies to reduce short-haul capacity up to 25%. Demand to Italy has suffered the most.

Yet airline CEOs were trying to reassure themselves March 3 that the spread of COVID-19 and the consequent demand slump will be short-lived and followed by a quick-recovery.

"I am quite confident we will get through this in a relatively short period of time," Air France-KLM CEO Ben Smith said at the Airlines for Europe (A4E) Aviation Summit in Brussels. "It is a big event with a huge impact but relatively muted in other regions."

Ryanair CEO Michael O'Leary expects "deflated bookings for the next 2-3 weeks," adding: "Then people will get bored about COVID-19 coverage. Bookings through summer are reasonably solid right now."

IATA requested slot rules to be suspended globally for the entire summer timetable (from the end of March to the end of October). A4E argued this would give airlines the necessary flexibility to cut back flights without the risk of losing access to slot-constrained airports in the summer of 2021. Airlines are generally required to use a slot at a regulated airport for at least 80% of the time or lose it for the next period. The rule was suspended after the outbreak of SARS in 2003, though.

Henrik Hololei, the European Commission's director general for transport and mobility, pointed out that there is no immediate pressure on regulators to act. He expects to make a decision in April at the earliest.

North American commercial carriers that operate in the Asia-Pacific region suspended all flying to China and Hong Kong in early February and slashed capacity to affected regions including Japan, Northern Italy and South Korea.

United Airlines, the U.S. carrier most exposed to the Asia-Pacific region, took still more aggressive moves March 4, cutting its international schedule by 20% in April—on top of previous cuts to Asia-Pacific service—with "similar reductions planned for May." The airline will also reduce its schedules across the U.S. and Canada by 10% in April, citing the decline in international bookings combined with lower demand from U.S. travelers. Domestic capacity cuts are also expected to extend into May.

Airbus Advances Autonomy Project as Part of Future-Cockpit Concept

> TAKEOFF AND LANDING TESTS HAVE SUCCESSFULLY EMPLOYED IMAGE RECOGNITION

> FIFTH-GENERATION COCKPIT IS NEARING THE DRAWING BOARD

Thierry Dubois Toulouse

The autonomous taxi, takeoff-and-landing (ATTOL) project is the first visible part of Airbus' work on a so-called fifth-generation flight deck, which is aimed at improving safety by allowing a crew more time for decision-making. As part of the project, a modified A350-1000 performed eight automated takeoffs in December in Toulouse, using an image-recognition system. Landing trials followed in mid-January.

Airbus flight safety experts see the main goal for the design of a fifth-generation cockpit as enabling the pilot to become a mission manager. Information should be presented more synthetically, says Pascal Traverse, Airbus' general manager of autonomy technology. Typically, a primary flight display with parameters such as a speed scale could disappear for most of the flight.

The electronic centralized aircraft monitor (ECAM, also known as the engine-indicating and crew-alerting system) usually recommends remedial actions. But "instead of telling the crew to shut down a pump, the ECAM would shut it down," Traverse says.

In a fifth-generation cockpit, the autopilot would be key. It would have more capabilities such as coping with wind gusts, and therefore could be engaged throughout the flight. It would become more reliable, thanks to increased computer redundancy, Traverse explains.

Enhancing the autopilot would allow an existing trend to continue. The A350 includes the latest in autopilot technology, which remains engaged even though flight-envelope protection becomes active. Moreover, the speed brakes automatically extend after the aircraft surpasses 5 kt. above maximum operating speed.

In the fifth-generation cockpit, the size of the crew no longer would be a factor of safety, according to Traverse. A long-haul flight would need two pilots instead of three, but "reducing the size of the crew is not an objective," he says.

The ATTOL system is intended to give the crew more time and bandwidth to analyze a situation, regardless of the airport's landing aids. It would enable the aircraft to land automatically, while the crew looks at the situation as a whole.

"Airbus commercial aircraft use 4,000 airports, 1,000 of which have an instrument landing system (ILS), and only a few hundred runways are compatible with our autoland capacity," says Sebastien Giuliano, ATTOL project manager.

Satellite-based guidance does not allow autolanding, but it can be seen as an alternative to ILS. However, loss of the signal from a global navigation satellite system is reported regularly.

With computer vision, the aircraft would no longer depend on an external system, Giuliano emphasizes.

The ATTOL project was launched in June 2018 for a duration of two years by Airbus UpNext, an organization that also manages the E-Fan X hybrid-electric demonstrator and Fello'fly project for fuel-efficient formation flight. One aim of the ATTOL system is to exploit the possibilities of image recognition when the system is close to the ground.

At the heart of ATTOL are a camera (mounted on top of the instrument panel and looking forward), image-processing algorithms and a control law. The system detects converging vanishing lines and deduces the runway's centerline.

The December flight test began with a deliberate 4-m (13-ft.) offset position before the brakes were released. The aircraft autonomously reached the centerline while accelerating. In a video released by Airbus, the copilot can be heard saying, "It is converging . . . overshooting . . . coming back on it."

At the preset speed, the control law took care of the rotation, and the autopilot took over with an existing mode, says Giuliano.

For the landing tests, the crew aligned the aircraft with the centerline in approach and then cut off GPS and ILS receivers. The aircraft landed autonomously, using visual cues. Two runways were used for the five landings, meaning the system adapted to different visual environments.

Airbus' autonomous takeoff system detects converging vanishing lines and deduces the runway's centerline.

AIRBUS

During deceleration, the system realigned the aircraft when required. The fifth landing involved the brake-to-vacate system, which regulates deceleration so the aircraft reaches the chosen exit at the correct speed. Coupling the two systems was deemed successful.

Could fog be a limitation? The ATTOL system can use sensors outside the visible spectrum, Giuliano answers. The resulting "image" would not have to be seen by a human eye and therefore could be analyzed directly by a software program.

Another limitation—sunlight dazzling the camera—has been overcome by using the camera that monitors the main landing gear, which is under the nose section and oriented rearward, shielding it from the Sun and enabling it to follow the runway's centerline, Giuliano explains. It can be used for every takeoff after rotation, once the cockpit camera is pointing at the sky and not the runway.

DEATH OF THE FIGHTER?

> USAF PLOTS FLEET INSERTION PATH FOR "LOYAL WINGMAN"

> KRATOS SET TO DELIVER 12 XQ-58s BY EARLY 2021

Steve Trimble and **Lee Hudson** Orlando, Florida

The format of the U.S. Air Force's "fireside chat" series is well-understood. A technology pioneer such as Jeff Bezos, Richard Branson or Mark Cuban appears onstage at an Air Force-affiliated event, counsels an audience of pilots and airmen about innovation and, not least, tries not to offend anyone. Elon Musk arrived at the Air Warfare Symposium on Feb. 28 with a different plan.

The founder of SpaceX and Tesla, who seems to delight in publicly tweaking established competitors in the space market such as Boeing and Lockheed Martin, sat on the Air Force Association's (AFA) stage and declared that the fighter aircraft—for decades the heart of the Air Force's tactical combat capability—is already irrelevant.

"The fighter-jet era has passed," Musk said, provoking audible gasps and murmurs in an audience peppered with officers clad in flight suits. Lt. Gen. John Thompson, Musk's interviewer, quickly changed the subject.

Hours later, Musk clarified in a tweeted reply to Aviation Week that he meant the fighter aircraft remains relevant, just not the pilot onboard.

"The competitor [to a manned fighter] should be a drone fighter plane that is remote-controlled by a human, but with its maneuvers augmented by autonomy," Musk writes.

Musk's comments on airpower should be taken with a grain of salt. Although his companies have sought to disrupt the space, automotive and mining industries, Musk has no track record in the aircraft sector. One of his symposium hosts, David Deptula, a retired lieutenant general who is now dean of the AFA's Mitchell Institute, also pointed out in a rapidly published rebuttal in *Forbes* that Musk's predictions about autonomy are often wrong, even when it concerns the self-driving capabilities of Tesla cars.

GA-ASI proposes defending tankers with jet-powered, missile-carrying drones like the Defender (pictured).

But Musk's remarks only differed with those of senior Air Force officials at the same event in the details of timing and scope. For over a year, Will Roper, assistant secretary of the Air Force for acquisition, technology and logistics, has championed a vision of future airpower populated by numerous, small batches of autonomous aircraft augmenting manned fighters with specialized capabilities. For the first time, Gen. James Holmes, head of Air Combat Command (ACC), offered a path to introducing such aircraft into the fleet around 2025-27.

In the near term, the Air Force is focused on replacing aging F-15C/Ds with a mix of Boeing F-15EXs and Lockheed Martin F-35As. The Air Force decided to add the F-15EX to its inventory last year even as the Air Force Research Laboratory (AFRL) began experimenting with a new class of low-cost aircraft with an "attritable" value.

The first such experimental aircraft, the Kratos XQ-58A Valkyrie, in March 2019 completed the first of

four flights made to date. Next year, the Air Force plans to fly the XQ-58A or a similar aircraft with an artificial intelligence "brain," which allows the so-called Skyborg aircraft to learn maneuvers as it flies. Such capabilities are not far from Musk's vision of future air combat, but they are too immature to replace a fleet of F-15Cs on the verge of being grounded; hence, the decision to buy the F-15EX instead.

The next opportunity to introduce a new kind of aircraft comes in about 5-8 years, Holmes says. That timing dovetails, perhaps intentionally, with the schedule for maturing aircraft such as the XQ-58A and Skyborg. The Air Force will need to replace hundreds of F-16 Block 25s and Block 30s, which entered production in the mid-1980s.

"There's an opportunity there if we want to cut in something new, a low-cost attritable, loyal wingman and the different things that we're looking at and experimenting with," Holmes says.

In late February, Holmes and Roper met to discuss the meaning of a "fighter aircraft" in the future with the Next-Generation Air Dominance (NGAD) program in the backdrop. The program office for NGAD began operations in October, with a focus on inventing a new production process capable of affordably producing small batches of advanced aircraft every 3-5 years. But Air Force officials are still grappling with the definition of basic requirements such as range and payload, as operations in the vast Pacific Ocean dominate the calculations.

"The equation and the kind of math that we use for a fighter still works pretty well in the European environment—the range and payload and distance," Holmes says. "It's not as effective a solution in the Pacific, because of the great distances. So as you look at NGAD and you look at the following programs, I wouldn't expect it to produce things that necessarily look like a traditional fighter."

The exhibit hall at the Air Warfare Symposium offered some clues. Besides the usual displays and posters of F-35s and F-15s, some new concepts appeared. General Atomics Aeronautical Systems Inc. (GA-ASI) showed a concept design called "Defender," an apparent variant of the Predator C Avenger, armed with air-to-air missiles and infrared search-and-track sensors. The Defender would protect an "outside force" of enablers, such as tankers and surveillance aircraft, from aerial attack while an inside force of stealth bombers and fighters engaged targets downrange, a GA-ASI spokesman says.

Kratos, meanwhile, continues working on the XQ-58. The AFRL initially funded five test flights, but despite a crash landing on the third flight, all test objectives were met after the third test, says Steve Fendley, president of Kratos' Unmanned Systems Division. The AFRL now is accelerating the "missionization" of the XQ-58, Fendley says, adding payloads and potentially weapons. The first payload integration will be demonstrated in April, when the XQ-58 serves as a communication conduit between the F-35 and the F-22.

Meanwhile, Kratos has started production, with 12 XQ-58s scheduled off the assembly line by the first quarter of 2021. The fleet will be assigned to multiple demonstration programs, funded by several agencies, Fendley says.

U.S. AIR FORCE

KRATOS

The F-16 Block 25/30 replacement could be a low-cost, attritable drone such as the Kratos XQ-58 Valkyrie.

The XQ-58's performance helps define the new class of aircraft, called "loyal wingman" in the U.S. and "remote carriers" in Europe. A critical feature shared by the XQ-58 and similar aircraft such as the Boeing Airpower Teaming System (ATS) is range. Both are capable of flying 3,000 nm unrefueled, almost three times the range of the F-35. Unlike the ATS, the XQ-58 does not need a runway to land, and instead deploys a parachute.

Both aircraft seem unrecognizable from the typical next-generation fighter favored by ACC, but the command is changing its approach, Holmes says.

"In the past at Air Combat Command, we would have built something that we call a fighter road map . . . to figure out what our fighter force will look like for the next 30 years," Holmes said. "What I would rather build is a capabilities road map that shows how we're going to accomplish the missions for the Air Force that we traditionally had done with fighters."

At the same time, Holmes' counterparts in the Air Force Materiel Command (AFMC) are also changing their approach to fighter acquisition. Last October, the AFMC established the Advanced Aircraft Program Executive Office, which is tasked with reinventing the acquisition process for the next class of fighters. A modern fighter is typically developed over a decade and then sustained for several more. For the next generation, the Air Force now prefers to produce multiple aircraft in small batches, in development cycles lasting only five years.

The sustainment phase would be minimal, as the aircraft would be phased out after a brief operational career. The approach requires that the Air Force make the design phase profitable for contractors, which now lose money in design and earn profits during the sustainment phase. The approach means paying higher prices up front for the design, but theoretically less overall during the shorter lifespan of the aircraft.

The Air Force is still trying to craft the contractual mechanism for such an acquisition approach, says Gen. Arnold Bunch, the head of AFMC.

"Industry is going to have to rethink how they want to go do this. They're gonna have to talk to their boards in a different way," Bunch says. "[Something] we also have to factor in to that is: How do I do my cost estimates? How do I do my financial planning? How do I interact with Congress?"

Check 6 *Aviation Week editors discuss whether the time for manned fighter aircraft has passed:* **AviationWeek.com/podcast**

Boeing Reveals Long-Awaited FARA Design

- U.S. ARMY TO AWARD TWO FARA PROTOTYPE CONTRACTS THIS MONTH
- FIVE ROTORCRAFT CONFIGURATIONS ARE ON OFFER

Boeing's FARA design includes a tandem cockpit, hingeless high-solidity main rotor, canted tail rotor and pusher propulsor.

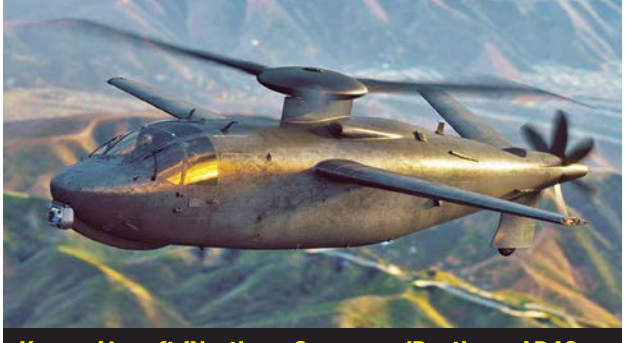
AVX AIRCRAFT/L3HARRIS TECHNOLOGIES

AVX Aircraft/L3Harris Technologies Compound Coaxial Helicopter (CCH) Side-by-side cockpit, articulated coaxial rotors, wing and ducted fans.

BELL

Bell 360 Invictus Tandem cockpit, articulated main rotor, wing, canted ducted tail rotor and supplemental power unit.

KAREM AIRCRAFT/NORTHROP GRUMMAN/RAYTHEON



Karem Aircraft/Northrop Grumman/Raytheon AR40 Side-by-side cockpit, active rigid rotor, tilting wing and swiveling tail-rotor/propulsor.

SIKORSKY

Sikorsky Raider X Side-by-side cockpit, coaxial rigid rotors and pusher propulsor.

Graham Warwick and **Lee Hudson** Washington

The last of the five competing teams for the U.S. Army's Future Attack Reconnaissance Aircraft (FARA) program to unveil its design, Boeing has revealed it is offering a thrust-compounded helicopter.

The clean-sheet design is being pitched to win one of two contracts the Army expects to award at the end of March to build FARA prototypes for a competitive flyoff at the end of fiscal 2023.

FARA is intended to replace Boeing AH-64E Apaches now used in the armed reconnaissance role—about half the Army's fleet—with the first unit scheduled to be equipped in 2028.

Boeing conducted trade studies looking at all possible configurations for an armed scout before selecting a thrust-compounded helicopter, says Shane Openshaw, FARA program manager.

"We did not go into this with our minds made up," he says, describing a "focused effort" over the past 18 months to define an all-new aircraft that "meets or exceeds all the Army's requirements," including a maximum speed of at least 180 kt.

Boeing employed model-based systems engineering for its FARA offering, similar to the method the company used to win the Air Force's T-X program and the Navy's Carrier-Based Aerial Refueling System effort—the company's T-7 and MQ-25, respectively—says Mark Cherry, vice president and general manager of Phantom Works at Boeing.

"We're doing that combination of listening to our customer, understanding our own capability and putting that together into a purpose-built clean-sheet design that we believe will meet all the needs the Army is looking for," Cherry says.

This includes close consideration of both life-cycle and acquisition costs for the new aircraft, Cherry adds.

Boeing's tandem-seat, single-engine design has a hingeless single main rotor with six blades for high solidity, a canted four-blade tail rotor and a clutched four-blade propeller on the tail for propulsion. Power comes from a single 3,000-shp General Electric T901, and there is no wing.

The five competitors are offering different rotorcraft configurations for FARA (see image box on facing page).

Boeing has not partnered with any other vendors for its FARA offering and is instead taking a "One Boeing" approach, Cherry says. "Our other suppliers and other partners are still something that we will build later, but at this point consider it a Boeing-led development," he notes.

Boeing's high-solidity hingeless rotor provides agility and maneuverability without the high flapping of a fully articulated rotor, Openshaw says. The tail rotor provides maneuverability at low speed, and the propeller provides maneuverability at high speed. Weapons are carried internally to minimize drag.

The configuration is reminiscent of Lockheed's AH-56 Cheyenne, flown in 1967, but is smaller because the FARA is limited to a rotor diameter of less than 40 ft. so that it can fly between buildings in urban combat. Boeing looked at the AH-56 for lessons learned, but the rotor is different, Openshaw says.

The rigid-rotor AH-56 experienced control challenges, but it was not a fly-by-wire helicopter, he notes. Boeing has experience with fly-by-wire from the RAH-66 Comanche armed scout developed with Sikorsky and the Sikorsky/Boeing SB-1 Defiant high-speed helicopter demonstrator that is now in flight testing.

The AH-64 has a four-blade, fully articulated rotor, but Boeing's experience with hingeless rotors dates back to its YUH-61 entrant in the utility-helicopter competition that produced the Sikorsky UH-60 Black Hawk. Flown in 1973, the YUH-61 had a composite four-blade hingeless rotor based on Boeing's experience working with MBB on the BO105 light helicopter.

Despite the addition of a propeller, which is driven via a clutch mounted aft of the tail rotor gearbox, "we do not see this as an overly complex design," Cherry says. "The Army has set the industry tough problems with its mandatory requirements and desirements. Every configuration has its pluses and its drawbacks."

Boeing Phantom Works is leading the FARA bid, working with the company's AvioniX and Aurora Flight Sciences divisions on the prototype. In common with the other bidders—and to meet the Army's accelerated schedule for development and fielding—Boeing has begun work on its FARA prototype in anticipation of winning one of the two contracts.

"We are not inventing new technologies," Openshaw says. "We are integrating and improving on mature technologies to meet the challenges of delivering with the risk, schedule and cost [the Army wants]. This is the right way to go."

Rotary-Wing Assets Vital for UK Carrier Protection

> WILDCAT TO GET MBDA'S SEA VENOM AND THALES' SEA MARTLET
> INTEROPERABILITY/MANNED-UNMANNED TEAMING DEMO IN APRIL

LEONARDO HELICOPTERS

The Wildcat Weapons Wing offsets the weight of the weapons in cruise flight, giving the helicopter an impressive loadout.

Tony Osborne Liverpool and London

Britain's Royal Navy is pushing to have two vital rotary-wing programs ready for when its first Carrier Strike Group (CSG21) sets sail for the Far East in 2021.

Both the Crowsnest helicopter-borne early warning system and the arming of the naval version of the Leonardo AW159 Wildcat are vital components in the protection of the UK's new aircraft carriers, HMS Queen Elizabeth and HMS Prince of Wales.

But both programs have fallen behind schedule. Crowsnest, which fits Thales' Searchwater 2000 radar onto the navy's Leonardo EH/AW101 Merlin Mk. 2 anti-submarine warfare helicopters as a roll-on/roll-off kit, was due to be ready by year-end. But it has emerged in procurement reports that the program will now only "deliver an incremental capability" to support CSG21. Also, plans to fit both MBDA's Sea Venom anti-ship missile and the Thales Light Multirole Missile (the Sea Martlet) onto the Wildcat have been affected by issues with the weapons and their integration onto the helicopter.

Crowsnest, led by prime contractor Lockheed Martin, has been challenged by "three different integration problems in one," senior Royal Navy officers told a conference in London in February.

"We were taking a system that had some original parts; others needed a firmware upgrade; and some have needed replacing entirely because of obsolescence," one officer said. "It has been a tough ride, but by CSG21 [deployment] we will have these platforms out and doing what they are supposed to be doing in terms of surveillance and control."

Lockheed Martin was selected as the prime for the program because it performed the upgrade of the Royal Navy's Merlins to HM2 standard and was selected to integrate the radar onto the helicopter.

Leonardo Helicopters is modifying all 30 of the Merlin HM2s in Royal Navy service to be ready to carry the Crowsnest system and is performing the flight testing. The UK Defense Ministry is buying 10 Crowsnest kits.

During the CSG21 deployment the Merlins will be primarily based on the aircraft carrier, but the Wildcats will operate from the decks of escorting frigates and air defense destroyers.

The carrier's Merlins will include aircraft configured for airborne early warning and others for the anti-submarine warfare (ASW) mission.

To put the weapons onto the Wildcat, Leonardo has developed the Wildcat Weapons Wing. Its aerodynamic profile is able to offset the weight of the weapons while in cruise, with each wing delivering 360 kg (795 lb.) of extra lift. The wings are constructed of aluminum and carbon-fiber composites, and each features two pylons. Once fitted on the aircraft, the Wildcat can carry up to four Sea Venoms, each weighing around 110 kg, or four weapons carriers capable of carrying up to five podded Sea Martlets each, for a total of 20 missiles.

According to the government's own defense procurement reports, planned initial operational capability for the Sea Venom is now 2022, while the introduction of the Sea Martlet is planned for the beginning of January 2021.

The Wildcat's role in the Royal Navy is primarily anti-surface warfare rather than the ASW mission normally performed by the Merlin HM2.

Putting 20 Martlet missiles onboard is a result of "weapon effort planning and design," says Louis Wilson-Chalon, maritime marketing manager at Leonardo Helicopters, speaking in Liverpool, England, at an exhibition aboard HMS Prince of Wales. The system is designed to deal with a swarm attack from fast-attack craft: "If you have 30 of them trying to attack your task force, you don't need to destroy them all; 20 should be enough," he says.

A similar mission with the Lynx helicopter that the Wildcat replaced would have resulted in a higher workload for crews and required more helicopters.

Wilson-Chalon says a mission to attack a small warship such as a corvette previously would have required at least two helicopters, but a single Wildcat with four missiles targeted to come in from different directions can overwhelm the close-in weapons systems ships use to defend against such missiles. Leonardo has already flown captive carriage trials with weapons fitted to the wing. No firings have taken place yet, but these will likely occur later this year.

Meanwhile, Leonardo is also gearing up to demonstrate a manned-unmanned teaming capability from a British Army-operated Wildcat in support of the UK's Defense and Security Accelerator technology program.

The flight trial will see the helicopter's mission commander, in the left-hand seat, take control of an unmanned aircraft system and prove a Level of Interoperability of 4, allowing the crew to control and monitor the UAV and its payload, but not perform launch and recovery. The trials are focused on studying crew workload during the UAV's operation.

Vulnerabilities Prompt Debate on Irish Air Defense

- IRELAND IS DEPENDENT ON BILATERAL AGREEMENTS WITH THE UK
- BRITISH AND IRISH AIR STAFF MET FOR THE FIRST TIME ON FEB. 24
- THERE ARE NO IRISH COMBAT AIRCRAFT FOR THE AIR-POLICING TASK

Tony Osborne London

Growing concerns about Ireland's vulnerability from the skies has sparked a public debate about whether the "Emerald Isle" should invest in an air defense capability.

The country may be one of the richest in Europe on a per capita basis, yet ministers in Dublin have taken very little interest in national defense.

Indeed, the subject is rarely discussed outside the country's Parliament.

Ireland currently spends a bare minimum on defense. In 2020, just over €1 billion ($1.1 billion) will be spent on protecting the nation from external threats—equivalent to 0.3% of the country's gross domestic product. That total is smaller than the percentage of GDP spent on defense in Malta and Luxembourg, 0.48% and 0.56%, respectively.

As a neutral nation not aligned with NATO, Ireland does not need to worry that U.S. President Donald Trump will publicly denounce Dublin's spending decisions, as he has with those not meeting NATO's 2% spending target. Nonetheless, there are growing calls from within the country for the government to take a greater interest in defense, according to security and defense experts who convened at the Slandail 2020 National Security Summit held Feb. 25-26 in Dublin.

Ireland has a small air force, the Irish Air Corps, equipped with 19 aircraft, the most potent of which are a fleet of eight Pilatus PC-9 turboprop trainers capable of carrying gun pods and unguided rockets. But those aircraft are certainly not capable of performing the country's air-policing mission. The Irish media regularly cites the appearance of Russian Tu-95 "Bear" strategic bombers, which flew just 40 km (25 mi.) from the Irish coastline in February 2015, prompting Irish air traffic controllers to divert airliners around the route the bombers had taken. But Dublin had no way to intercept and escort them away.

Major events such as visits by international leaders are protected by anti-aircraft guns or point-defense missiles, but there is little provision for early warning.

"The role of the Air Corps under the Defense Act is to 'contribute to the security of the state by providing for the military air defense of its airspace,'" notes Irish defense expert and journalist Don Lavery.

"It is obviously incapable of doing that. . . . There is no nationwide military radar system to monitor our airspace, no fast jets to respond if a threat is detected," Lavery adds. "And successive governments seem quite happy to acquiesce in that situation."

The last jets that served with the Irish Air Corps were Fouga Magisters jet trainers employed with the service until 1999, when they were replaced with the PC-9.

The last time the Irish Air Corps had a fighter was in 1955, when it had a squadron of Supermarine Seafires, a naval derivative of the wartime Spitfire.

Part of the concern around Ireland's air defense vulnerabilities is stemming from Britain's exit from the European Union.

Irish media outlets have reported that a secret bilateral agreement between the UK and Ireland is in place to allow the UK Royal Air Force (RAF) to perform an air-policing mission in the nation's airspace. A 2016 report by the *Irish Examiner* newspaper states the agreement has been in place for several years, but that the Irish Defense Forces were not involved in its negotiation.

On Feb. 24, it was announced that the air staffs of both the RAF and the Irish Air Corps had met formally in London. It was the first time in the history of both air services that such a meeting had taken place.

It remains unclear if the bilateral agreement has ever been put to use, and there are still crucial questions about whether the British government will want to continue the arrangement in the future.

London recently began a review of its foreign policy and defense capabilities as the UK looks to define its place in the world post-Brexit. There are some in Dublin who wonder if the British taxpayer will be happy to keep providing such a layer of protection.

A white paper published in 2015 by the Irish defense department called for the "development of a more capable air combat/intercept capability" to be considered for when the fleet of Pilatus PC-9s are retired in five years. But there has been no political discussion about such a capability so far. The acquisition of a fighter, even just for air policing, would be a sizable investment. It would arguably also require the creation of an air defense radar network to provide some level of early warning, not to mention infrastructure, training and weaponry.

European nations, many smaller than Ireland and not as rich or well-developed, have invested and continue to invest in such a fighter capability. Slovakia is purchasing F-16 Block 70s, while Croatia is looking to replace its MiG-21 fleet with a Western type. Lavery cites the cost of Saab Gripen leasing arrangements by the Czech Republic, which pays €70 million a month to Sweden for the fleet of 14 aircraft.

Nonetheless, Ireland is making investments in new military aircraft: purchasing two Airbus C295s for the maritime surveillance mission, while a trio of Pilatus PC-12s are being modified by Sierra Nevada Corp. in the U.S. for the intelligence, surveillance and reconnaissance mission.

Irish Air Corps Fleet

Type	Number of Aircraft
Airbus CN235-100MP	2
Airbus EC135P2+	2
Bombardier Learjet 45	1
Leonardo AW139	6
Pilatus PC-9M	8

Source: Aviation Week Network data

New 'Air Force Ventures' Set To Transform Technology Strategy

> U.S. AIR FORCE PLANS TO MAKE 50 LARGE "BETS" ON TECHNOLOGY

> NEW ACQUISITION TRAINING BASED ON FIGHTER WEAPONS SCHOOL

Steve Trimble Washington

The U.S. Air Force has adopted a three-phase strategy to select small, innovative companies outside the traditional defense industry to perform advanced development work and to tap Silicon Valley-style venture capital firms to help taxpayers finance the new technology.

A new process could help rationalize the one-year-old Air Force effort to attract high-tech startups with dozens of Air Force Pitch Day events. These conferences have led to hundreds of small contract awards but no obvious path to guide the aspiring defense contractors further into the byzantine military acquisition process.

For the private startups and venture capitalists involved, the Air Force Ventures initiative is designed to offer a new route to the commercial market for potentially game-changing technologies that could benefit from a risk-tolerant government customer providing funding and early support.

"We don't really think of ourselves as a [stand-alone] market, but we purchase things in quantities that [are] meaningful enough that we can bridge companies until they reach a level for commercial success," says Will Roper, assistant secretary of the Air Force for acquisition, technology and logistics. "That's one reason that [venture capitalists] are interested in this."

The Air Force Ventures process starts with the Pitch Day events, during which the Air Force can place

U.S. AIR FORCE

initial "bets" worth up to about $50,000 each in Phase I Small Business Innovation Research (SBIR) grants on promising, potentially game-changing ideas, says Roper, speaking to about 1,000 Air Force acquisition officials during a Feb. 14 webinar.

As the companies transition toward Phase II SBIR awards, the Air Force plans to grant about 300 contracts worth up to $1 million each—with a program office agreeing to fund about one-third of the costs. The fund-

Air Force Wants To Help Grow U.S. Advanced Air Mobility Industry

> THE SERVICE AIMS TO OPERATE FIRST EVTOLs IN 2023

> LOGISTICS AND DISASTER RELIEF AMONG LIKELY EARLY MISSIONS

Graham Warwick Washington

JOBY AVIATION

U.S. Air Force acquisition chief Will Roper does not want history to repeat itself. The history in question is the shift of the small drone industry to China and subsequent security concerns that have led U.S. agencies to ban the use of Chinese drones and left the Pentagon without a strong and trusted domestic supply base.

As the Defense Department eyes the potential of emerging electric vertical-takeoff-and-landing (eVTOL) technology to transform air mobility, and particularly logistics, it is moving to engage and assist U.S. developers so it does not lose another industry to its global rival.

The Air Force has launched the Agility Prime program with the goal of accelerating the FAA certification of commercial eVTOL cargo and passenger vehicles so it can potentially become an early adopter and capitalize on promised capabilities and cost reductions.

The Defense Department has already formally observed tests of Joby Aviation's eVTOL.

Acquisition chief Will Roper is implementing Air Force Ventures, a new method of attracting high-tech startups to the government.

ing match is meant to link the SBIR award to a program office, creating a path for the technology to potentially transition beyond the laboratory stage and into a program of record.

The third and final step in the Air Force Ventures concept whittles the pool of awards to about 50 recipients. The amount of the award is potentially "unlimited," Roper says, but is generally regarded as at least $10 million.

The first of the "big bets" in Phase III are now under evaluation, Roper says. The contract awards could be announced at South by Southwest, a week-long technology conference and entertainment festival scheduled for March 13-22 in Austin, Texas.

The initiative explicitly seeks to help the Air Force break from traditional defense contractors. As the Air Force attempts to field leap-ahead capabilities within the next decade for the Advanced Battle Management System and Next-Generation Air Dominance, leveraging the innovative ideas and technology flowing into the commercial market is seen as critical.

"[R&D] in this country is 80% commercial," Roper explains. "So in the 21st century, the [defense] industrial base should be dual-use. And so we've got to crack the code on how to have public and private funding work seamlessly inside an Air Force program."

But there are significant challenges as the Air Force tries to leverage commercial-sector technology investments: Small companies often need to find a market quickly to generate revenue and cash flow, whereas government program offices tend to make decisions slowly—and inconsistently.

"In many cases, their commercialization [strategy] is devalued [by investors] if they have government funds," Roper adds.

The Air Force's program managers also face a learning curve.

"If we're making 1,000 small bets a year, the reason we're making 1,000 is that we know most of them aren't going to pan out. So we can't manage the companies the way we would a traditional program," Roper says. "But we can manage them as a portfolio—the same way that a private investor or a venture capitalist would."

To prepare, the Air Force is sending acquisition officials back to school. Next year, a cadre of program managers will be enrolled in a six-month course at Stanford University, which will teach the Air Force to manage technology investments like a venture capitalist, Roper says. The next step is to expand educational opportunities within the Air Force. A new acquisition curriculum, modeled on operational training centers such as the Fighter Weapons School, will be created, Roper says.

"What we don't want is what happened with the small drone migration to China. It was a commercial technology, the Pentagon didn't take a proactive stance on it, and now most of that supply chain has moved to China," Roper said at a roundtable in Washington on Feb. 21. "Agility Prime is saying we are not going to let that happen again."

On Feb. 25, the Air Force released its Agility Prime "innovative capabilities opening" (ICO), establishing a contracting framework for prototyping projects designed to show whether, as their developers claim, eVTOL vehicles can revolutionize mobility.

Under the ICO framework, which will remain open until Feb, 28, 2025, the service plans a series of solicitations for different "areas of interest" (AOI). The first of these—the "Air Race to Certification"—was also released on Feb. 25.

Under AOI No. 1, the Air Force office plans to issue contracts for test reports to substantiate company claims for their vehicles. Based on a test report, the service could proceed to the next step, potentially an early procurement, says Col. Nathan Diller, Agility Prime integrated product team lead.

The Air Force does not intend to set requirements for eVTOLs or fund their development. Instead, it wants to help developers move toward commercial certification by providing testing resources and possibly enabling a near-term government public-use market for their vehicles in advance of FAA certification.

In lieu of setting explicit requirements, the service has launched studies of potential missions for commercial eVTOL vehicles—both passenger-carrying and larger unmanned cargo aircraft—including distributed logistics, medevac, firefighting, search-and-rescue, disaster relief and installation security.

The AOI calls for vehicles carrying 3-8 people, with a range greater than 200 mi., speed exceeding 100 mph and endurance of more than 60 min. Diller says Agility Prime is looking at unmanned aircraft heavier than 1,320 lb., because the other services are focused below that weight, as well as at passenger-carrying eVTOLs.

The Air Force is aiming for an initial operating capability in fiscal 2023 with a "handful-plus" of vehicles in a squadron. "We have begun a series of studies to look at the business case associated with these different missions, and started looking at some basic constructs for what these [operating] units might look like," Diller says.

Diller says the Air Force is not imposing military requirements on eVTOL developers because it wants to benefit from the low acquisition and operating costs as well as the high production volumes that could come out of the commercial market.

"Since we are not putting research and development money in this, we are going to fall into accordance with what the industry partners want to do," he says. "Our intent is that any testing they do with us will be something that takes them along the path to commercial certification and is not diverting them."

If the Air Force were to set requirements and fund development, "we would feel we are putting at risk a very large market that would allow us to eventually capitalize on that affordable quantity based on potential mass production at an automobile rate," he says.

U.S. General Links Chinese Hypersonic Glider to Nuclear Program

> NEW ASSESSMENT ECHOES 2014 WARNING

> U.S. AIR FORCE ADDS $4.4 BILLION FOR B-21 PROCUREMENT

Steve Trimble Washington

A powerful new weapon has appeared in a U.S. military assessment of China's nuclear arsenal as Pentagon officials launch a campaign to win congressional support for allocating 4.1% of the fiscal 2021 defense budget to its own nuclear weapon enterprise.

All previous U.S. military assessments of China's nuclear arsenal included a mix of ICBMs, with silo-based DF-4 and DF-5 rockets, road-mobile DF-31s, DF-31As and the recently unveiled DF-41 missiles. The warheads for each missile are known to include several multiple independently targeted reentry vehicles, with maneuverable reentry vehicles also believed to be in development or deployed.

GREG BAKER/AFP/GETTY IMAGES

Now added to this inventory is a nuclear warhead on a hypersonic glide vehicle (HGV), says Gen. Terrence O'Shaughnessy, head of U.S. Northern Command. "Among the novel weapon systems China is testing is an intercontinental-range hypersonic glide vehicle—similar to the Russian Avangard—which is designed to fly at high speeds and low altitudes, complicating our ability to provide precise warning," O'Shaughnessy said in written testimony submitted to the Senate Armed Services Committee on Feb. 13.

The acknowledgment by the head of the North American Aerospace Defense Command that China is actively testing a nuclear intercontinental-range HGV took many nuclear and defense analysts by surprise.

O'Shaughnessy's testimony echoes a nearly forgotten 2014 statement by Lee Fuell, then technical director for Force Modernization and Employment at the National Air and Space Intelligence Center, the U.S. Air Force's clearinghouse for technical assessments of foreign weapons. An appearance by Fuell before the U.S.-China Economic and Security Review Commission in 2014 came as China ramped up testing of an HGV then known as the WU-14. Although most nonmilitary analysts attributed China's interest in HGV technology to conventional weapons, Fuell, privy to classified information, linked the efforts to the People's Liberation Army's strategic nuclear weapon programs.

If later confirmed, the U.S. military assessment of a nuclear role for China's nearly operational HGV technology would add a significant new capability. So far, China has confirmed plans to deploy an HGV only on the DF-17 missile, which, as unveiled at the National Day Parade last Oct. 1 in Beijing, appears to be a conventional weapon with medium-to-intermediate range. Only Russia has a nuclear HGV on an intercontinental-range missile: the aforementioned Avangard, which the Kremlin declared operational at the Dombarovsky launch site in December. By contrast, among the Pentagon's several ongoing HGV and scramjet-powered cruise missile programs, none are linked to a nuclear weapon capability.

The disclosure comes as the U.S. Defense Department continues to justify a more than $1 trillion nuclear weapon modernization program over the next decade, including a $28.9 billion request for fiscal 2021 released on Feb. 10. The Pentagon's spending plan lacks a nuclearized HGV but continues support for replacing the Minuteman III ICBM with the Ground-Based Strategic Deterrent, the Northrop Grumman B-2 bomber with the B-21, the AGM-129 with the Long-Range Standoff cruise missile and the Ohio-class fleet with the Columbia ballistic missile submarine.

The funding profile, as signaled by Air Force Chief of Staff Gen. David Goldfein's remarks in an October speech, indicates a significant increase in procurement spending for the B-21. The $22.6 billion requested for the aircraft in the fiscal 2021 version of the Pentagon's five-year spending plan reserves $10.3 billion for procurement. By contrast, the fiscal 2020 version of the five-year plan requested $5.9 billion through fiscal 2024 for B-21 procurement, starting with a $200 million allocation for long-lead procurement in fiscal 2022, followed by $2.4 billion in fiscal 2023 and $3.3 billion in fiscal 2024. The new five-year plan adds about $4.4 billion for B-21 procurement compared with the fiscal 2020 proposal.

A line of medium-range DF-17s on parade in Beijing in October 2019 may have offered only the first glimpse of China's planned hypersonic weapon capabilities.

The B-21 spending plan suggests the Air Force is continuing or even accelerating an aggressive production ramp-up for the new bomber. The first flight of the prototype aircraft funded under the engineering and manufacturing development is not expected until at least December 2021.

Boeing Builds ATS Assembly, but Will Not Say Where

> BAE IS SUPPLYING THE FLIGHT MANAGEMENT SYSTEM

> THE POTENTIAL PRODUCTION LIKELY WILL BE LARGE

Bradley Perrett Melbourne, Australia

Even the manufacturing locations are being kept secret. Development of a loyal-wingman drone by Boeing in Australia may not be a black program, but it is at least light gray.

Still, the company has let a little light in by releasing a photograph of the first major assembly of the first prototype—its center fuselage. It reveals that the fighter-like Airpower Teaming System (ATS), as the drone is called, has large adaptable spaces for payloads.

At first, these will surely be for electromagnetic missions: passive intelligence, surveillance and reconnaissance, and perhaps jamming. Yet even the intended tasking of the ATS is not confirmed amid a general withholding of information about the program since its public unveiling in February 2019.

When it released the photograph on Feb. 9, Boeing reiterated the plan for the ATS to fly for the first time this year. The type is aimed at the global defense market, with Australia as the potential launch customer. The 11.7-m (38-ft.) type may be a candidate for U.S. and British programs, too.

BAE Systems says it is supplying the flight-management system among other items, including technology from the British Taranis and Mantis and Australian Kingfisher experimental drone programs. The Royal Australian Air Force (RAAF) is a partner in the work, which the service calls the Loyal Wingman–Advanced Development Program, but has not committed to quantity production.

The potential production quantity—easily hundreds of aircraft—underlines the importance of the location of manufacturing and identity of the manufacturer. In the photograph the major assembly is seen in what looks like a small, new factory.

Asked where the aircraft is being made, Boeing referred Aviation Week to the RAAF. The Australian defense department, responding on behalf of the RAAF, in turn attributed its inability to disclose information to Boeing's need for commercial secrecy. The defense department "is unable to release information on specific locations at this time due to Boeing customer and supplier sensitivities," it says.

"Design, development and manufacturing of the prototypes is occurring across three Australian states by more than 22 suppliers," the defense department says. "Boeing has a number of sites and teams focused on the design, development and manufacture of the Airpower Teaming System."

The commercial reasons for not disclosing the manufacturing locations are unclear. But the policy also helps keep the details of the design secret.

The drone is aimed at the international market and intended to be cheap—and not subject to U.S. export restrictions. It seems likely ATS would be mostly kept in storage, like missile rounds, minimizing support costs. Hinting at the number of ATS an air force might need, Boeing says it has studied concepts in which 4-16 of the drones would accompany one manned fighter. Even if a customer did not buy at least four ATS for every fighter, unusually large-scale production must be envisioned.

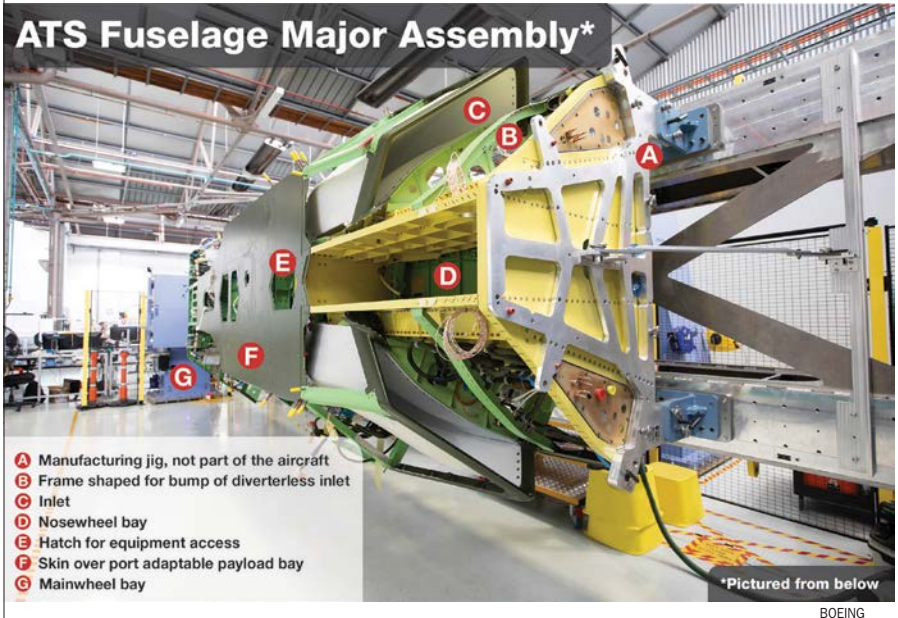
The states involved are evidently Queensland and Victoria and perhaps South Australia. The photograph revealed a conventional structural scheme in which an aluminum substructure was covered by a composite skin. Lining of the inlet ducts also appears to be made of composite. Boeing is presumably making the composite parts at its factory in Melbourne, Victoria, which specializes in such materials.

AME Systems, in Victoria, is making wiring looms. The Australian subsidiary of RUAG, also in Victoria, is supplying landing gear. Globally, RUAG maintains business-jet landing gear, a hint at the origins of the ATS undercarriage.

BAE Systems is making hardware kits including flight control computers and navigation equipment. Its autonomous-vehicles team is in Melbourne, but the company makes electronics in South Australia. Ferra Engineering of Brisbane, Queensland, is making precision machine components and subassemblies, Boeing says. That notably does not include building up major assemblies such as the fuselage.

According to Boeing, the program's industrial team comprises 16 companies. This contrasts with the defense department's reference to 22 suppliers.

The ATS appears to be designed for high subsonic speed in level flight; it will need that to keep up with the manned fighters it accompanies. Its single engine is of an unidentified type used in very light personal jets. The Australian government said last year the aircraft could be armed—presumably in a later version.



BOEING

The RAAF's head of air-combat capability, Air Cdre. Darren Goldie, underlined Australia's withholding of a commitment to volume production of the ATS, saying in a Boeing statement that working with the company would help the air force consider options for manned-unmanned teaming. But there is industrial pressure on Australia to place an ATS order: Boeing said last year the fabrication equipment was not too big to be moved to another country.

The major assembly in the photograph is most of the fuselage of the first aircraft, from the well for the nose landing gear to the wells for the main landing gear. If the assembly includes the rear fuselage, the camera angle has been chosen not to show it. Rear fuselages are sensitive parts of stealth designs. That rear was covered on a mockup that Boeing presented at the Australian International Airshow in February 2019. In general, the fuselage major assembly appears to conform to the design of the mockup.

"The next major milestone will be weight on wheels, when the fuselage structure moves from the assembly jig to the aircraft's own landing gear to continue systems installation and functional testing," Boeing says. "The Australian team has applied digital engineering and advanced composite materials to achieve cost and agility goals for the . . . aircraft, which is designed to use artificial intelligence in teaming with other manned and unmanned platforms."

BAE Australia has a strong background in autonomous systems. Apart from the flight management system, it is providing simulation capability, flight control computers and navigation equipment. This equipment will be allied with Boeing's autonomous mission systems, BAE says. Another partner is the government's Defense Science and Technology Group.

Visible in the fuselage assembly, are the insides of the inlet ducts. These snake inward and upward to hide the engine face; this is a conventional stealth feature. Access hatches and doors in the belly are hexagonal, a low-observability feature supplementing an airframe shape that appears intended to be highly stealthy. ATS missions must demand a level of detectability comparable to that of the Lockheed Martin F-35 Lightning, since the two types would operate together in Australian service.

Lines of fasteners in the lower corners of the fuselage and the position of frames inside indicate the location of payload bays. These are forward of the main landing gear wells and abreast of the downstream section of the inlet duct, where it would be a single tube. The ATS already was known to have space near the center of gravity for payloads. "Customers will be able to tailor ATS sensors and systems based on their own defense and industrial objectives," Boeing says.

The bays may open at the sides rather than below. Since fasteners are visible in the photograph, the first ATS prototype will not have full stealth features. The forward fuselage is full of avionics, a source close to the program said in 2019. Conceivably, some of that equipment also could be customized, especially to take advantage of the nose position.

The fuselage major assembly appears to conform to the design of the ATS mockup (pictured) displayed in February 2019.

BRADLEY PERRETT/AW&ST

Since the ATS could be armed, designers may intend the adaptable midfuselage spaces to become weapon bays in a later version. The evident size of the bays seems to rule out the possibility of carrying air-to-air missiles, but glide bombs might fit, making the ATS a strike aircraft useful against undefended or lightly defended ground targets. The GBU-39 Small-Diameter Bomb is 1.78 m long, only half as long as a Raytheon AIM-120 Amraam.

An aircraft such as this might be flown for only hundreds of hours, offering the potential to cut structural weight. The fuselage does not appear to have heavy-duty gauges, and elements could be spaced more widely than would be done in an aircraft designed for intensive use. Bent-metal frames abreast of the inlets are much lighter than would be expected on a fighter. The robustness of the overall structure probably is governed largely by maneuver loads, not fatigue life.

The inlet shapes and mild bumps on the sides of the fuselage upstream—seen in the mockup and on the major assembly—correspond to the design of supersonic diverterless inlets, which are stealth features. This suggests the slippery aircraft may be supersonic in a shallow dive, a valuable characteristic in fleeing from enemy fighters. With an engine unlikely to much exceed 3,000 lb. thrust, it could hardly rely on repeated hard maneuvers to survive.

Yet the positioning and shaping of the inlets, suiting high angles of attack, indicates that the ATS is intended to pull high-G maneuvers. Otherwise, stealth considerations would recommend a dorsal inlet. In a Japanese concept, loyal-wingman drones could serve as missile sponges. In that role, an ability to maneuver hard once or twice before running out of energy would be valuable. So would extremely low cost.

The aircraft appears to lack hydraulics, which would be troublesome for long-term storage. Instead, actuation of flight control surfaces and doors may be entirely electric.

The large fuel load for a range (perhaps ferry range) of 3,700 km (2,000 nm) probably is carried at least mainly in the upper fuselage and wing.

— With Guy Norris in Los Angeles and Graham Warwick in Washington

China Seeks Human Lunar-Landing Technology

- AN ENGINE WITH 8 TONS OF THRUST COULD BE USED BY A LUNAR LANDER WITH A MASS OF 30 TONS
- LUNAR LANDERS WITH CRYOGENIC ENGINES COULD BE AN ASSET IN A FUTURE WITH LUNAR "FUELING STATIONS"

Anatoly Zak New York

After almost two decades of rumors and semiofficial reports, the latest evidence of China's ambition to put its astronauts on the Moon comes from . . . Ukraine. According to well-informed sources, the Chinese space industry has solicited help from Ukrainian engineers at KB Yuzhnoye in the city of Dnipro to study several engine designs that could softly land a very large vehicle on the Moon's surface.

Although the Chinese clients have not confirmed to their Ukrainian peers that the yet-to-be-developed lunar-landing engine would carry astronauts, the mass of the lander specified in one technical assignment to the Ukrainian specialists can only be justified by the needs of the human exploration program.

The Ukrainian company KB Yuzhnoye is known to have provided China assistance in developing the YF-100 engine that propels the Long March 5 rocket.

The engine, with a thrust of 8 tons and a specific impulse of 360 sec., would be suited for a lunar lander with a mass of 30 tons when fueled. For example, the Eagle lunar lander, which put the Apollo 11 astronauts on the Moon, had a mass of about 15 tons at liftoff. New-generation landers currently studied by NASA for the return to the Moon have a mass reaching about 45 tons.

China has a long history of turning to Ukrainian propulsion and rocket design experts for help with the most advanced projects in its civilian space program. KB Yuzhnoye is known to have provided China with critical expertise in the development of the YF-100 engine, which today propels the most powerful Chinese space launcher—Long March 5. The YF-100 resembles the Soviet-era RD-120 engine, which China acquired from the former Soviet Union in the early 1990s. The Chinese industry apparently struggled to reverse engineer it until Ukrainian experts pitched in.

A number of Chinese veterans of the YF-100 project, who later ascended to prominent positions within the nation's space industry, had a very high opinion of their Ukrainian counterparts and their contribution to the success of the Long March 5 project. It might explain China's continuing interest in cooperation with Ukraine, even though lunar-landing systems have not been the focus of specialization for propulsion engineers at KB Yuzhnoye in recent years.

In December 2013, China successfully landed a robotic probe on the surface of the Moon, and last year it became the first nation to send a spacecraft, including a rover, to the lunar far side. However, building a platform capable of carrying astronauts to the Moon would still require a major leap in Chinese technology, particularly in propulsion.

WIKIMEDIA

Around 2017, KB Yuzhnoye sold China the Soviet-era Block E propulsion system for the one-person LK lander, which was developed in the late 1960s as part of the ill-fated Soviet effort to beat Apollo astronauts to the Moon.

KB Yuzhnoye denied reports about selling the Block E propulsion system to China, possibly because its contracts with Chinese entities include clauses requiring such denials in case of unofficial public disclosures. But for the past three decades, it is well-documented that Chinese firms have acquired historic space hardware and related know-how from various countries, in an effort to gain experience, train a cadre and find technological shortcuts.

This time, the Chinese interest in lunar-landing propulsion has clearly expanded from studies of historical prototypes to research about new-generation engines.

The most unusual aspect

MARCH 2020

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AUSTRALIAN ASPIRATIONS

Navigating Uncertainties in China

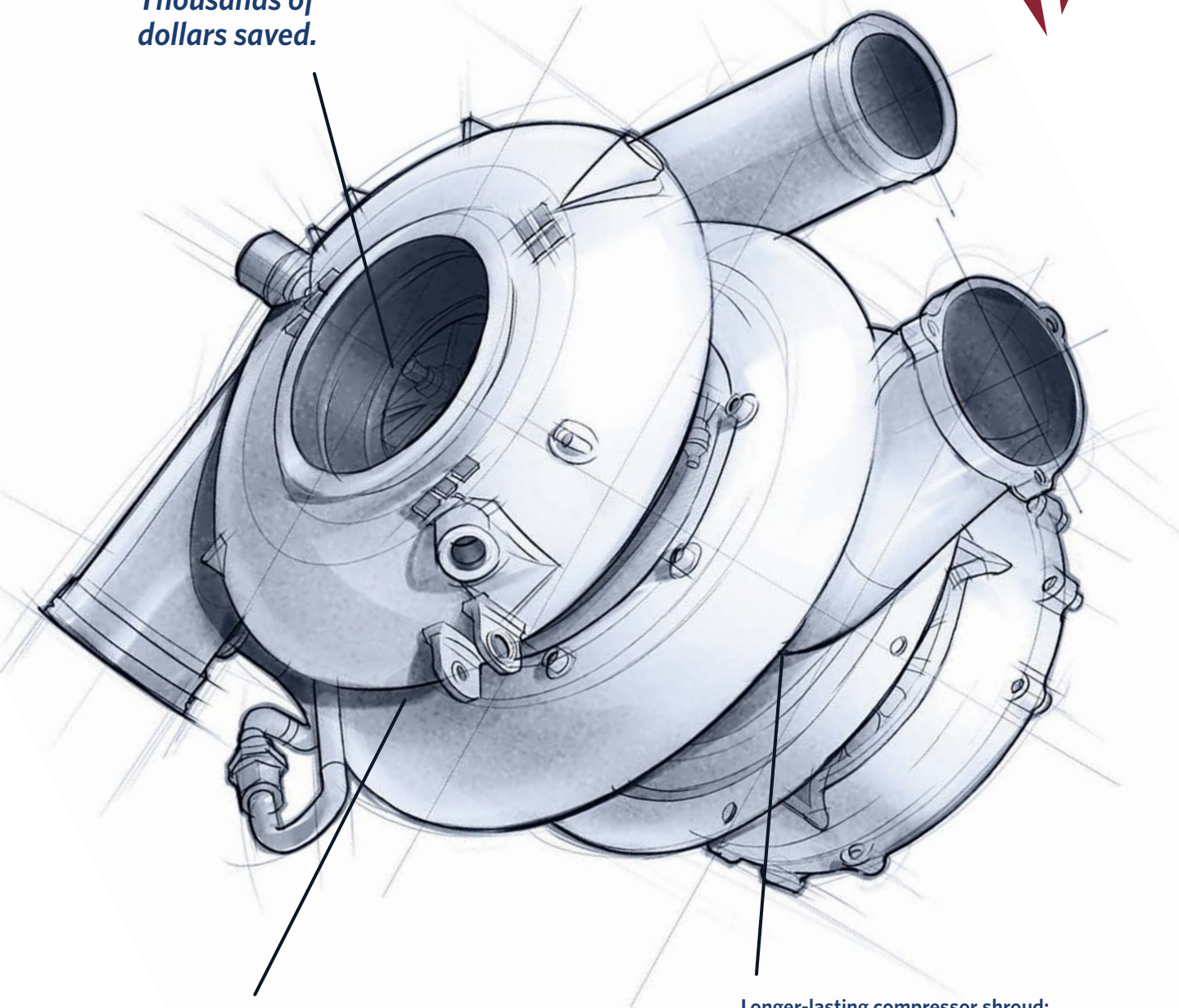
Electric Propulsion Evolutions

Will the A380 Have an Aftermarket?

AVIATION WEEK NETWORK

Custom-repaired flange:

Thousands of dollars saved.



Corrosion-free bearing plate:

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Longer-lasting compressor shroud:

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We know a lot about your air cycle machine. Like that when one isn't working, passengers will get heated. Or that our DER repair costs 50 percent less than the standard OEM replacement — and lasts longer. So, if you want an MRO that will give your bottom line a lift, visit **DeltaTechOps.com** and learn how our Oper-chanics mindset can work for you.

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MAINTENANCE CHECK

The Known Unknowns

While aviation is full of positive, growth-mode news, the amount of COVID-19-related bad news is making an impact—from canceled flights to supply chain slowdowns.

The day last week I traveled through five cities on three continents could illustrate today's market situation. I started in Dubai, at the end of our MRO Middle East event, where I spoke with executives from around the Middle East who say business is robust. (The region's projected 8.3% year-over-year MRO growth rate is higher than for others, according to Aviation Week's forecast for 2020-29.)

Sanad Aerotech announced adding several new engine capabilities last year and is focusing on growing its global network to accommodate that work. It announced a partnership with Ethiopian Airlines to establish a center of excellence for narrowbody APU MRO and is "actively looking at Southeast Asia and the Americas" for expansion opportunities, says Mansoor Janahi, Sanad Aerotech CEO.

Lufthansa Technik Middle East (LTME) has been building up its spare component levels and repair capabilities, including for the Boeing 787 nacelle. While the business was originally set up to focus on Middle Eastern customers, it has become a center of excellence for GE90 thrust reversers, which is drawing GE90 and V2500 business from Europe as well, says Ziad Al Hazmi, CEO of LTME.

Meanwhile, Aerostructures Middle East Services has expanded in Dubai's Jebel Ali Free Zone to accommodate new preventive maintenance inspections and associated repairs on GE90 fan stator modules. And Jordan Airmotive says CFM International approved its application for a CFM56-7B license.

The mood at MRO Middle East was optimistic and very businesslike, but when I landed in Zurich, news of the spreading COVID-19 in Europe seemed top of mind. Italy, in particular was having problems, making me rethink my vacation there in a few weeks.

Don't let the short term get you down.

Delays out of Zurich and New Jersey hindered my timely return to Chicago O'Hare, where I ended one business trip and began one planned the day before. Without much time to spare, I grabbed my bag, switched terminals and checked onto a flight to Tulsa, Oklahoma, late that night. The mood during this portion of the trip was strained by delays and uncertainty about connections and the supply chain.

I did catch the flight, and the trip to Tulsa was fantastic. I met with American Airlines' senior leadership, including Chairman and CEO Doug Parker and Kevin Brickner, senior vice president for technical operations, before they announced a $550 million investment in its Tulsa maintenance base. American has been expanding its largest base's capabilities to enable it to insource more work—and now it is adding a widebody hangar and modernizing the rest of its World War II-era facilities and infrastructure to keep up with its younger fleet. The mood there, as you can imagine, was optimistic.

We're in uncertain times, but our industry will prevail and become stronger than ever. Make sure you're balancing a short- and long-term view—and don't let the short term get you down. Now more than ever, look at the positives.

—Lee Ann Shay

Keep up with Shay on **Twitter @AvWeekLeeAnn**

Highlights

Revima Enters Malaysia MRO Collaboration

Revima, the French provider of auxiliary power unit (APU) and landing gear repairs, has announced a new maintenance partnership with Malaysia Airlines through which both parties will collaborate on offering services to operators in the Asia-Pacific region.

Revima says the landing gear overhaul and replacement contract with Malaysia Airlines will focus on servicing third-party Revima customers from the airline's hangar in Kuala Lumpur.

This will be reciprocated by Revima, which will offer landing gear overhauls for Malaysia Airlines' MRO customers across its network of facilities, along with offering its customers landing gear replacement packages with Malaysia Airlines. Revima will also help the carrier with technical and training support for fleet landing gear replacements.

American Airlines To Add Widebodies in Tulsa

American Airlines plans to add a widebody maintenance hangar at its Tulsa, Oklahoma, location as part of a $550 million upgrade.

The $550 million is the single largest investment the airline has made at a maintenance location. Some of the money will go to updating the rest of its hangars on the 80-year-old base.

Construction of the 193,000-ft.^{2} hangar, which will accommodate two widebody aircraft or six narrowbodies, will start in early 2021 and is scheduled to take about 18 months. After its completion, hangars three and four will go offline because they can no longer accommodate American's fleet.

The other hangars and infrastructure will also be updated—with new roofing, IT upgrades and ramp repairs.

Tech Ops Tulsa maintains more than 900 aircraft and is American Airlines' largest maintenance base facility.

Nacelle Panel Work for MAXs Before Return

An FAA draft directive published Feb. 26 called for Boeing 737 MAXs to undergo inspections and modifications before their return to service to ensure engine-control wiring has adequate protection from electromagnetic interference.

The issue, discovered during Boeing's review of the MAX following two fatal accidents and the model's March 2019 grounding, affects composite engine nacelle panels. During production, gaps were left in protective foil lining some thumbnail and mid-strut fairing panels located on top of the engine that are meant to shield wires located just below.

Boeing issued a special-attention service bulletin on Dec. 11, 2019, recommending that operators inspect the areas and modify the thumbnail fairing assembly within six months. The FAA's draft airworthiness directive calls for the work to be done "before further flight," making it likely that MAX operators will opt to tackle it before the model is cleared to fly again, even if the mandate—which other regulators are expected to adopt—is not finalized.

Airbus A321 Converted Freighter Is Certified

An Airbus A321 passenger-to-freighter (P2F) conversion—developed by joint-venture partners ST Engineering, Airbus and Dresden-based freighter conversion specialist Elbe Flugzeugwerke (EFW)—secured European Union Aviation Safety Agency supplemental type certification (STC) on Feb. 25.

The A321P2F program launched in 2015, with ST Engineering handling engineering development and Airbus providing certification support and original equipment manufacturer data. As the STC holder, EFW is heading up the program and will handle adaptation engineering for serial production, sales, marketing and customer support.

Contracts

AJW Group secured a long-term power-by-the-hour (PBH) contract from **El Al** for component support for 26 Boeing 737NGs.

Commsoft was selected by **SalamAir** to provide OASES MRO IT software.

De Havilland Canada was selected by **Nordic Aviation Capital** as launch customer for Dash 8-400 classic overhead bin extension modification to provide additional stowage being developed in partnership with **Safran Interiors**.

Eirtrade Aviation is expected to part out an ex-Air France A380-800 (040) for **Dr. Peters** at Knock Airport, Ireland.

GE Aviation secured **BeauTech** and **Sky Regional Airlines** as launch customers for the CF34-8 high-pressure turbine durability upgrade program.

Liebherr-Aerospace won a **Great Dane Airlines** contract to provide landing gear overhaul for its Embraer 195s.

MTU Maintenance Canada secured a 10-year, $225 million contract to provide F138 (CF6-80C2) depot maintenance for U.S. Air Force C-5Ms.

Sabena Technics was selected by **Safran Nacelles** to provide on-site product support through its GO TEAM mobile unit.

Swiss International Air Lines took delivery of its first of 25 GTF-powered Airbus A320neos it has on order. **Pratt & Whitney** will also provide Swiss with engine maintenance through an EngineWise Protect service agreement.

VD Gulf won a contract from **FlyOne** of Moldova to provide heavy maintenance/mods on two A320-200s at Sharjah.

Contract Source: SpeedNews

Wings of change

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FAA Revamping Southwest Oversight After Audit

The U.S. FAA certificate management office (CMO) responsible for Southwest Airlines was wrong to allow the carrier to clear 88 used aircraft for service through what inspectors knew was a flawed conformity process, the agency admits, concurring with a Transportation Department audit that found several major shortcomings. The agency plans to act on 11 recommendations made by the auditors, including more training on root-cause analysis for addressing airworthiness issues.

"We agree that the Southwest Airlines (SWA) FAA Certificate Management Office (CMO) did not perform in accordance with existing guidance by allowing 88 aircraft (the 'Skyline' aircraft) to enter service through SWA's conformity process, which lacked a comprehensive conformity inspection for used aircraft," the agency says in a formal response to the report, released in early February.

Auditors also found that consistent reporting of inaccurate weight-and-balance figures to pilots disclosed by the airline was not handled correctly. "Regarding performance weight and balance, we agree the SWA CMO, at times, did not perform in accordance with existing guidance," the FAA says.

The Skyline-aircraft issues involve 88 used Boeing 737s that Southwest bought in 2013-17. Southwest tapped consultants to review the aircraft records and verify specific items highlighted in Southwest's "summary documentation," the report says. But Southwest's processes did not factor in certain unknowns, such as repairs with inaccurate or incomplete documentation, or paperwork that differed from FAA protocol. It also did not call for any independent records analysis, the Office of Inspector General (OIG) found. The 88 737 NGs were previously operated by airlines in China (23 aircraft), Canada (14), Argentina (14), Russia (10) and Mexico (9).

In late 2017, the FAA discovered potential gaps in Southwest's aircraft-conformity process. In mid-2018, the agency discovered some of the airline's used aircraft were in service without properly documented repairs and records that had not been translated into English. The agency and Southwest agreed to a plan, the Repair Assessment Program (RAP), under which all 88 would be inspected, all repairs validated, and any other issues resolved within two years. The FAA also began participating in Southwest's conformity process.

The agency, facing pressure from lawmakers digging into airline oversight, later ordered Southwest to speed up the process, giving the airline a Jan. 31, 2020, deadline. As of Feb. 1, Southwest had confirmed that 80 of the affected aircraft completed the RAP, and eight others—all in heavy maintenance—were undergoing RAP inspections.

Inspectors in the Southwest CMO pointed to risk analysis done under the carrier's FAA-approved safety management system (SMS) as justification for allowing the aircraft to keep flying during the RAP time frame. The OIG says the plan violated FAA regulations—specifically Part 121, Subpart H—and the two-year deadline for fixing the issues did not reflect the FAA's Compliance Program philosophy that allows operators to "achieve rapid compliance" with the regulations.

FAA inspectors overseeing Southwest's maintenance operation did not follow regulations, an audit found.

SOUTHWEST AIRLINES

The FAA plans to "ensure" that designated airworthiness representatives review and validate aircraft records and verify that they conform with U.S. standards. The agency also will issue inspector guidance on evaluating air carrier safety risk assessments, making sure SMS are not used "as a substitute for regulatory compliance," the report says.

The agency will retrain Southwest CMO inspectors on proper use of voluntary disclosure processes and will develop guidance on evaluating risk assessments and root-cause analysis.

The FAA also changed personnel in Southwest's CMO last year.

On the weight-and-balance issue, the FAA learned in January 2018 that the carrier's pilots were regularly receiving inaccurate data. Southwest self-disclosed using the FAA's Voluntary Disclosure Reporting Program (VDRP). The FAA ordered the airline to audit 25% of its flights, investigate any findings that were inaccurate by 300 lb. or more, and report to the FAA discrepancies of at least 1,500 lb. "We found that inspectors did not ensure Southwest Airlines fulfilled its requirements or verify that the carrier took the agreed-upon actions," the OIG says.

FAA rules require carriers to report "accurate" weight and balance data, but the term is not defined. Southwest's risk analysis concluded that variances of up to 1,500 lb. were low-risk. It continued to use its VDRP to report discrepancies at a rate of 10-25 per month for two years and inaccuracies up to 7,000 lb. In some cases, multiple events were lumped into a single disclosure, This, the OIG says, violates FAA guidance.

"The FAA principal inspector deemed these actions acceptable because the airline justified inaccurate weight and balance calculations as a low risk," the OIG says. "Additionally, the inspector stated handling the noncompliances in this manner would minimize the administrative burden within the local oversight office. These decisions indicate a need to ensure FAA inspectors in the local oversight office are trained on the purpose and proper use of VDRP."

The OIG also took issue with the leeway granted to Southwest without a clear plan to solve the problem.

"FAA granted the carrier multiple extensions to determine the root cause and then granted additional time for the carrier to implement corrective actions, even though the principal inspector did not feel the carrier had identified the true cause," the OIG says. "According to FAA managers, this was because they believed that the root-cause [analysis] is the responsibility of the carrier and the inspectors should not be involved in that process. However, these statements are contradictory to FAA guidance that requires inspectors to work with air carriers to determine the root cause of safety concerns."

Southwest is working on making the process—which relies on handcounts of baggage and their positions on the aircraft—more accurate. "In addition to the increased surveillance by the SWA CMO, the airline integrated new technology to better manage its baggage count and is working to implement this technology with cargo as well," the OIG says.

The OIG's findings on root-cause analysis shortcomings dovetail with conclusions in a December 2019 report that focused on FAA oversight of Allegiant Air. That report recommended "a comprehensive review" and, if necessary, modifications to FAA root-cause analysis training for inspectors, which the agency plans to implement this year.

—Sean Broderick

ARSA UPDATE

The Power of Presence

ONE OF MY FAVORITE "BITS" (AS IN AN "ACTION ASSOCIATED with a particular activity," not a tool or drill bit) is to ask this question in the March edition of *Inside MRO*: Where are you right now?

You might be at ARSA's annual conference, which is hosted each March in and around Washington. The event is small by the standards of large expositions and trade shows—like Aviation Week's MRO Americas gathering in April—but like much of ARSA's work, it punches above its weight in terms of industry importance.

But this isn't a sales pitch for the conference; it's my opportunity to reassert the importance of face-to-face engagement made possible through events. There are certainly other ways to gather information and plenty of media for communicating with colleagues, regulators and the general public—after all, you're reading this even if you're not at the conference—but the professional and personal enrichment that comes from attending events endures.

The key value of that interaction is access. After going back and forth via email or hearing distant voices on conference calls—or worse, in a constant string of voicemails—a 5-min. discussion can solve intractable problems quickly.

My favorite example is a simple one (and, yes, it comes from an ARSA event). In 2014, a symposium attendee asked a question regarding the FAA 8130-3 form. Briefly put, his people were being told to include unnecessary verbiage, and it was creating hang-ups when the paperwork was included on work performed for foreign customers. After raising the problem with staff from the FAA's Aircraft Certification Service, quick agreement was reached to issue a memorandum ensuring agency personnel and designees didn't demand use of the unnecessary language. The memo was issued a month later—it went from a Q&A session to agency action in fewer than 30 days. Surely, similar examples abound every time industry members, government officials and other interested parties come together: Things get a little better.

So if you do happen to be reading this in the ballroom of the Ritz-Carlton (or before a meeting at a U.S. government office or between stops on Capitol Hill), make good on this opportunity. Use your time in the same room with the FAA, European Union Aviation Safety Agency, Transport Canada or other government representatives to make progress that serves your business and improves the aviation community.

If you're not with us, go to your calendar and plan (or confirm your plans) for the next conference, trade show, expo, air tattoo or industry forum you can attend. (Did I mention

ANDRESR/GETTY IMAGES

MRO Americas next month? ARSA and its members will be there.) Plan some face time with those who matter to your work, and then make good on the power of your presence.

And if you want a little more detail on that 2014 example, visit *arsa.org/8130-3-story*

Brett Levanto is vice president of operations of Obadal, Filler, MacLeod & Klein. He provides strategic and logistical support for the Aeronautical Repair Station Association.

Bangkok Airways

Christophe Clarenc, senior vice president of maintenance and engineering at Bangkok Airways, talks to James Pozzi about its plans to insource more MRO work while expanding predictive maintenance.

BANGKOK AIRWAYS

What are some of the key elements of Bangkok Airways' maintenance strategy?

Our first strategy is to invest in our team. We have a core team that has been with us for a very long time, with a low turnover, and this gives us a good level of experience and valuable expertise, even more so as the two families of aircraft we operate have been with us for a significant amount of time. We then invest in training to make sure that the new staff can grow in a satisfactory way to support the core team. This staff retention and investment in staff development are central to everything we do. We are strong believers that the quality of our staff is the most important factor for us to succeed. We also believe this is what helps us to remain relatively lean. We maintain a fleet of 40 aircraft with a team of 400 total, including line maintenance, base maintenance, shops, store, purchasing and repairs, CAMO, admin, finance, and even some asset-management activities.

What are your arrangements in terms of insourcing maintenance work and outsourcing your requirements?

We insource as much as possible, whenever it makes sense from a value-for-money standpoint and when the initial capital investment is reasonable, and whenever we believe we can find qualified staff to correctly implement the new activities. If required, we hire staff to cope with the additional capabilities. It may complicate our job, but in our opinion it gives us better control over turnaround times and quality and more flexibility.

Whenever we outsource, we favor regional solutions as much as we can: We save on logistics and reduce the risk of a much-needed part being offloaded at a transit airport somewhere. When we outsource, we are very flexible with regard to the type of contract we sign, based on what we believe is the best choice for the equipment to be repaired, and in most cases we initially go with flexible short- or mid-term contracts. We would go into longer-term arrangements only once the supplier has demonstrated its worth. We may go with OEMs or independent MROs.

What does Bangkok Airways look for in a maintenance partner, be it an MRO, a tooling supplier or a logistics company?

Reliability, quality and value for money. We may not go for the cheapest option if we are not comfortable that it can deliver the quality and reliability we seek, so we prefer to aim for value for money instead of the lowest price. We don't want to go cheap if we might end up with more aircraft on ground or compliance issues. We also expect flexibility from the MRO when we are discussing contractual terms, and we value fairness very highly.

In 2018, Bangkok Airways announced plans to build an MRO center at Sukhothai. What is the latest on this project?

The plan is still on and making progress. We had more difficulties than originally envisaged to complete the paperwork required for such a project, and we have also considered other locations besides Sukhothai. This has been causing some delays, but we are definitely going to build a hangar to serve our own fleet and also to resume providing services to third parties.

What are some of the main challenges for your maintenance operation?

The main challenges I would say are to find qualified manpower in Thailand and to work in a rapidly evolving regulatory and compliance context. The Thai Department of Civil Aviation disappeared following some issues with the International Civil Aviation Organization, so the Civil Aviation Authority of Thailand (CAAT) started up and with it many new requirements with short implementation times, to implement changes rapidly and efficiently. The pace of change in the industry is accelerating, and people do not like change.

Which new technologies is Bangkok Airways looking at for its maintenance processes?

We have been trying a solution for predictive maintenance on our Air-

Bangkok Airways Fact Box

FLEET: Approximately 40 aircraft, consisting of Airbus A320s and ATR 72-500s and -600s.

IN-HOUSE CAPABILITIES: Airframe maintenance for ATR and A320-family aircraft. Repair capabilities for wheels and brakes and batteries. Non-destructive testing; some electrical and mechanical parts repairs; some borescope inspections of cabin, safety equipment and propellers; quick engine changes; and a composite repair shop.

IN-HOUSE VS. OUTSOURCED MAINTENANCE: 80% in-house, 20% outsourced (intending to bring all work in-house as soon as possible). One-third of component work is done in-house.

HANGARS AND LINE STATIONS: One hangar at Don Mueang International Airport; a second at Sukhothai Airport expected in early 2022. Line stations at Bangkok Suvarnabhumi, Samui International, Phuket International and Chiang Mai International airports in Thailand and Phnom Penh International Airport in Cambodia.

AVIATION WEEK
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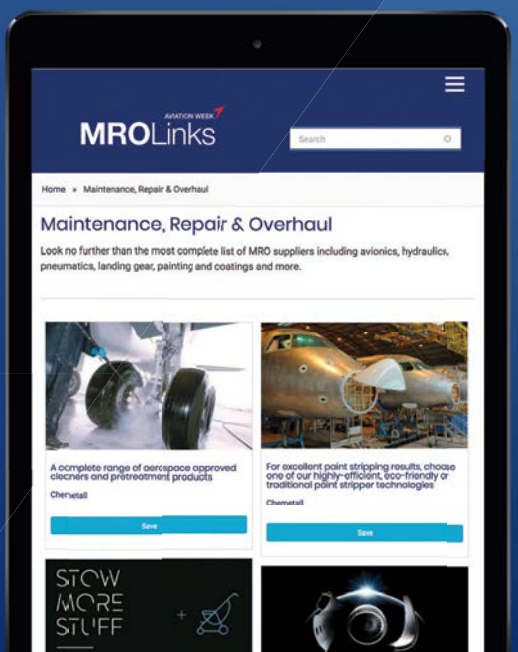

AVIATION WEEK NETWORK

bus fleet, but we just suspended it last month. The concept is very good, and we are strong believers in it, but the implementation was a major disappointment. Algorithms were few and of poor quality, and overall we got no benefit from this experiment. We are convinced that data analysis tools can bring benefits and have been using Skywise Core extensively to look into our data, using their analysis to improve our processes and all our activities, with applications ranging from better identification of recurring defects to better hangar-check planning and management, or proactive maintenance. The difficulty is to find people who understand maintenance and data mining and analysis well enough, and to change the mindset of the staff who have been doing maintenance jobs the same way for years—all of a sudden, we are going to tell them we are going to make big changes to their processes.

NIGEL HOWARTH/AW&ST

Bangkok Airways operates a mixed fleet of Airbus A320 and ATR turboprop aircraft.

How is Bangkok Airways investing in IT for its MRO operation?

We have an approach that is conservative in one way and open-minded and very active in another way. We did not invest in a fancy, complete and expensive management information system (MIS), as they are very costly and maybe not necessary for us up to now, considering our size. We also carefully avoided having the company enterprise resource planning present everywhere in our MRO operation as it is too heavy and too rigid. But we developed a lot of in-house solutions to address our specific problems and help us improve our processes. These solutions in several cases have been developed by complementing the capability of our existing MIS with the data analysis capabilities of Skywise Core to give us the exact tools or reports we wanted. The savings from not buying the fancy and expensive MIS were invested instead in training. We prefer a skillful driver in a Toyota Corolla rather than a mediocre one driving a fancy car!

What strategies are you using to acquire skilled MRO technicians?

The airline industry has been growing a lot in Thailand over the past decade, and the schools producing MRO technicians did not keep up with this growth or do much to improve their curricula. So basically, we hire mostly technicians fresh from school and invest a lot in their training and education. We have had our own internal challenges, too: In the past, we inducted very low numbers of new staff every year, so on-the-job training was a very good solution because we had very few new staff surrounded by experienced technicians. Then we grew faster, hired more, some of the experienced guys retired or left, and so we had a lot of new staff with fewer experienced guys around them. We had to develop more systematic knowledge-sharing or training processes. We could no longer let it happen naturally, by immersion so to speak, and we also had to carefully document the training process to accommodate the new requirements of the International Air Transport Association Operational Safety Audit and CAAT. So we had to change our training very significantly.

How has the MRO business been built up considering the fleet expansion and the introduction of more ATR 72 aircraft?

Our MRO business has not been built up and has suffered tremendously from the fleet expansion. Simply put, our current facility is not even big enough to serve our own fleet. We have had to contract out some hangar checks over the past two years, and we also had to stop working on third-party components. The only positive in this current situation, where we are forced to outsource some airframe maintenance, is that it provides us with a very valuable benchmarking opportunity. We can learn from others, and we are trying to look at them with an open mind. But the goal is to resume our MRO business once our new hangar is up and running. We do have the team and the tools. Once we have the facility, we have everything we need to resume the business, and we have every intention of doing so because we believe we can offer something different. We will never be able to compete with the big guys in the business, but we have experience and expertise, and we can maybe give more attention and care to the smaller customers than the big guys do. We brand ourselves as the boutique airline, so maybe we will be a boutique MRO, too.

Are you looking to insource any maintenance work or will you look to further outsource?

Insource. First, take back in all of the base maintenance as soon as our facilities allow that and continue to grow the capability list of our shops whenever we see the opportunity.

Home Front

Smaller MRO operations are helping keep heavy maintenance in Australia

Adrian Schofield

While industry trends in Australia—and elsewhere—point toward greater overseas outsourcing of aircraft maintenance, a handful of companies are ensuring the country retains a strong heavy maintenance capability.

Australia's largest airline, Qantas, is the most obvious example, as it still performs its own heavy checks for certain fleet types. However, smaller operators are also increasingly active in the heavy maintenance sector. Regional Express Holdings (Rex) conducts all levels of maintenance on its turboprop fleet and is considering expansion, while Heston MRO sees an opportunity to add heavy work and other capabilities to its line maintenance operation. Hawker Pacific is another company that is expanding its heavy maintenance capacity in Australia.

Qantas represents both the insourcing and outsourcing approaches. Most of the group's heavy maintenance is done at its own facilities, although it also sends a significant amount offshore. Airbus A330 and Boeing 737 heavy checks and cabin reconfigurations are performed at its main Brisbane engineering base, with turboprops handled at Tamworth, New South Wales (NSW), and Jetstar's A320s at Newcastle, NSW.

On the outsourcing side, the airline's heavy maintenance on A380s and its dwindling fleet of 747s is conducted overseas. Qantas announced last year that it would outsource its Boeing 717 heavy checks—previously handled at Canberra—to Singapore-based ST Engineering. The carrier has yet to reveal where heavy maintenance on newer aircraft such as Boeing 787s will occur, and similar decisions will eventually have to be made for future fleet types the Qantas group intends to order in the next few years.

Virgin Australia, the country's other major airline, outsources its heavy maintenance to companies in Asia and New Zealand.

Rex handles heavy maintenance on its Saab 340 fleet in its hangars at Wagga Wagga, New South Wales.

In contrast to its larger brethren, Rex performs all of its airframe maintenance within Australia and almost all of it in-house. The carrier is now looking to expand its component capabilities and is also assessing where it could construct new facilities to accommodate future growth.

Rex operates a fleet of nearly 60 Saab 340B turboprops. It has light maintenance bases in Adelaide, Brisbane, Melbourne, Perth and Sydney, with its main heavy maintenance base in Wagga Wagga, NSW. Rex also has some A and B check work done under contract by Hawker Pacific in Cairns.

While airframe maintenance is conducted locally, the CT7-9B engines are sent to a GE-approved facility in Indonesia for major overhauls. Rex can perform some limited engine work itself.

The main Wagga Wagga facility has two hangars, accommodating one Saab 340B each. It has an aircraft paint shop that is operated by a contractor. There are also workshops for engines, batteries, components and wheels.

Rex completes about 15 C checks per year at Wagga Wagga, says Png Yeow Tat, the carrier's general manager for engineering. The existing hangars could handle up to 17 per year, so they can still accommodate some degree of fleet

REGIONAL EXPRESS HOLDINGS

expansion by Rex, Png says. However, if the airline grows by another 5-10 aircraft, it would have to add more hangar space.

There is no room to build at the Wagga Wagga facility, Png says. Consequently, Rex is in discussions about establishing another heavy maintenance facility elsewhere. The most promising options are Adelaide and Sydney, where Rex already has light maintenance bases. A backup option would be to contract more work to its partner in Cairns, but the carrier would prefer to keep the maintenance expansion in-house, says Png. He stresses that there are no plans to build immediately, as the existing hangars are adequate for the near future.

The Saab 340 fleet has grown steadily in recent years along with the Rex regional network. The average age of these aircraft is more than 25 years, according to the Aviation Week fleet database. However, Rex is in no rush to replace them, as the Saabs have at least 10 more years of operational life, Png says. The aircraft have about 40,000 flight hours on average and are certified up to 60,000. Manufacturer Saab believes the limit could be extended to 80,000 hours.

Many other regional carriers around the world choose to outsource their heavy maintenance, but Rex has calculated that it makes more sense to keep it within the company. One of the main reasons is cost—"it has definitely proven to be cheaper to do it ourselves," Png says. Some airlines cannot take this approach because they do not have the capital to invest, but Rex is financially healthy and owns its aircraft.

Another factor is that with an older fleet, aircraft and parts reliability is a particularly important issue. By handling its own maintenance Rex can ensure it "has direct control over the reliability and condition of the aircraft," says Png. It also makes it easier to coordinate the timing of scheduled maintenance with operational needs, and Rex does not have to worry about being a lower priority for one of the big MRO providers.

Rex applies this self-reliant approach to as many areas of the airline as possible. For example, the carrier established a pilot academy to help address the problem of attrition. The company also trains its own maintenance staff, from entry-level apprentices through to licensed engineers. Rex has about 250 maintenance staff, of which 150 are engineers.

The carrier's plans for aircraft components are another example of wanting to do as much as possible in-house. Rex already does some component repairs, but it is looking to expand this to a greater range of parts. This helps because Saab 340 parts are becoming harder to find, and "it cuts down our dependency on overseas suppliers," says Png.

Rex aims to manufacture some parts. For example, the carrier estimates it can fabricate its own flight-attendant handsets for about one-third of the market price. It is currently testing this process and seeking approval to use the

handsets in its fleet. Retrofitting parts is also a focus, and Rex has pioneered the replacement of cathode-ray-tube electronic flight displays with more reliable LCD technology.

Heston MRO, headquartered in Brisbane, is another company looking to expand its scope with new capabilities —including base maintenance. Heston Aviation acquired what was then Aircraft Maintenance Services Australia from SIA Engineering in 2018.

Heston is already one of the largest independent maintenance providers in Australia, focused mainly on line maintenance at six facilities around the country. Its largest customer is Singapore Airlines, and it also serves several other overseas-based carriers that operate to Australia.

The company sees some prospects for "organic growth" in line maintenance, with expansion options in Perth and even Southeast Asia, says Jonas Butautis, Heston's director and representative shareholder. However, Heston believes the main expansion opportunities are in other areas such as light-heavy maintenance, engine work, components and training, Butautis says. He envisages the company evolving to become almost a "total care" solution for smaller airlines in the South Pacific region.

Butautis says Heston is in "active discussions" regarding a location for a heavy maintenance base. The company is trying to "find the right formula to capture the potential [for base maintenance work] in Australia."

Moves to outsource maintenance overseas during the past 10-15 years "went a bit overboard," Butautis believes. Now there are not enough domestic alternatives to sending aircraft offshore. He notes that the cost advantage offered by Asian MRO companies is eroding, and the growth of Asian airline fleets is making it harder to find open maintenance slots in the region.

Because of these factors, "sooner or later some heavy maintenance [will] return to this country," says Butautis. And Heston wants to be one of the companies taking advantage of such a shift.

Heston looked at the possibility of acquiring an existing hangar for base maintenance operations but has not found one that meets its requirements. This means the company is more likely to build its own hangar from scratch, Butautis says.

An advantage of the new-build option is that the hangar would be compatible with the advanced MRO technologies the company aims to deploy. Butautis has previously headed MRO companies in Europe and will use this experience to plan the facility and its MRO systems if the project proceeds.

Ideally, the hangar would be able to accommodate at least four narrowbodies and would also be high enough to fit a widebody aircraft, says Butautis. The company could start by activating one bay and then progressively open others as work develops.

The aim would be to handle light-heavy maintenance up to some types of C checks. Talks with potential customers suggest there is healthy market interest for such services, Butautis says.

HESTON MRO

Heston MRO focuses on line maintenance at six facilities in Australia.

However, he also stresses that the company is not yet committed to establishing the heavy maintenance facility. The hangar would represent "a big risk, and [high] fixed cost." So if the project cannot be done the way Heston envisages, it will not proceed. "We'd really like it to happen; but if not, there are other areas to grow into," says Butautis.

One such avenue is engine maintenance, and Heston is in the process of applying for certification to expand into on- and off-wing engine services. As well as meeting demand from airline customers, Heston could handle warranty support work for engine OEMs.

Another potential growth area is component support. Heston has already entered the component trading business, and it wants to take this a step further and establish a component repair capability within the next 18-24 months, Butautis says. It will probably start with items such as emergency equipment and wheels and brakes. The company also wants to build up component pools for customers.

There are challenges to being a smaller, independent MRO provider, Butautis admits. "Some people would say [such businesses] have no right to exist," he says. But he sees a niche for the smaller operators, particularly since the major manufacturers "have overstretched themselves" in MRO support and are increasingly looking to outsource work.

Independent businesses of Heston's size are also more adaptable and can focus on the requirements of small airline customers, Butautis argues. It is harder for such carriers to obtain the flexibility they need from a large MRO attached to a major airline, he says. Given these factors, many smaller MRO providers like Heston have found ways to not only exist but prosper and grow.

Electrifying Powerplants

Influx of funding is spurring electric engine development

Graham Warwick Washington

Electric-powered light aircraft are in production, prototype air taxis are flying, and now industry is looking at how the benefits of electrified aircraft propulsion could be brought to the commercial aviation market.

Spurred by concerns over carbon emissions from aviation, government money is beginning to flow in significant amounts into research to advance the state of the art in electric propulsion. And much of the work is focusing on developing technology for larger aircraft, up to the size of single-aisle airliners.

U.S.-based startup Wright Electric is working with EasyJet to define a 180-seat turboelectric short-range airliner.

WRIGHT ELECTRIC

Current limitations on the energy density of batteries and the power density of motors and electronics have restricted the use of electric propulsion to lightweight, short-range two- and four-seat aircraft and the emerging category of electric vertical-takeoff-and-landing (eVTOL) air taxis. But already academia and industry, including several startups, are looking beyond these limits at the near-term development of commuter and regional aircraft with 9-19 seats and all-electric or hybrid-electric propulsion.

Electrifying the propulsion of the larger regional and commercial aircraft that generate the bulk of aviation's carbon emissions, those with 70 or more seats and ranges measured in thousands of miles and not hundreds, is a far more daunting challenge. But government-funded research programs are getting underway in Europe and the U.S. that are targeting electric-propulsion technology for these larger aircraft.

In January, a consortium of 33 European aviation research and industry partners launched the Investigation and Maturation of Technologies for Hybrid Electric Propulsion (Imothep) program to assess its potential for reducing the emissions from commercial aviation and develop a technology road map for its development.

With €10.4 million ($11.3 million) in funding from the European Commission under its Horizon 2020 research program, Imothep will perform an in-depth investigation of hybrid-electric technologies, advanced aircraft configurations and innovative propulsion architectures that take advantage of synergies between propulsion and airframe.

Led by French aerospace research agency Onera, the program brings together European aircraft manufacturers Airbus and Leonardo; engine companies Safran, GE Avio, MTU, ITP and GKN; as well as aerospace research organizations CIRA (of Italy), DLR, AIT (of Austria), ILOT (of Poland), INCAS (of Romania) and NLR. Universities in France, Germany, Italy, Sweden and the UK are also involved, as is German aviation think tank Bauhaus Luftfahrt and intergovernmental air traffic organization Eurocontrol.

In the U.S., the Energy Department's advanced research projects agency, ARPA-E, has announced plans to launch two research programs to develop propulsion technology for all-electric, 150-200-seat narrowbody airliners. The overall objective is the efficient conversion of the chemical energy in liquid fuel into electrical energy delivered to the aircraft's propulsors.

With the stated goal of developing enabling technologies for Boeing 737-class aircraft with net-zero carbon emissions, the programs will focus on lightweight, ultra-efficient electric motors, drive electronics and thermal management systems as well as systems to convert carbon-neutral liquid fuels to electric power for propulsion.

The agency expects to make $35 million in funding available for the Ascend program (for Aviation-class Synergistically Cooled Electric Motors with Integrated Drives). Another $20 million is earmarked for the companion Reeach program (Range Extenders for Electric Aviation with Low Carbon and High Efficiency). Expected to run for up to 48 months, both efforts are planned to begin in November.

The programs are aimed at developing technologies for a propulsion architecture comprising an energy storage and power generation subsystem and an all-electric powertrain. Ascend is focused on the powertrain and Reeach on energy

storage and power generation. A fault-resistant kilovolt distribution system is envisioned for transmitting power from the generation system to the motors driving the fans or propellers, but the electric bus and propulsors are outside of ARPA-E's programs.

Ascend and Reeach would complement research into electrified aircraft propulsion for commercial aircraft already underway at NASA. Under the Hybrid Gas-Electric Propulsion (HGEP) project, the agency has funded development and testing of megawatt-class electric machines and power converters by Boeing, GE Aviation, two universities and NASA Glenn Research Center. HGEP included maturing concepts for hybrid-electric commercial aircraft. NASA is now planning to launch the Electrified Powertrain Flight Demonstration (EPFD) X-plane program in fiscal 2021.

In fiscal 2019, the agency conducted initial ground tests of a megawatt-scale powertrain in the NASA Electric Aircraft Testbed (NEAT) facility at Plum Brook Station in Ohio. The test used commercial off-the-shelf, non-flight-weight components and focused on communication and control. This year, NASA will test powertrain components at simulated flight altitude in the NEAT, looking at effects such as corona discharge. And in 2021, it plans to test a flight-weight megawatt-class inverter at 30,000 ft. in the NEAT.

Also in 2021, the agency plans to complete the critical design review on a project to demonstrate large-scale power extraction from both the high- and low-pressure spools of a turbofan. Power is extracted from only the low-pressure shaft of current engines, but future electrified aircraft will require more power-generation capacity. In 2016, GE demonstrated dual-spool power extraction using an F110 fighter engine, pulling 250 kW from the high-pressure shaft and 750 kW from the low-pressure shaft.

Pulling large amounts of power from a turbofan can affect its operability. But integrating a megawatt-scale motor/generator with the shaft of a gas turbine so that electric power can be extracted or stored energy inserted could allow the engine to be operated closer to its limits. That could reduce design margins, improve efficiency and potentially enable the use of smaller turbofans burning less fuel. This approach minimizes the battery weight required and could be a first step in hybridizing propulsion for single-aisle airliners.

NASA Glenn's NEAT is the first electric-propulsion test facility of its kind, but other organizations are looking at the infrastructure that will be required to develop, test, certify and operate electric aircraft. Under the EU-funded Green Flyway project, Norway and Sweden are creating a test area providing an environment for testing electric aircraft as well as small and medium-size unmanned aircraft.

The test area provides hangar space, a large amount of little-used airspace, cross-border flying between Ale Ostersund Airport in Sweden and Roros Airport in Norway, and point-to-point routes—Sweden's Harjedalen Sveg and Ornskoldsvik Airports are also part of the project. As a first step toward enabling all 10 of the country's airports to handle electric aircraft, Swedish airport operator Swedavia is equipping Ale Ostersund as a test site, with battery charging infrastructure and the electrical power supply needed.

There are also several government-supported programs underway to electrify existing aircraft as testbeds and potential commercial ventures. In the UK, Project Fresson led by Cranfield Aerospace Solutions will modify the 11-seat Britten-Norman Islander with hybrid-electric propulsion for short-range and island-hopping routes. The UK government is providing half the £18 million ($23 million) cost of the project. First flight is planned in 2022.

Germany's DLR and Bauhaus Luftfahrt have studied an all-electric 19-seater based on the Jetstream 31.

DLR

With support from the Bavarian government, German aerospace center DLR is to modify a Dornier 228 into an electrified aircraft propulsion demonstrator. The first fully electric flight is planned for this year and the first hybrid-electric flight for 2021. The regional government of Berlin/Brandenburg plans to fund another electric-propulsion project, using a purpose-designed technology demonstrator, the APUS i-6. The French government, meanwhile, is supporting a project by Airbus, Daher and Safran to convert a TBM900 to distributed hybrid-electric propulsion.

With the continued high level of interest in electrified aircraft propulsion as a way to reduce aviation emissions despite the many challenges to scaling up the technology, the growing amount of government support is likely to propel progress.

Automakers Drive Change in UAM

Aircraft OEMs look to "verticalize" their hold on the UAM market as automakers increase competition

Lindsay Bjerregaard Las Vegas

When Hyundai officially threw its hat into the urban air mobility (UAM) ring this year with the debut of its S-A1 electric vertical-takeoff-and-landing (eVTOL) concept in January at CES, the big consumer technology event in Las Vegas, the automaker's head of urban air mobility, Jaiwon Shin, asserted that the company's automotive experience would give it a significant advantage in achieving affordability for UAM vehicles.

Hyundai is not the only automaker betting that its experience producing large fleets will give it a leg up in the crowded UAM arena. Porsche partnered with Boeing late last year to explore the UAM market, and Toyota recently invested nearly $400 million in startup eVTOL-developer Joby Aviation, with plans to provide manufacturing and cost-control expertise.

These developments signal that the automotive industry sees UAM as a future market segment it wants to penetrate. But will this competition prove to be a drawback or an opportunity for aircraft OEMs trying to conquer the burgeoning segment?

According to Robin Lineberger, global aerospace and defense leader at Deloitte, traditional automotive companies do have some advantages over aircraft OEMs, particularly when it comes to building to scale and enabling autonomy. "Many of them have already shifted to understanding, organically, autonomy," he explains, pointing to the example of Tesla vehicles, which already feature basic components of eVTOL such as electric motors, battery technology and early-stage sense-and-avoid autonomy. "On the air vehicle, many of those things are very synonymous [with] or parallel to the experience they have on the ground," he says.

What automakers lack, says Lineberger, is the experience and partnerships traditional aircraft manufacturers have in making these vehicles airworthy. Antonio Campello, president and CEO of EmbraerX, echoes this sentiment.

"In our point of view, everybody is very welcome, because the more companies we have on board, the sooner and more robust the ecosystem will be; and it's good for everybody," says Campello. "[However], the most important point is that certification of an aircraft is a huge barrier for everyone, including to the incumbent OEMs. So, yes—the car industry can help a lot, but I don't see them doing it by themselves and getting the results in the short term that we [EmbraerX] have to make it happen."

Brian Schettler, senior managing director of Boeing HorizonX Ventures, says he sees a lot of value in partnerships between automotive and aerospace in the UAM sector. "It's definitely different from typical aerospace from a volume perspective, and there will of course be different cost expectations to make the business models feasible," he says. "That said, bringing a relentless focus from the aerospace side on safety, redundancy and security will be critical."

During a panel at CES on whether aerospace or ground vehicle manufacturers have the advantage in building autonomous fleets, Scott Drennan, Bell's vice president for innovation, indicated that customer demand will drive the market for production scale

Hyundai's S-A1 eVTOL concept made its debut at CES 2020.

LINDSAY BJERREGAARD/AW&ST

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Bell believes its AerOS will serve as the digital backbone for UAM fleet data.

of eVTOLs but said he expects the number to fall somewhere between traditional rotorcraft scale and the larger scales the automotive industry is anticipating. He argues that this is an area where aerospace/automotive partnerships can be beneficial, and that aerospace OEMs may need to change their manufacturing techniques to keep up.

Hyundai declined to comment about the specific production volume it is targeting for the S-A1, but during the CES panel, Uber Elevate—with which Hyundai is partnering—indicated it sees the opportunity for the production of eVTOL aircraft to exceed the number of traditional rotorcraft by a factor of 20.

Matt Holvey, manager of intelligent systems at Bell, says the challenges of UAM will require unique industry perspectives outside of aerospace's comfort zone. "Obviously, aerospace manufacturers know aerospace manufacturing, specifically around the tolerances required and how to handle aerospace-grade composites, but the automotive industry brings to the table high-rate production, so there's definitely something to be learned there."

Lineberger also points out that this will affect the entire supply chain for eVTOL—and potentially increase competition between aerospace and automotive OEMs for the same resources for batteries and electric distributed power. If aircraft OEMs increase scale for eVTOL, the entire supply base will have to "think about how they move into manufacturing and componentry at a scale that they hadn't done before," he says. "They have to start thinking about how they [will] produce the classic equivalents of their old products in the new environment at rates that they haven't been challenged to do before."

DIGITAL BACKBONE

One way in which aircraft OEMs are evolving within the UAM market to stay competitive, says Lineberger, is "verticalizing" their offerings. Instead of just building the vehicles themselves, Lineberger says OEMs are "getting another bite of the value chain" by moving into in areas such as sustainment, operations and fleet management. Clearly looking to corner more of this market is Bell, which introduced its AerOS operating system alongside its Nexus 4EX eVTOL concept at CES.

"One of the positions Bell took was that infrastructure is so important that we need to do more than just have conversations about it today," explains Holvey. "As we look at the UAM environment, there's a lot of conversation around the vehicle; there's some conversation about charging infrastructure; there's some conversation about vertiports. But what seems to be lacking is a conversation around the digital backbone that's going to connect all of this together—because we're going to have to operate and optimize in ways we never had to before."

Holvey views AerOS as the "connective tissue" between UAM elements such as air traffic management and MRO, integrating with traffic management and providing data about fleet usage for better predictive maintenance. He argues that predictive maintenance will be a key factor in bringing down operating costs for UAM vehicles, particularly when there is demand for high-volume manufacturing.

"The standard of schedule-based maintenance that exists today is a very conservative approach, and we believe that with proper data and data collection all the way from fleet usage and component-tracking, we could probably come up with more

optimized ways of identifying components that need to be replaced sooner or components that need to have longer life," says Holvey. He adds that although on "Day 1, out of the gate" the maintenance model for Bell's eVTOL vehicles will probably entail "the same schedule-based maintenance that we know and love," AerOS will set the company on a path toward more predictive-based MRO.

EmbraerX's Campello believes the company's Beacon digital maintenance platform—which it describes as similar to "Uber for [aircraft on ground]"—could be particularly useful for connecting local mechanics with maintenance work needed on eVTOLs. The platform locates mechanics, parts and tools during aircraft-on-ground situations away from an operator's maintenance base and enables operators to follow along and keep track of the maintenance process.

"We shortened what today is a very difficult process to find mechanics and bring them to work. There are many features that expedite return to service, and there is no need to have a physical place," says Campello, referring to the popular premise within UAM of maintenance centers needing to be built at dedicated vertiports. "The mechanic can live in his house close to a skyport or airport; he will be found, and he can accept or not to take the job. If you compare with the cars that we are using for Uber, the more demand you have, the more drivers you need. The more drivers you have, the sooner they come to pick you up."

CARGO AND PERSONAL UAM

Another area where OEMs including EmbraerX, Bell and Boeing are broadening their reach within the UAM market is the unmanned air cargo segment. Boeing unveiled an eVTOL cargo air vehicle prototype in 2018 capable of 500-lb. cargo delivery, and Schettler says Boeing HorizonX is investing in early-stage companies with technology to make it "incredibly capable," such as connectivity, batteries and autonomy. Bell recently partnered with Japan Airlines and Sumitomo Corp. on launching UAM services in Japan using its APT (autonomous pod transport) delivery drone and Nexus eVTOL. EmbraerX announced a collaboration with Elroy Air at CES to expedite entry into service of Elroy's Chaparral autonomous logistics aircraft.

Campello sees the massive growth of e-commerce creating high demand for UAM cargo solutions. "The more you grow the number of items that have to be supported, the more you're going to have to have a way of transportation that is quick, mainly to transport perishable items and so on, that could have a very acceptable transportation price and that optimizes the volume," says Campello. He adds that the Chaparral's ability to both fly and load/unload cargo autonomously will be fundamental to the demands of high-throughput logistics.

Campello suggests that in addition to cargo transport, EmbraerX's eVTOL could eventually be used for missions such as air rescue. And while the air taxi model seems to be the most popular within UAM right now, Lineberger says the personal eVTOL market is "wide open" and that a derivative of a flying taxi could potentially fly alongside it or even disrupt the market. For instance, at CES, exhibiting within the same hall as Bell and Hyundai, was Pegasus International, which introduced its vertical-takeoff-and-landing Flying Car concept that it says "could fly right to your garage." The gas-powered vehicle switches between driving and flying modes with the touch of a button, which automatically folds the rotor blades for parking.

Although Lineberger thinks it is unlikely that most people will fly vehicles like this from their backyards to the office, for reasons similar to why private helicopter owners do not fly them for their daily commute—such as air traffic management and parking—there is still potential for the personal-use market to be viable. "If you go to a traditional small airport and you go out to your eVTOL aircraft and you can fly it, I suspect there will be communities that develop around it," he says.

Elroy Air's Chaparral system can autonomously deliver up to 500 lb. of cargo over distances up to 300 mi.

ELROY AIR

Workflow Scheduling Software Emerges

Different options will make the art of maintenance scheduling more fluid and accurate

Paul Seidenman and David J. Spanovich San Francisco

As MRO workloads increase, project scheduling, from induction to invoicing, becomes more complex. Software has automated workflow management by replacing magnet waterfall boards and Excel sheets, but today that is no longer enough. Instead, software designed to maximize workflow efficiencies must function as an integrated component of a total enterprise resource-planning (ERP) system, which is now likely to be cloud-hosted.

Because today's MRO industry incorporates more predictive maintenance operations, "a more dynamic scheduling capability is therefore needed that optimizes across manpower, tools, facilities, capabilities, finance and materials—with a significant degree of granularity," says Torsten Welte, SAP's global vice president and head of the industrial business unit for aerospace and defense, travel and transportation. "MROs are looking for a real-time, integrated, holistic view of all resources, along with intelligent decision-support, tools that are easy to use, and the ability to eliminate duplicate tasks and manage a portfolio of projects," he says.

"Interactive, collaborative and integrated" resource planning is also critical for effective and efficient maintenance execution, adds Johann Schactner, SAP's industry solution manager in the travel and transportation industry business unit.

Supervisors and planners often allocate resources using virtual tools. "This capability is provided by a multi-resource scheduling tool to aid users when making scheduling decisions, visualize the planning situation, visualize the usage of resources, and perform manual, automated and optimized work assignments," Schactner explains.

SAP's MRO tools offer core planning and scheduling capabilities as part of a total enterprise management package, such as the vendor's Enterprise Portfolio and Project Management, Multi-Resource Scheduling and Integrated Business Planning. In that way, additional capabilities can be deployed and seamlessly integrated to enhance planning and scheduling, says Schactner. "We provide dedicated capabilities to schedule critical resources—which could be human resources, machines, tools and events. Due to the integrated nature, constraints such as skills of human labor and machine availability can be easily considered," he says.

WINAIR

WinAir's aviation MRO scheduling and inventory control software is designed to integrate with existing systems, such as accounting and flight operations, so customers can continue using those systems and leverage data within them.

In general, the MRO industry is looking for more automation in the scheduling and assignment of resources for proposed or planned maintenance events. "At the earliest stages of planning a maintenance input, the provider wants to see proposed hangar slots and manpower availability against the workload," says Chris Clements, sales representative for Swiss Aviation Software (Swiss-AS). "This may not be just hangar-based maintenance, but it also needs to include the workshops in case there are any components that require [outsourced] processing."

Clements says another emerging trend for scheduling software is to incorporate the ability to determine what portions of the manufacturing or repair process should be sequenced or prioritized, along with planning for the infrastructure or supplies needed.

While there are still more requirements being identified, "once the initial requirements for the workscope have been defined, the next steps should be proposed and scheduled, and all associated resources and parts should then be identified and planned as part of that process," Clements says. He adds that this particular scenario is being addressed by Swiss-AS by upgrading its AMOS Component Maintenance modules. AMOS is the vendor's widely used maintenance management system.

Chris Lawn, marketing specialist for global aviation management software producer WinAir, reports that WinAir Version 7, the company's aviation maintenance scheduling and inventory control software product, is designed to integrate with other systems, such as accounting and flight operations.

"While many maintenance software systems claim to do everything for everyone, rarely does this turn out to be the case," Lawn says. "On the other hand, software that integrates with a customer's existing systems not only provides the ability to continue

LTAA scrapped Excel sheets and moving magnets on waterfall boards for a digital data-driven system a decade ago.

LUFTHANSA TECHNIK

using those systems, but enables the customer to leverage the data within them." These integrations save MRO operations significant time because they automate procedures, eliminate duplicate data entry and boost overall business efficiencies.

Michael Perrotta, a WinAir product support specialist, says MRO scheduling software should provide the capability to schedule as well as forecast, taking into account scheduled and unscheduled work, the parts that will be required and current inventory levels.

Among WinAir Version 7's latest enhancements is "Work Packages," designed to address scheduling and workflow management across multiple MRO locations. "With a Work Package, all parts of the project can be bundled together, focused on where the work will be done and when scheduled," he explains. "The package also allows tracking as production moves among different MRO facilities, including labor allocation and parts stock flows."

Work Packages, along with Access Groups, says Perrotta, are applicable to a multilocation MRO, as well as to one that outsources some of its work. "If some of the work has to be outsourced, that facility can be given access to whatever data they need to accomplish the work. This is a feature more customers are asking for, especially when there are expertise or lower labor costs at locations out-of-house." Work Packages is now in its first phase of development; the next two phases will be released during the second quarter of this year, he says.

WinAir is a cloud-based product, largely as a result of preference by the MRO industry for software as a service (SaaS). Doing that, Perrotta says, saves the MRO the expense of setting up an in-house hosting infrastructure and makes it easier to manage data in real time. "If you cannot keep up with data management in real time, forecasting goes out the window," he stresses.

One example of an MRO using work scheduling automation is Lufthansa Technik AERO Alzey (LTAA). Technical Director Thomas Hoffmann says that in 2010, LTAA scrapped Excel sheets and moving magnets on waterfall boards in favor of a digital data-driven system. "This system offers scheduling of single work steps and much greater visibility of the overall production status," he says.

For scheduling, LTAA uses a standard production software product called FAST/Pro from GTT, which is connected in real time to LTAA's SAP-ERP system, and an add-on, SAP iMRO.

"Adjusted to MRO needs, FAST/Pro is continuously improved by local programming staff to meet our evolving needs," he notes. "It also interfaces with our customer information system, LUCIS. Having FAST/Pro as a separated platform from our standardized SAP iMRO ERP system allows us to quickly adjust it to our production needs."

As Hoffmann explains, every engine is inducted into the shop using a "net plan" that reflects the customer's approved workscope. With this net plan, manpower resources—needed today and projected—as well as material availability, reflecting actual delivery dates from suppliers, are factored in. "The software tells the mechanic what to do next in order to have an optimum production flow," and customers can view projected delivery dates, he says. "We need to reflect the whole value chain, from receiving a customer order to writing the invoice. All processes that are needed in between are integrated in the workflow."

To manage the complexity, each person working on engines has his or her own visualization and workflow screen, based on role and responsibility.

LTAA considers FAST/Pro's ability to prioritize material needs as critical. "Having the material needed to build an engine is a daily challenge, with a few missing items sometimes delaying assembly on or near the scheduled due date," says Hoffmann. "A clear visibility of potential late deliveries, optional material usage or internal repair issues is key. For example, we may need to know when a part is required for a special assembly task, and the system tells us if the delivery date fits, or if we need to look for alternatives."

Hoffmann admits that without an automated scheduling system, handling more than 100 engines—with hundreds of thousands of parts, simultaneously—would be impossible. "With Excel sheets and magnet waterfall boards, we had daily status meetings requiring a lot of preparation time, with more than 25 foremen and engineers lasting close to 2 hr. in peak times," he notes. Now, production status is available in real time. "The mechanic just clicks 'started' and 'finished' for an assigned work step. No one has to walk around collecting the information and writing it in Excel sheets," he says.

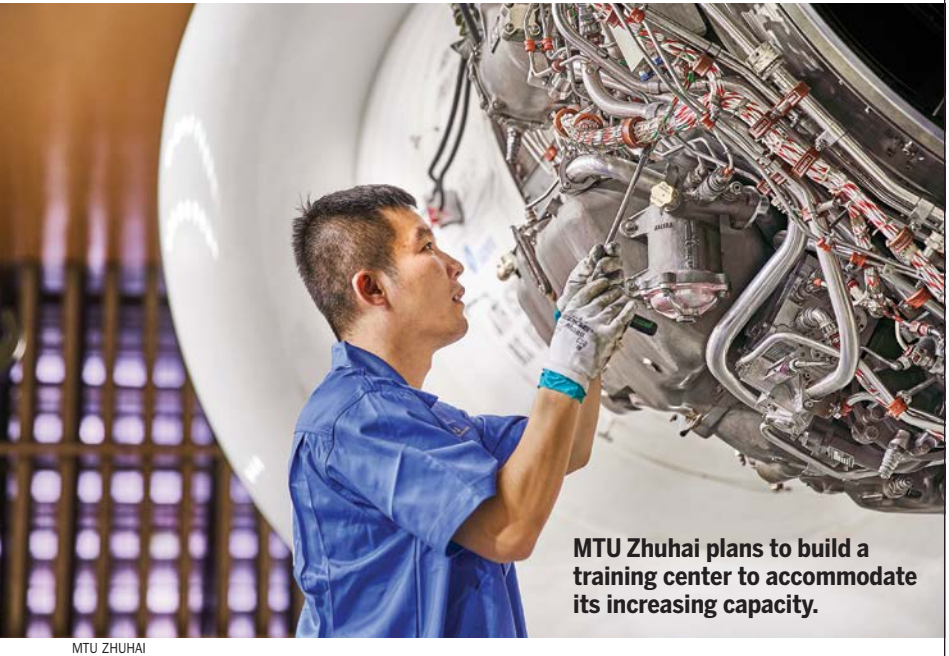
Building a China Shop

How Western aftermarket companies are navigating cultural differences and exogenous shocks in their Chinese ventures

Alex Derber

The history of Western aftermarket ventures in China goes back almost as long the country's first flag carrier, although most of the growth has occurred in the last 20 years.

Ameco Beijing was established by Lufthansa Technik (LHT) and Air China in 1989, a year after Air China split out from former flag carrier CAAC Airlines. At the time, China constituted a relatively insignificant part of global maintenance demand, but the country's meteoric growth since then means that it has now the second-largest domestic passenger market after the U.S., as well as a significant share of international demand.



MTU Zhuhai plans to build a training center to accommodate its increasing capacity.

MTU ZHUHAI

Thirty years after LHT blazed a trail, many Western OEM and maintenance companies have established some presence in China; the market is just too big to ignore. For technical facilities, this almost always means a joint venture with a Chinese business, often with one of the "big three" state carriers—Air China, China Eastern and China Southern—but sometimes also with local authorities, lessors or MRO providers.

There are dozens of examples of these joint ventures in mainland China, but some of the most significant include: Ameco Beijing; Boeing Shanghai Aviation Services, a base maintenance and cargo conversion joint venture with China Eastern; FL ARI Aircraft Maintenance & Engineering, between China Aircraft Leasing and FL Technics; GE Aviation Services (Xiamen), with China Eastern; Lufthansa Technik Shenzhen, a component maintenance joint venture with Beijing Kailan Aviation Technology; MTU Maintenance Zuhai, a narrowbody engine maintenance facility run by MTU and China Southern; Pratt & Whitney Shanghai Engine Center, a joint venture with China Eastern; and SSAMC, CFM's engine overhaul joint venture with Air China.

In addition, there are numerous manufacturing partnerships by airframe, engine and component OEMs, the best known of which is probably the Airbus Tianjin final assembly line.

Whether in manufacturing or the aftermarket, joint ventures in China historically have been founded using a common model, with Western companies seeking access to the huge local market (and sometimes also to cheap labor) and their Chinese partners looking to gain technical expertise and much-needed MRO capacity. However, recently those dynamics have been rattled, with labor-cost differentials between China and the West eroding and U.S.-China trade tensions contributing to slower economic growth in China. Furthermore, since early 2020 there has been the far bigger impact of the COVID-19 outbreak.

CORONAVIRUS IMPACT

As of early March, the COVID-19 virus had killed more than 2,000 people, mostly in mainland China, and infected about 75,000. The resulting slump in travel demand to, from and within China has seen many international air carriers cancel services to the country, while domestic demand has also slumped.

This will have a knock-on effect on maintenance demand, says Konstantin Stathopoulos, senior director of corporate sales for northeast Asia at Lufthansa Technik. "We [Lufthansa Technik Shenzhen, or LTS] surely have felt the impact on our production and are preparing for less demand during the next months, since most airlines in China have reduced their flight schedules."

Day-to-day operations have also been disrupted. Airbus Tianjin, for example, shut down production for about two weeks in February, while work at maintenance sites was also affected.

"The extended [Chinese] New Year break until Feb. 9 gave the task force here in Lufthansa Technik Shenzhen sufficient time to establish all the pandemic control mechanisms and to resume operations with almost 90% production capacity effective Feb. 10," says Stathopoulos.

MTU Maintenance Zuhai was also affected by the extended New Year holiday, during which "we did our best to serve customer needs," says Jaap Beijer, president and chief executive of the engine MRO provider. However, he adds that the facility is back operating at full capacity and that he expects the long-term impact to be minimal.

"In general, the aviation industry has proven its long-term robustness in

the context of former—and even more severe—fatal disease outbreaks in the past," he says.

Others are also keen to downplay the impact on aftermarket operations. "The disruption is not serious and is controllable," says Francis Liu, a board member of Estonia-based Magnetic MRO, which was acquired by Guangzhou Hangxin Aviation Technology in 2018 and operates an engine stands facility in China. "A certain level of delay for the return of our materials sent for repair is expected but acceptable," Liu adds.

TRADE TENSIONS

President Donald Trump's efforts to redraw his country's economic relationship with China has already had an impact on the air cargo market, and while passenger airlines are far more concerned—at least in the short term—by COVID-19, any restrictions on the export of commercial aircraft technology or parts from the U.S. to China would have repercussions for the aftermarket. As of the beginning of March, the Trump administration was reportedly considering a ban on sales of the CFM Leap engine for the Comac C919.

Certain tariffs already are affecting the supply chain, says Stathopoulos. "In 2019, LTS had a noticeable cost impact due to increased trade duties, since the vast majority of the parts we use for repair is from abroad. The duration and severity of this impact depends on the outcome of the negotiations between China and the USA."

Beijer has a different view: "The U.S.-China trade tensions have not affected MTU's business in China at all. We also expect no impact in the future, as the aviation industry is crucial to both countries, and we doubt that this market will be put in danger," he says.

Liu describes the impact of trade tensions as "quite insignificant," although he does note that "the increased import tax rate leads to a higher price for the imported spares that our parent company is using to repair our material."

Even without trade disputes, the ease of doing business for any aftermarket company is determined in part by how a particular region interacts with the global supply chain via its export and import regimes. These can vary in different parts of China. Free trade zones, for example, benefit from simplified customs procedures.

"Our facility is located in the Zhuhai free trade zone and is easily accessible within the Pearl River Delta—from Macau, Guangzhou and Hong Kong," says Beijer. "Connectivity improved even further last year, as the bridge between Zhuhai and Hong Kong was officially opened—an MTU truck was even one of the first to make the crossing!"

Established in 2002, Lufthansa Technik Shenzhen has worked hard to streamline its supply chain, gaining an "Authorized Economic Operator Advanced" certificate and an "Export Benchmarking Enterprise" award, which mean that almost none of its parts are physically screened by customs, with checks instead being conducted online, "which provide a huge advantage in speed," says Stathopoulos. LHT Shenzhen also uses the bonded process for the repair of units received from overseas. There is no import duty for such units and material consumed, if the material was also imported as bonded goods.

LABOR

High-technology companies like Lufthansa Technik and MTU deny that labor costs have had much influence on their decision to locate in China, while also noting that wage differentials with the West have narrowed. "For skilled and qualified workers, the average wage has increased at a much higher growth rate than the average in general," says Stathopoulos. "Certainly, the labor-cost advantage for a company still exists in China, especially also taking into account productivity, as this is on a high level too."

Of more concern to these companies is the supply of skilled labor, which is becoming a challenge in their home countries and in China.

"It has become hard in China to find the right skilled workers," says Stathopoulos. "I would not say it is easier or harder, as we face similar challenges in both regions. However, the constant growth in our industry and the limited number of young talents and students choosing the growing aviation and engineering sector makes it difficult to find and also retain a good skillful workforce."

To address this, many big companies provide training facilities. "Alongside our current facility expansion of 50% to a capacity of 450 shop visits, we are also planning to build a training center toward the end of the year. This will enable us to train even more staff to our specific needs following a system similar to the dual-education system in Germany," says Beijer.

Liu, however, says: "It is much easier to find the right mechanic in China than here in Estonia. That has become the No. 1 restriction for further developing our business."

CULTURAL DIFFERENCES

"The culture here in Estonia tends to lead to more communication, decision-making and efficient work style than in the state-owned companies in China, so I'd notice this as one of the major differences," says Liu at Magnetic MRO. "However, such tendencies are quite similar in the small and innovative Chinese companies."

From another perspective, Westerners often note the importance of Guanxi—or relationships—in Chinese corporate culture. Of course, networking and contacts are vital elements of business in the West, too, but they take on a special significance in China. "Having a relationship and fostering this is one of the core values, be it within the company or making business with others [in China]," says Stathopoulos.

The Lufthansa executive also highlights a sense of corporate nationalism in China that foreigners may be unused to. "The Chinese are highly focused in doing business with other Chinese companies and keeping the business within the country, whereas in Germany we tend to look for the best business partner in general," he says. "That describes the strong value of collectivism and national pride in driving the culture in companies in China."

As for what tips he would give other Western MRO providers contemplating expanding in China, Stathopoulos recommends they have "a long-term plan and a lot of stamina," adding that quick success is difficult to attain, given the competitive landscape.

Liu, meanwhile, says that good translators are vital to avoid costly misunderstandings. He also notes that "having a local partner influences all processes from the very beginning."

LED Retrofit

With greater reliability and efficiency, LEDs are supplanting conventional lighting

Thierry Dubois Lyon, France

LED lighting is one of the fastest-evolving technologies in use in aviation. Because LED lighting can be adapted almost directly from the world of consumer electronics and involves a relatively straightforward approval process from civil aviation authorities, it helps operators keep up with passenger expectations. Transforming the atmosphere of a cabin may also boost a carrier's sales.

Upgrading to LED lighting is virtually an all-around improvement. Not only is it more reliable and more fuel-efficient, but it can also make passengers feel more comfortable during the flight. Such a feature is essential, as the trend toward tightening seat width and pitch seems never-ending.

Meanwhile, crews may enjoy more dependable cockpit switch indicators and landing lights. In the cockpit, LEDs have been replacing incandescent bulbs in switches. Inside the cabin, they replace incandescent bulbs and fluorescent tubes. On the aircraft exterior, LED lighting replaces incandescent and halogen bulbs as well as xenon lamps.

The technology has matured significantly in the past two decades. LEDs, or light-emitting diodes, are solid-state semiconductor structures that emit light when energized. Initially, it was possible to install lower-power lighting in the cockpit, for cabin signage and on the aircraft exterior, says Bob Lenz, director of product management for lighting at Honeywell Aerospace. Then came cargo lights, anti-collision lights and complete interior suites. Finally, the highest-power flood lighting installations (such as for a carrier's logo on the tail, wing inspection and landing and taxiing) became possible.

For a designer, the challenge lies in the integration with optic and electronic components. The product has to remain reliable in a harsh environment that could include vibration and low and high temperatures, says Darren Cavan, Oxley Group CEO.

The maximum temperature in which LEDs can function is around 140C (284F). "If you switch it on in a 70C [158F] environment, you have to ensure you are not going to overheat—the closer you get to 140C, the more you degrade the LED, so a lot of technology goes into cooling," says Georg Hartl, quality and certification administrator at Aveo Engineering. On the tailcone, near the auxiliary power unit, the design should factor in the gradient of temperature, fluid spattering and vibration, says Joel Berkoukchi, head of electromechanics and cockpit activities for Safran Electronics & Defense.

Are LED manufacturers building products to aerospace specifications? Not really. "Consumer electronics is driving LED technology—we use a fraction of the LEDs produced," says Stephen Scover, vice president and general manager of Collins' interior lighting solutions. "As new technology is introduced, we keep a close eye on consumer electronics. Our expertise is in adapting components to aerospace grade."

> ***"Lighting is one of the most cost-effective methods to change the ambiance of a cabin."***
>
> **Stephen Scover,**
> vice president and general manager of Collins' interior lighting solutions

"In business class, we introduced LED reading lights in the mid-1990s," Armin Plichta, Schott's head of business development, aviation and automotive, recalls. The first Airbus A380 cabin lighting systems, in the mid-2000s, had a combination of LED strips and fluorescent tubes. The technology has even prompted the formation of some companies such as Germany-based Aveo Engineering, in 2006.

Despite the many advantages to LED technology, the one drawback is price. "The cost of switching an existing aircraft installation to LED technology is a hurdle to adoption," Lenz admits. In a passenger service unit, the cost is close to $10, up from $1.05 for a conventional bulb, adds Katja Kroejby, director of business development at Leki Aviation.

The benefits, however, outweigh the costs. Most visible from the passenger's point of view is color consistency. "When aging, the color of a fluorescent tube alters, possibly changing from a nice clear white to yellow or green," Collins' Scover explains.

LEDs can also change color when aging, but that can be controlled. "Designers know where color shift takes place and accommodate the phenomenon in circuit design," Scover adds. "Color correction happens as LED ages, and you do not see a difference after 12 years."

Schott has developed its own solution. "Our HelioJet technology avoids heterogeneous aging of LEDs, as they usually become darker or their color deviates after 1-3 years," Plichta says. "We use four LEDs at the ends of a glass rod, which distributes light into the cabin. Thanks to the built-in sensor, the sys-

For a cabin interior designer, LED lighting offers unlimited choice in color and mood creation.

COLLINS AEROSPACE

tem can regulate each individual LED and thus distribute light homogeneously and reliably over the full lifetime."

Over the years, LED lighting has opened a field of possibilities for cabin interior designers. LED lighting offers an unlimited choice in color and mood creation, and the colors are warmer. "As they are smaller than conventional bulbs, LEDs enable a better focus," Aveo's Hartl says. LED lighting provides so much flexibility that seasonal changes can be envisaged.

Light color is critical in the passenger service unit—choosing the wrong color may cause food to look strange, Leki's Kroejby notes.

"Lighting is one of the most cost-effective methods to change the ambiance of a cabin," Scover emphasizes.

Not only is installing LED lighting cheaper than upgrading seats and monuments, LEDs do not emit lightwaves that cause colors to fade. Compared with conventional lighting, they extend the life of carpeting and upholstery.

From the flight attendant's perspective, various ambiances can be chosen. Different lighting options can alter the mood during boarding, at night, for dinner or between flights, when it is important to flood the cabin with light during cleaning operations.

Hamburg-based Jetlite offers "human-centric lighting" to fight jet lag. Adjusting light color, temperature and intensity throughout long-haul flights helps passengers adjust their sleep schedule, according to the company.

"For an external use case, LED lighting is 4-6 times more efficient than the latest xenon bulbs."

Joel Berkoukchi,
head of electromechanics and cockpit activities for Safran Electronics & Defense

Roughly 30-40% of airlines are interested in customized lighting, Collins' Scover notes.

A second generation of LEDs is being installed in some aircraft. Thermal properties have improved over recent years, opening new possibilities. Flexible accent lighting can thus be added to seats and furniture. Efficiency gains are spectacular. Depending on the installation, power needs can be cut 66-80%, Lenz says.

In durability, too, the improvement is dramatic. "LEDs have a life expectancy of 70,000-80,000 hr.," Scover says. This compares with a fluorescent tube's 3,000-5,000 hr. Oxley's smart health monitoring can provide an early warning when an LED needs replacement.

Exterior lighting is more regulated because of its greater intensity and more advanced optics. And it is typically 2-3 times more expensive than conventional lighting. "But unit price is less critical than the maintenance cost, as the man-hour cost of removing an LED from a landing light is about $40, compared to hundreds of dollars for a conventional bulb," Aveo's Hartl says.

In terms of power consumption, LED lighting is 4-6 times more efficient than the latest xenon bulbs, Safran's Berkoukchi adds. LEDs on aircraft exteriors can last 20,000 hr.—in stark contrast to 20-50 hr. for incandescent bulbs, 100-200 hr. for halogen lamps and an average 2,000 hr. for xenon technology, he estimates.

Operators can expect reasonably priced upgrades for in-service aircraft. LEDs themselves are costly, but much of the installation uses a drop-in approach. "The power supply, sometimes referred to as the LED driver, will be contained within one of the new system components, so no new unit or wiring will be required," Lenz says.

"A complete full-color mood lighting system—as an old cabin management system does not allow more than three color schemes—involves replacing it with an independent light controller and some wiring to interconnect," Schott's Plichta says. "It takes 160 working hours on average for a widebody cabin. If you switch to LED, return on investment comes after 1-2 years."

As for certification, "to replace a halogen landing light [the most constraining case] with an LED one that uses the same interface, [a European Union Aviation Safety Agency] minor modification approval is needed," Oxley's Cavan says.

What could the future hold for LED lighting technology? "Efficiency is still increasing, by roughly 10% every three years," Safran's Berkoukchi says. Focus may become more accurate, without a halo around the target point. Ultraviolet LEDs may also help avoid bird strikes because birds better perceive those wavelengths, Aveo's Hartl suggests. In galleys, some other wavelengths may be used for disinfection.

Diminishing Returns

MRO providers focus on other aircraft types as A380 numbers dwindle over the next decade

James Pozzi London

Early 2019 saw Airbus announce that production of its A380 superjumbo—a beloved but unviable aircraft program—would cease starting in 2021. With just eight A380s delivered last year, the decision to axe the A380 program little more than a decade after the first aircraft entered service was sad but inevitable.

In the past few years, several relatively young aircraft types have exited airline fleets. A380 launch customer Singapore Airlines has already returned some of its aircraft to German investor Dr. Peters, with the first A380s being parted out in 2019 by Tarmac Aerosave in France.

While Singapore plans to retrofit its remaining fleet, other carriers are looking to offload their A380s entirely. Air France plans to phase out the A380 by 2022; its first deactivated aircraft was sent to Ireland's Eirtech in February, with its fate yet to be determined. Speaking at Aviation Week's MRO Middle East, Yann Cambier, a senior manager at consultancy ICF International, said the airline had a choice to make. "They are at the stage where they have to make the decision between refurbishing the aircraft, which is a very costly task, or moving on to new aircraft types," he said.

However, despite a decreasing fleet, an aftermarket for the superjumbo will remain, with a sizable proportion of the aircraft yet to reach their first D check phase. Aviation Week's Fleet & MRO Forecast data predicts aftermarket spending of $26.1 billion for the aircraft from this year through 2029.

ETIHAD AIRWAYS

The sizable fleet of A380s in the Middle East will help keep its aftermarket alive during the next decade.

The A380 has in excess of one million parts, so the components market for it will be just short of $3 billion over the next decade. Much of the activity in the short-to-medium term will center on the Middle East, a region accounting for more than half of the global A380 fleet in 2020.

There, Emirates operates the world's largest A380 fleet of 115 aircraft. The Dubai-based airline is among the remaining operators with future A380 commitments in place, but has reduced its orders and chosen to switch to A350 aircraft. Over the next decade, the retirement plan will begin, with a fleet reduction to 90-100 in-service aircraft by the mid-2020s and a fleet of 80-90 A380s by 2030.

Etihad Airways and Qatar Airways each operate 10 of the aircraft, but the latter has also signaled its intention to remove them from its fleet by switching to Boeing's 777-9 before its A380s reach 10 years of age. Allan Bachan, vice president and managing director of aviation MRO operations at ICF International, believes some of this forecasted heavy check work may not be done in the Middle East. "We would expect Emirates to schedule its retirements before any D checks to avoid higher costs, as it does its A380 maintenance in-house," he says.

Given the fleet reductions, other operators are not anticipating large volumes of work. Etihad Airways Engineering, which services the Etihad fleet but mostly operates as a third-party provider with more than 70% of its work carried out for other airlines, makes A380 fleet repairs in a joint venture with Airbus at its Abu Dhabi facility. Unlike Emirates and Qatar, the carrier has not announced any A380 retirement plans yet, but Abdul Khaliq Saeed, CEO of the maintenance business, believes the A380 aftermarket is strong enough for now, since the company is also repairing the aircraft for other airlines. But the MRO has no plans to add further capacity for work on the aircraft, even though volume is currently tight.

The past few years have seen Etihad's MRO unit add Boeing 787 and A350 repair capabilities as it moves to other aircraft types, and this trend is being replicated at other MROs with A380 repair capabilities. French maintenance provider Sabena Technics is another repair specialist that is turning elsewhere in the widebody market.

To date, Sabena Technics has carried out projects such as modifications work on the A380, but despite having C check capabilities, it has yet to perform this service on the superjumbo. CEO Philippe Rochet says that it instead foresees collaborating with companies like Emirates on airframe work at its station in Dubai. "It's not in our core strategy to develop an offer on the A380. . . . We want to develop further in the A350 and 787 markets, as they are the most current widebody aircraft in service," he says.

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Spotlight on Seating

A guide to companies sprucing up aircraft seating through repairs, refreshes and reconfigurations

Lindsay Bjerregaard Chicago

1. Differentiation Through MRO Capabilities

Company: Haeco
Specifications: Specializing in seating ranging from economy to business class on commercial aircraft and crew seats for freighters, Haeco is best known for its Vector seating platform. It recently launched its Vector Y+ passenger seat with Cathay Pacific Airways, and Haeco says the program's success has given it credibility to win additional programs at other large airlines. It will be unveiling its newest seating product, Vector Light, at Aircraft Interiors Expo (AIX) later this month, which it says will "make the slimline seat obsolete." Haeco says its MRO capabilities set it apart from competitors since it can also certify cabin configuration changes and perform touch labor.
marketplace.aviationweek.com/company/haeco-cabin-solutions

2. Repair, Overhaul and Refurbishment

Company: Dretloh Aircraft Supply
Specifications: Based in Anaheim, California, Dretloh Aircraft Supply is an FAA-certified repair station that provides aircraft seat repair, overhaul and refurbishment ranging from new dress covers to inflight entertainment (IFE) upgrades. Dretloh also provides services for interior reconfiguration and seat plastics, cushions and foam. Through its A&D Foam Products division, Dretloh designs and builds custom seat cushions and covers for all seat models for passengers and crew. It also provides flammability testing and reports, as well as engineering and modification certification.
marketplace.aviationweek.com/company/dretloh-aircraft-supply-inc

3. Modifications and Makeovers

Company: Avianor
Specifications: Canada-based Avianor offers full seat refurbishment and modification services, including engineering design and approval of modifications, manufacturing of support components, IFE installation, and sewing and upholstery. The company often performs seating "makeovers," ranging from projects like rebranding former WOW Airlines seating to modifying Airbus A330 seats for A320 or Boeing 767 aircraft. Avianor says it is the only new seat manufacturer in Canada supporting crew seats for small-volume production such as special-mission aircraft, including the Viking Air CL-415 water bomber. The company sold 50% of its business to Drakkar in 2019, which it says will help accelerate its growth strategy.
marketplace.aviationweek.com/company/avianor-inc

4. Family-Owned Advantage

Company: Ipeco
Specifications: Family-owned for 60 years, Ipeco says its long-term planning culture sets it apart from competitors—notably with its long-standing apprenticeship program, which two of its current vice presidents completed. Ipeco's primary seating focus is crew and executive jet passenger seats, and it recently supplied pilot, observer and high-comfort attendant seating for the Boeing 777-9 and executive jet cabin seating for NetJets' Bombardier Challenger 350 aircraft. The company is expanding its London Southend Airport campus, with the construction of a new 125,000-ft.^{2} manufacturing facility, set to open in 2021.
marketplace.aviationweek.com/company/ipeco

5. Commercial Aircraft Expertise

Company: Acro Aircraft Seating
Specifications: Acro Aircraft Seating has certified and manufactured more than 150,000 seats since 2007 and serves more than 45 airlines worldwide. The company focuses on economy and premium-economy seats for commercial aircraft and recently obtained Part 145 accreditation to perform MRO on and off wing. In 2019, Etihad selected Acro's Series 6 economy-class seat for an upgrade program on its Airbus A320/321 fleet, and Spirit Airlines became the launch customer for Acro's new Series 6LC economy-class seat, installed on 40 line-fit and 43 retrofit A320 aircraft. The company says it will be moving into the widebody market with a new product it plans to unveil at AIX later this month.
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6. Sustainable Seating

Company: Mirus Aircraft Seating
Specifications: Launched in 2015, UK-based Mirus Aircraft Seating designs and manufactures aircraft seats using best practices from aerospace, automotive and Formula 1 racing. In 2019, it delivered its first line-fit seats to Airbus final assembly for AirAsia Group and delivered its first Boeing 767 retrofit for TUI Group. It also launched its Sustainable Aviation Initiative, which will entail putting a percentage of all sales revenue into a fund dedicated to improving the sustainability of aviation interiors and reducing $C0_2$ emissions. Mirus says it is committed to becoming a carbon-neutral company by the end of this year.
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7. Seating Stock and Support

Company: Aero Cabin Solutions
Specifications: Founded in 2004, Aero Cabin Solutions specializes in passenger seat refurbishing, remarketing and cabin reconfiguration. Its Part 145 repair shop for aircraft seat overhaul, repair and modification has capabilities to provide seat refresh, new cushions and dress covers, installation or removal of IFE, seat inspection and European Union Aviation Safety Agency certification.

Aero Cabin Solutions also provides spare-parts equipment support, with a large on-site stock of interior equipment such as passenger seats and IFE components, for 24/7 aircraft-on-ground support.
marketplace.aviationweek.com/company/aero-cabin-solutions

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By PETER WHITE
Peter White is the service life-cycle management lead in the aviation and defense sector at Capgemini.

Improving Reliability Programs

The updated AC 120-17B could help MRO providers and aircraft operators build capabilities

One year ago, the FAA released a complete and necessary rewrite of Advisory Circular 120-17, Reliability Program Methods—Standards for Determining Time Limitations.

This guidance document applies to air carriers conducting operations under Part 121; Part 135, §135.411(a)(2) or §135.411(b); or Part 91K operators choosing to maintain program aircraft under a Continuous Airworthiness Maintenance Program (CAMP) and standards for determining time limitations.

The last revision of this document was released in 1978. This is a necessary rewrite because there have been major changes to aircraft maintenance program developments since the 1970s as well as aircraft technology in general. A significant evolution in structures and aircraft computing systems has forced maintenance program development to keep up. Also, there has been enormous progress in computing technology and analytics in the 40 years since the original circular was written.

The original AC was a reliability program written for a Part 121 carrier; this new version is better written, with more practical advice on processes, technology and how a reliability program fits into the whole maintenance and engineering operations model than that previously available in the industry. Here are some highlights:

- The enhanced description of reliability program management with an excellent flow chart tied to the AC chapters, reliability program management and administration.
- More information on training standards for reliability program resources.
- A significantly enhanced chapter on data collection.

This AC does a great job of providing the key elements of a robust reliability program.

An entire chapter on analysis and recommendations, with suggestions on techniques and tools. This also includes a more thorough explanation of techniques and methods for monitoring scheduled maintenance program performance—typically a difficult area for many operators.

- Recognition of how reliability programs fit into the new safety management system requirements for operators.
- A good collection of process flows for various aspects of failure-mode evaluation and determining scheduled maintenance program task effectiveness.

Although every operator's program is customized to their needs, whether FAA-approved with limits on self-directed maintenance program changes or a program requiring FAA approval of any maintenance program changes, the structure and goals are the same. This AC does a great job of providing the key elements of a robust reliability program.

Typical areas operators need to focus on for an effective reliability program include:

- Identifying and training appropriate resources for reliability analytics.
- Working with your IT department to ensure you have a single source of truth from all your maintenance, quality and flight systems to have quality data for root-cause analysis.
- Setting strategy and investments to enhance processes and systems to move to a full electronic data interchange.
- Investing in having IT set up a secure collaboration hub with your key data partners: OEMs, MROs and suppliers, and insist on using the ATA eBusiness Spec 2000 EDI standards to further drive data quality.
- Working with your maintenance operations and engineering centers to understand how reliability can best consume and utilize the real-time health monitoring data coming off the aircraft to support reliability root-cause analysis and maintenance task analysis.
- Investing in R&D and collaborating with universities, consultancies and software providers to identify leading-edge tools to move the reliability program from reactive to prescriptive. That means using AI, machine learning, natural language recognition and other technologies.
- Ensuring you have worked with finance and leadership to an agreed definition of the cost of a delay to enable ROI-based maintenance program changes and decisions on engineering modifications.

If you are an operator with a reliability program and haven't read AC 120-17B yet, spend some time doing so and then review your program to see where you have opportunities to enhance your capabilities. Being efficient and effective in monitoring your fleet at the lowest cost (using a continuing analysis and surveillance system) will set the great programs apart from the mediocre.

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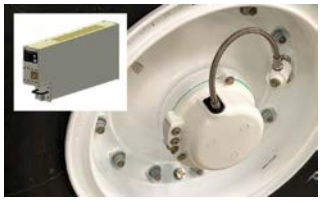

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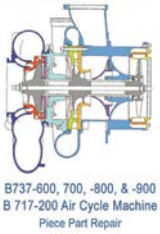

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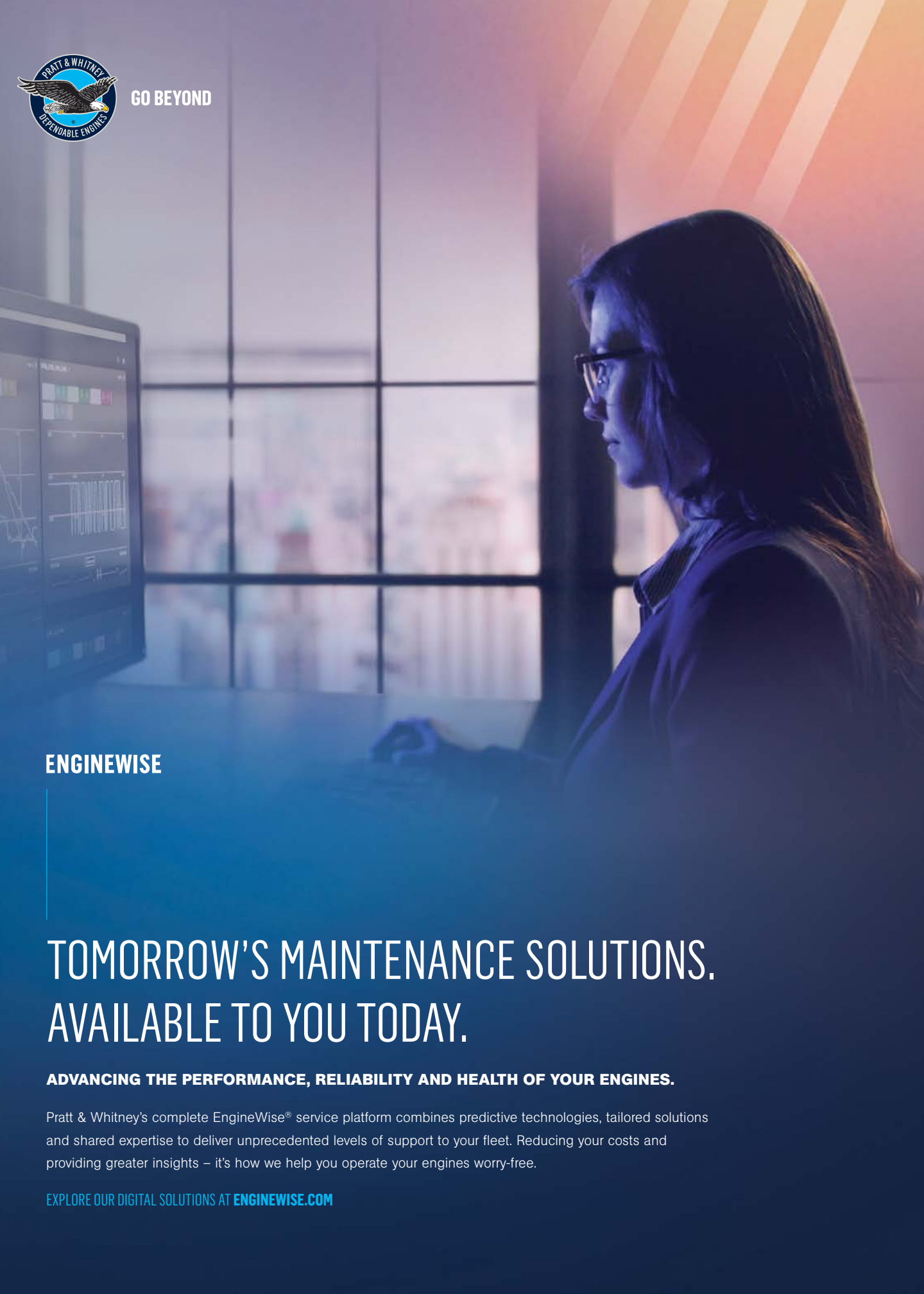
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of one of the latest Chinese technical assignments for the Ukrainians is the idea of propelling a future lunar engine with a mix of kerosene fuel and liquid oxygen as opposed to hypergolic propellants such as hydrazine, traditionally used on thrust-controlled lunar-landing engines.

Liquid oxygen has to be stored at very low temperatures and therefore requires cooling to prevent its loss to evaporation in the harsh sunlight on a trip from the Earth to the Moon. Even more challenging is the development of a throttle mechanism capable of varying the thrust of the engine up to 10 times from its base level, in order to give the pilots the capability to maneuver their lander up and down and hover over the lunar surface during their risky final descent.

To tackle the Chinese requests, Ukrainian specialists had to rely on the technological heritage of the RD-8 engine, which had provided steering for the second stage of the Zenit launch vehicle. However, the RD-8 uses a so-called closed-cycle design whereby the oxidizer-rich gas from a gas generator is routed into the combustion chamber to increase the thrust and improve the combustion stability. Unfortunately, the closed-cycle architecture makes the engine very difficult, if not impossible, to adapt for deep throttling action because of severe combustion stability and vibration problems.

The use of cryogenic engines on lunar landers could become attractive in the future with the availability of lunar "fueling stations," equipped for breaking down presumed deposits of water ice on the Moon into liquid oxygen and hydrogen. Under such a scenario, cryogenic engines burning a mix of liquid oxygen and hydrogen could theoretically receive both fuel and oxidizer extracted from lunar resources.

Peculiarly, the Chinese have requested Ukrainian specialists to study hydrogen- and liquid-methane-burning engines, even though KB Yuzhnoye had never seriously worked with these propellant components.

The Chinese have also asked for Ukrainian assistance on at least three more rocket engines that burn traditional hypergolic propellants—an area where KB Yuzhnoye has very extensive expertise. The Chinese asked the Ukrainians to examine a 2-ton engine with a throttling capability of up to 70% from nominal thrust that could be clustered into a three-engine propulsion system. Two smaller engines with a thrust of 40 and 10 kg (88 and 22 lb.), respectively, which could be used for orbital maneuvering and steering the vehicle in flight, were also on the Chinese wish list.

Based on the broad range of assignments from China, Ukrainian experts speculate that the Chinese industry might be in the initial phase of its development work on a human-rated lunar lander. At this juncture, the industry might still be accumulating a broad knowledge base in the field rather than searching for the suitable propulsion system to fit the scale and technical specifications of the yet-to-be-approved lunar exploration program. The Chinese might also be working on a piloted lunar lander behind the scenes and using the engineering approaches of their Ukrainian counterparts as a yardstick to measure their own progress.

The preliminary studies into lunar-lander engines are just a small part of much wider cooperation between Chinese and Ukrainian propulsion specialists, which also includes large rocket engines of 300-360 tons in thrust—large enough to propel booster stages of space launch vehicles. The cooperation also includes an abundance of smaller new engines and the revival of some old designs. Among Chinese clients of KB Yuzhnoye are the China Aerospace Science and Technology Corp., the prime conglomerate of the nation's rocket industry and new start-up organizations.

Overall, Ukrainian specialists are universally surprised by the breadth of the Chinese effort on many fronts of rocket development.

In turn, for KB Yuzhnoye, cooperation with China became a financial lifeline after an all-but-complete breakdown of economic links between Ukraine and Russia in 2014. The Ukrainian company also has clients in Europe, India, Saudi Arabia, South Korea, the United Arab Emirates and the U.S.

Issues with the sunshield that caused recent delays were cleared following successful deployment in October.

CHRIS GUNN/NASA

JWST Observatory Testing Enters Homestretch

- NASA IS CHECKING PRIMARY MIRROR WING DEPLOYMENT THIS MONTH
- NORTHROP GRUMMAN AND NASA ARE OPTIMISTIC ABOUT CURRENT SCHEDULE

Guy Norris Los Angeles

NASA says it is still "pressing" toward launching the James Webb Space Telescope (JWST) on schedule in late March 2021 as prime contractor Northrop Grumman enters an extended final round of environmental and deployment tests on the complex spacecraft.

Whether the launch of the huge 14,300-lb. observatory remains targeted at the allotted time or slides to a few months later will be assessed by NASA in May. The review will largely depend on the results of ongoing tests, the next phase of which is beginning early this month with deployment checks of the side-mounted wings of the 21.3-ft.-dia. primary mirror.

"The agency is going to take a quick look at where we are in the schedule against technical risk, and we will make a decision then if the launch date should change," says Greg Robinson, the JWST program director at NASA headquarters. "Right now, all indications are that if it does, it won't be much. But our direction from the administrator down is we are still pressing to March."

Development of the JWST, which is a primarily near-infrared (IR) successor to NASA's Hubble Space Telescope, has been fraught with technical challenges that have progressively delayed the program and raised its cost. Originally conceived in the late 1990s as the Next-Generation Space Telescope, the projected launch target for what was later renamed the JWST has moved several times, from the late 2000s and 2010s to the current target of March 2021.

But despite the findings of a report issued in late January by the U.S. Government Accountability Office (GAO) that concluded a delay of several additional months is possible, both the agency and Northrop Grumman say recent progress makes them optimistic the schedule will hold. Pending successful completion of ground tests, this should see the JWST shipped from California by year-end via the Panama Canal to Kourou, French Guiana, where it will be launched on a European Space Agency (ESA) Ariane 5.

Optimism is partly based on the recent completion of fixes to address issues with a faulty traveling wave tube amplifier and a command and telemetry processor, which the GAO report indicated had experienced "errant powering issues during testing." The devices form part of the JWST communication systems that will enable science data and telemetry to be sent back to Earth.

Problems were revealed during thermal vacuum tests, said Scott Willoughby, Northrop Grumman JWST vice president and program manager. "I'm kind of hard-pressed to think of a first article that doesn't go through thermal

vacuum with some more issues, so that was good. But we needed to replace that hardware, and that's exactly what we did." The work was completed around mid-February and included fitting a replacement amplifier and an upgraded engineering version of the command and telemetry processor. "The units were ready in December, and in February we removed the other units, installed the new ones, and now those [failed] units are back at the manufacturers to see what the root cause was."

NASA says it will shift the launch timing if additional discoveries occur during what it acknowledges will be a busy test plan. "You work as hard as you can toward March, and if things pop up and cause it to move out, then we will adapt to that, and we will work it," says Bill Ochs, NASA JWST project manager. "Our No. 1 priority was always mission success. So when we go to environmental testing, if we see something funny, we will stop and look at that and make sure we fully understand it, or we will move on. We do not want to break anything."

Following fold tests of the wings, which comprise the outer six sections of the 18-piece segmented mirror, attention will turn to exercising the deployment tower assembly—a 10-ft.-long composite extendable tube. The assembly is one of the critical devices that enables the JWST to be packaged within the Ariane's payload fairing, and it will be used to separate the telescope mirrors and instruments from the spacecraft bus and sunshield. The deployment will allow the sunshield to unfurl and shade the telescope and instruments from radiant heat and stray light from the Sun and Earth.

After the deployment tests, scheduled to take around 2.5 months, the JWST will be subjected to a battery of comprehensive electrical tests. "Part of that is also where we're going to let the satellite be commanded by the mission operations center back at the Space Telescope Science Institute at Johns Hopkins University in Baltimore," Ochs says.

The JWST will then be inducted into the Northrop Grumman environmental test chamber in El Segundo, California, for a 1.5-month evaluation of acoustic and vibration loads. Although all the individual telescope and spacecraft elements have already been through these tests, this final phase will be "the first time we're doing this as a complete observatory," he adds.

The observatory will then return to the clean room for restowing of all the major elements and a final electrical check. During this four-month-long phase, the vehicle will again spend part of the time under the control of the operations center in Baltimore. "Then basically we go into a period where we'll be doing all the final closeouts and preparations for shipping. That's about a two-month period, but almost a month of that is actually scheduled reserve," Ochs says.

In parallel, the JWST team is conducting contingency planning and mission rehearsals, of which 13 have been run to date. A further 17 are planned before launch. In addition, preparations are underway for some 800 specific tasks that will need to be completed during the 72 days that NASA and the international JWST team partners, ESA and the Canadian Space Agency, expect to spend at Kourou before launch.

Following launch, the JWST will undergo a complex unfolding process as 178 devices that hold it in place for launch are gradually released. "You start this choreography, which happens in sequence where the sunshield opens, then the mirror wings open, and then the secondary mirror comes out," Willoughby says. The process will take 2.5 weeks as the spacecraft coasts to its observation location at the second Lagrange point, some 940,000 mi. from Earth.

The five-layer sunshield will enable the IR telescope to cool to approximately -380F (-229C), making it sensitive to light at 0.6-28.5 micrometers. Reflected by the gold-covered, beryllium-segmented mirror, the faint light of distant galaxies, stars and planetary systems will be analyzed by a suite of instruments including a near-IR camera, near-IR imager/spectrograph, multiobject spectrograph and cryocooled mid-IR detector.

James Webb Space Telescope Time Line

1996 NASA initiates a feasibility study for a companion/successor to the Hubble Space Telescope. Initial cost estimate is $1 billion, with launch in 2007.

2000 Project is several hundred million dollars over budget and unable to meet a 2008 launch target.

2002 TRW (later acquired by Northrop Grumman) is named prime contractor. Launch target becomes 2010.

2004 Launch slips to August 2011.

2005 NASA picks Ariane 5, slips launch target to June 2013.

2008 Project clears its Preliminary Design Review.

2009 NASA budget issues prompt launch slip to June 2014.

2011 Congress implements $8 billion development cost cap. Launch target moves to October 2018.

2016 JWST enters integration and test phase.

2017 NASA delays launch to spring 2019 as the schedule reserve dissolves.

2018 After an independent review, NASA slips launch to May 2020.

2020 NASA to assess program in May. Launch date rescheduled to March 2021.

Sources: Space Telescope Science Institute, U. S. Government Accountability Office, NASA

Bristow-Era Merger Is First Step in Offshore Helicopter Consolidation

> COMBINED COMPANY WILL HAVE A FLEET OF 300 HELICOPTERS

> BRISTOW-ERA WILL BE FIRST OPERATOR OF AW609 TILTROTOR

Tony Osborne London

Operators in the offshore oil-and-gas-support business have not had an easy time over the past five years.

Low energy prices put demand in the doldrums, left helicopters idle and pushed three of the best-known operators—Bristow, CHC and Petroleum Helicopters Inc. (PHI)—into Chapter 11 bankruptcy and have even prompted other operators to consider leaving the market altogether.

Consolidation was perhaps inevitable, but it has been a long time coming. Bristow, an industry pioneer that began regular offshore helicopter operations in the 1960s, is being merged with Era Group in a deal announced in January.

Together, the two Houston-based companies will become the largest offshore helicopter support operator, with a fleet of more than 300 rotorcraft and combined revenues of $1.5 billion a year.

"Both companies have believed for a number of years that Bristow and Era was really an optimal combination," says Chris Bradshaw, who has been elevated from his previous role as CEO of Era to become CEO of the combined company, to be known as Bristow.

"On the back of Bristow's restructuring process emerging from Chapter 11, the time was right to finally put these two companies together," he tells Aviation Week.

Bristow exited the Chapter 11 process in November after a restructuring freed up $900 million of debt, while Era had managed keep its head above water despite the challenging marketplace.

Bradshaw has long been a proponent of consolidation in the industry, stating in Era's financial reports last year that the industry was in "dire need" and that even after the numerous bankruptcies that have affected both operators and leasing companies, more restructurings would likely follow.

"The industry challenges are real," says Bradshaw, and he believes there will be further consolidation. He says the combined company could be in the "best position" to capitalize on the opportunities.

The companies' operations only really overlap in the Gulf of Mexico and Brazil. Bristow also has a significant presence internationally, notably in what was once its domestic market, the North Sea, with operations out of both Norway and the UK. It has a presence in Africa and Australia. Era, meanwhile has international operations in Latin America and India.

Bristow is also contracted to operate the 22-strong search-and-rescue (SAR) helicopter fleet on behalf of the UK Maritime and Coastguard Agency.

Bradshaw says $35 million of savings have already been identified, including eliminating corporate functions and combining bases in the Gulf of Mexico region. The combined company will be able to optimize maintenance programs for the wider fleet, too. It would be the largest operator of the Sikorsky S-92 and Leonardo's AW189 and AW139 helicopters. Bristow has now eliminated its Airbus H225 fleet. It had stored the fleet for several years after the fatal crash of a CHC-operated example in Norway in 2016 prompted oil companies to give the aircraft the cold shoulder. An order for 22 Airbus H175s has also been canceled.

Further rationalization of the fleet could follow, suggests Bradshaw, notably including some of Era's older Bell medium machines and Sikorsky S-76s.

"As the market continues to improve, we may see different models, or more of the newest-generation models, coming into the fleet," says Bradshaw. Although he does not believe there is a need for large orders of aircraft immediately, he notes the company is now better positioned to do that, should it need to.

Despite lower operating costs associated with the new-generation super-medium helicopters such as the H175 and AW189, Bradshaw says there will be a continued need for larger machines such as the S-92, particularly for missions over 200 nm.

The combined company will be the largest operator of Leonardo AW139s and AW189s and Sikorsky S-92s (pictured).

MARK BENNETT

"Eventually, customers are going to want us to replenish our fleet . . . and in order to do that we're going to need access to capital, and we believe the combined company is better positioned to do that," he says.

Leasing, Bradshaw says, will continue to be used as a financing option for the combined company's helicopter fleet, although the proportion of leased aircraft will be small, just 18% of the current fleet.

Lease rates had previously been identified as a significant factor affecting the bottom line of some operators, particularly when demand for the helicopters bottomed out. It was a situation that also hurt the lessors themselves, with Waypoint Leasing ending up in Chapter 11 in late 2018 before being taken over by Macquarie in March 2019.

"We think that with improving market conditions and rational behavior among the lessor community we can have a sustainable industry structure over the long term," says Bradshaw.

And the market is beginning to pick up again, with incremental improvements in demand and utilization rates, although dramatic improvements are not expected any time soon, if at all. "We're encouraged by the trend, but it is not a significant increase," he notes.

The merger has not been designed around significant increases in market activity, but instead an expectation that any future growth in the market will be incremental.

"The merits of it [the merger] work very well in today's environment, and in a future environment that looks more like today, so we don't need to see much of an increase to realize the benefits of the combination," says Bradshaw. The new company's priorities include completing the acquisition and optimizing the oil and gas operations for "better performance," says Bradshaw. It will then look at diversifying its operation, particularly seeking opportunities for contracted SAR, with plans to bid for the upcoming UK SAR-helicopter fleet tender expected in 2021-22.

The company will also be the launch customer for Leonardo's AW609 commercial tiltrotor. It expects to receive the first aircraft in late 2020 or early 2021, subject to FAA certification (see page 42).

"We look forward to being the launch operator of that aircraft," says Bradshaw. "We think it has the potential to be revolutionary."

The company is already eyeing two missions for the aircraft: long-range aeromedical tasks and the VIP role, both initially in the U.S. "We're going to field-test it for both missions," says Bradshaw.

"When you think about having an [AW609] stationed in lower Manhattan, you could have a real point-to-point connectivity from Washington to Boston or to Cape Cod. Similarly, if you had one in Houston, you would have very good range to Dallas, Austin and large parts of Louisiana, so we see those markets as being some of the initial test markets for the aircraft."

Tiltrotor Approaches Final Hurdles Before Commercial Service

- PROTOTYPE AC4 TOOK TO THE AIR ON DEC. 23
- AW609 PRICE TAG IS $20-30 MILLION PER AIRCRAFT

Tony Osborne Los Angeles

Could 2020 finally be the year the commercial tiltrotor enters the market?

Seventeen years after first flight of the aircraft formerly known as the Bell-Agusta BA609, now the AW609, manufacturer Leonardo seems more optimistic than ever about the timelines.

Many of the pieces are now in place. The fourth prototype, AC4, which is fully representative of production examples, flew at the end of last year, while the first two production aircraft, AC5 and AC6, are now in the early stages of final assembly at Leonardo's facility in Philadelphia, where AW609 production and training will be focused.

Furthermore, elements of an AW609 training system are also lining up: A training syllabus is in the works, with finishing touches being made by CAE on a Level D simulator in Montreal, and Leonardo has developed a Virtual Enhanced Training Device (VETD) that replicates the cockpit and systems. The VETD is seen as a "next step in the evolution of the procedural trainer," says Bill Sunick, Leonardo's senior AW609 marketing manager.

There is even growing consensus on cost, with the Pratt & Whitney Canada PT6C-67A-powered rotorcraft expected to be priced at $20-30 million—roughly that of a heavy helicopter such as a Sikorsky S-92.

"We are building confidence," Leonardo Helicopters CEO Gian Piero Cutillo told Aviation Week at Heli-Expo in January. "Test after test shows we are on the right path. It is a development program, and there are challenges ahead."

The path to certification is not entirely in the company's hands, but certifying the first aircraft to comply with the FAA's newly established Powered Lift category means Leonardo is moving hand in glove with the regulator, Cutillo notes.

The program timelines were challenged by the FAA shutdown at the beginning of 2019, and complex certification programs could still be affected by the fallout from the Boeing 737 MAX debacle. Even Bell is no longer indicating timelines for the certification of its fly-by-wire Model 525 super-medium.

The arrival of AC4 into the flight-test fleets means that for the first time there are three AW609s flying, with AC1 based in Italy and AC3 and AC4 based in Philadelphia supporting certification activities. The second prototype was lost in a fatal crash in 2015.

AC4 is the first of the aircraft with the Collins Pro Line Fusion avionics suite.

"There are some specific AW609 tiltrotor-related displays such as a nacelle position indicator symbology on the displays," Sunick says. "But any pilots familiar with that system will feel right at home, and that was the idea."

Current plans see the tiltrotor being certified with a maximum gross weight of 17,500 lb. There will then be a delta to reach the planned 18,000 lb. The initial configuration for certification will be passenger carriage, with the capability of additional missions such as search and rescue (SAR) added later.

Other changes to AC4 include the introduction of a widened main entry door, which at 35 in. (89 cm) should allow stretchers to be loaded onto the aircraft and able to turn the corner into the cabin. The door on early-model Learjet business aircraft is also split that way, with the lower section fitted to airstairs while the upper section will enable the fitment of a hoist for SAR-equipped aircraft. Plans are also in place for external fuel tanks, which will be fitted snugly against rotating nacelles. These will add an extra 900 lb. of fuel without requiring additional tankage in the cabin or baggage compartment.

Many of the changes were part of a review after Leonardo took over the program from Bell in 2011.

"We did a lot of critical thinking about where the aircraft was in its development and what new emerging systems were out there, and we essentially embarked on another development," says Sunick. "Had we been in production, I'd be calling this the B-model or AW619."

While AC4 will prove the avionics suite and production-standard modifications in 2020, AC3 will be fitted to a ramped test stand so that the engines

Leonardo's Philadelphia plant is building the first two production AW609s. The company hopes to make its first delivery this year.

LEONARDO

and nacelles can be operated throughout from the vertical to the horizontal, to support drive-system component testing as well as setting intervals for inspections and part lives. During 2019, AC3 had been involved in handling quality, aeroelastic stability and dive tests.

So far, just two AW609 customers have been formally named—U.S. oil and gas operator Era Group, which recently merged with the Bristow Group, and the United Arab Emirates Joint Aviation Command, which plans to use the aircraft for SAR missions. Beyond those official customers, Sunick remains tight-lipped, stating that interest in the machine is "robust." Work is underway to convert letters of intent into firmer agreements, with VIP and corporate customers likely to sign agreements first.

"Like with any new technology, you typically see early adoption by the VIP market," he says.

It is undecided whether AC5 will be the first aircraft delivered to Era, Sunick says, but he would like to retain a demonstrator aircraft for future customers. Providing emergency medical services appears to be a promising market, too, particularly in parts of the world with geographically remote populations—such as in the Australian outback or the Japanese island chain. Having a pressurized cabin and being able to fly over weather could be a "game changer," Sunick says, potentially paving the way for medical treatments and procedures to be performed on the aircraft. Leonardo has also been studying technologies that could allow medical procedures to be performed in flight (*AW&ST* April 8-21, 2019, p. 55).

The AW609 will also play a role in the development of future tiltrotor technologies as Leonardo plans to use an AW609 fuselage as the basis for its Clean Sky 2 Next-Generation Commercial Tiltrotor Technology Demonstrator (NGCTR-TD). Equipped with a fixed engine, tilting gearbox and a V-tail, the aircraft will also be fitted with a distributed flight control system with active inceptor controls and a new fuel system using fiber-optic fuel sensors.

The NGCTR-TD is planned to fly in 2023.

ADS-B in Europe

> ABOUT 74% OPERATOR COMPLIANCE IS EXPECTED BY JUNE

> EXEMPTIONS POLICY FOR THE NONEQUIPPED IS UNDER CONSULTATION

Thales has delivered ADS-B ground stations worldwide, including this one in France.

THALES PHOTOS

Bill Carey Washington

Months after operators in the U.S. were required to equip their aircraft for automatic dependent surveillance-broadcast (ADS-B) Out position reporting, a similar requirement enters force in Europe, but it will be less comprehensive and less evenly applied.

The EU's Surveillance Performance and Interoperability regulation takes effect on June 7, requiring that aircraft with a maximum takeoff weight exceeding 5,700 kg (12,566 lb.) or with a maximum cruise speed greater than 250 kt. be ADS-B Out-capable.

As of December 2019, 62% of EU-registered aircraft subject to the regulation—5,580 of about 9,000 aircraft—had been equipped with the necessary ED-102A standard Version 2 ADS-B Out transponders, according to Eurocontrol. The percentage of equipped aircraft is expected to increase to 74% or more by the June compliance date.

The Single European Sky ATM Research (SESAR) Deployment Manager (SDM), the Brussels-based agency responsible for coordinating technology deployments across the continent, counts 10,000-11,000 aircraft that are subject to the regulation when including EU-registered large and state aircraft and third-party foreign aircraft transiting the airspace.

A multilateration and ADS-B Ground Surveillance System ground station cabinet.

Published in 2011, the EU rule originally set an equipment compliance date of January 2015; it has been amended twice, to the 2020 date. An amending regulation that would allow older, nonequipped aircraft to retrofit ADS-B avionics by June 7, 2023, is undergoing consultation.

The SDM asked 32 air navigation service providers (ANSP)—representing 27 EU member states, Eurocontrol's Maastricht Upper Area Control Center, and the UK, Norway, Switzerland and Iceland—if they would be in a position to support aircraft separation using ADS-B as a complementary surveillance system by 2023.

Twenty ANSPs "responded positively" to the inquiry, about half with caveats that included the rate of equipage by operators. Typically, larger ANSPs have "concrete" plans to introduce the new surveillance method, says Jan Stibor, the SDM's ADS-B program manager.

"We don't anticipate rolling out sole means [ADS-B] much in Europe," says Stibor. "In high-level surveillance, we always anticipated ADS-B will cooperate together with radar or with multilateration [MLAT]. They will help each other to provide an improved, more cost-effective surveillance picture."

Overall, the SDM estimates that European states will spend €656 million ($710 million) to install the ground infrastructure for ADS-B, while aircraft operators will spend €415 million to equip their fleets.

The Indian Ocean nation of Seychelles also will require aircraft flying within its flight information region to be ADS-B capable by June 7 as countries around the world that have not already done so implement the broadcast surveillance method. Seychelles will track aircraft using a combination of ground-based stations and Aireon satellite-based receivers.

In the U.S., the FAA requires that all aircraft flying in

most controlled airspace signal their position using 1090ES Mode S transponders certified to DO-260B, the RTCA equivalent of Eurocae ED-102A. The agency's dual-frequency approach to ADS-B allows aircraft flying below 18,000 ft. to have either 1090ES transponders or Universal Access Transceivers operating at 978 MHz.

The ADS-B regulation in the U.S. affects tens of thousands of aircraft. As of Feb. 1, a month after the compliance deadline, the FAA estimated that 114,615 aircraft were properly equipped. Another 10,059 aircraft were equipped but not broadcasting correctly.

The FAA views ADS-B as its new surveillance standard, when complemented by radar and wide-area multilateration (WAM) systems that use networks of ground-based receivers to calculate aircraft positions based on Mode S transponder signals.

ADS-B enhances safety and efficiency by improving controllers' situational awareness of aircraft in the airspace, the agency contends. Its once-per-second update rate allows controllers to reduce aircraft separations to 3 nm from 5 nm in some terminal airspaces where ADS-B provides coverage beyond that of radar—a separation standard that will be applied in en route airspace starting this year in the Boston and Seattle areas.

"ADS-B is a paradigm-shifting technology that provides the foundation for the FAA's initiative to modernize our [air traffic management (ATM)] system," writes Dan Hicok, director of the FAA Surveillance Services Directorate, in the winter 2019 issue of the Journal of Air Traffic Control. "[T]he FAA has seen a correlation between increasing ADS-B equipage and a decreasing number of accidents and near-misses, demonstrating potential long-term ADS-B safety benefits."

The ADS-B broadcast surveillance method also allows the FAA to divest legacy radars that are no longer needed to provide air traffic services. The agency plans to divest 32 radar sites by 2025, David Gray, FAA deputy director for surveillance services, informed the FAA's NextGen Advisory Committee in December.

Europeans recognize all of the same benefits that ADS-B Out provides ANSPs as well as the operational efficiencies promised for airlines by ADS-B In. But the technology seemingly has less cachet in Europe, perhaps reflecting the fragmentation of needs and priorities within the EU.

ADS-B "is used as a primary means of surveillance in some isolated pockets of airspace where you don't have radar coverage or where radar coverage is not good and you need to have other means; in these cases, you would need ADS-B or multilateration," says Holger Neufeldt, Thales ADS-B product manager.

"In fact, Europe is a bit conservative in this relationship—[states] will be looking more at keeping at least one radar layer or probably dual radar layers in some areas and then adding ADS-B on top of that because they see the economic advantages in tracking," adds Neufeldt.

On Feb. 28, Eurocontrol and Aireon announced a 10-year agreement to acquire Aireon's space-based ADS-B data, which is collected from receivers hosted on Iridium Next satellites. The data will be integrated into Eurocontrol's enhanced tactical flow management system to provide more accurate flight trajectory predictions.

Safety and efficiency requirements are dictating economic considerations about the optimum timing to replace legacy radars with ADS-B, Thales says. But rationalizing the radar infrastructure where possible is prominent among drivers of the new surveillance method in Europe, with its many countries and overlapping coverage areas.

Testing conducted by German ANSP DFS, Eurocontrol and the FAA in the vicinity of Frankfurt in 2000 revealed that aircraft flying at 10,000 ft. are interrogated by as many as 40 civilian and military radars, says Neufeldt.

"Of course, ANSPs see the operating cost of radar, which is considerable, compared to the absolutely small operating cost of ADS-B ground stations," says Neufeldt. "What they are currently planning is to not upgrade some of the radar stations anymore—not to give up the site but to decommission the radar and put ADS-B on that site."

Thales has delivered 2,300 ADS-B and MLAT ground stations worldwide; it is the sole supplier of countrywide ADS-B networks in Australia, New Zealand and South Africa.

The manufacturer has delivered 340 ADS-B ground stations in Europe, but many are used primarily for MLAT and WAM surveillance systems. This includes 112 ground stations supplied by the Aquila joint venture of Thales and UK NATS for Project Marshall, the UK military's terminal ATM program.

Europe is developing a performance-based approach to surveillance that will be technology-agnostic, says Neufeldt. He expects Eurocae will publish a "Safety and Performance Requirements for a Generic Surveillance System" standard designated ED-261 within months, in coordination with Eurocontrol's new "Specification for ATM Surveillance System Performance 2.0" standard.

From the Thales perspective, "this is not a competition between radar and ADS-B," emphasizes Neufeldt. "We try to address the performance-based [requirements], to support customers in solving their surveillance problem. We can design the coverage as needed, and this might be very well a mixture of ADS-B and radar in some areas, to balance costs and benefits to get the optimum solution."

ADS-B Mandates Coming Due

Country/Region	Compliance Date
Australia (foreign-registered aircraft)	June 6, 2020
Europe	June 7, 2020
Seychelles	June 7, 2020
Saudi Arabia	Jan. 1, 2021
Mexico	Jan. 1, 2022
South Africa	June 15, 2023

Source: OpsGroup

Sean Broderick Washington

The FAA alone will determine how the Boeing 737 MAX saga reshapes U.S. aircraft certification, and agency officials will have numerous reports—not to mention probably some well-intentioned congressional mandates—for guidance. Many questions still remain a year after a second MAX fatal accident led to the fleet's grounding and triggered a series of investigations beyond the two crash probes, but work completed by accident investigators and two task forces reveal several common themes that will help shape the FAA's thinking. Topping the list: increased emphasis on human-factors principles during aircraft design, more complete risk assessments, and closing gaps in—but not necessarily overhauling—the delegation process.

AIRCRAFT CERTIFICATION

HOW THE MAX

> FAA CERTIFICATION PROCESS UNDER A MICROSCOPE > FLIGHT DECK HUMAN-FACTORS

The FAA's human-factors work has led to significant regulatory changes in the last decade, and more change was on the way even before the crash of Lion Air Flight 610 (JT610), the first of the two fatal MAX accidents in five months that led to the fleet's global grounding. But the Joint Authorities Technical Review (JATR), the task force representing 10 global regulators that looked into elements of the MAX's certification, concluded that the agency is not going far enough.

"Based on the JATR team's observations and findings related to human factors-related issues in the certification process, JATR team members recommend that the FAA integrate and emphasize human factors and human system integration throughout its certification process," the group's report says.

Considering the FAA's recognition of how critical the man-machine interface has become as flight deck technology evolves, the agency's shortcomings are puzzling. Prompted by a series of accidents in the early 1990s and related NTSB recommendations, the FAA launched an extensive, multi-stakeholder study to examine flight deck human factors.

The study's original charter focused on flight-crew systems interaction, but "we quickly recognized that considering only the interface would be insufficient to address all of the relevant safety concerns," the study team wrote in its 1996 report, "The Interfaces Between Flightcrews and Modern Flight Deck Systems." The team analyzed contributing factors including design, training, and the regulatory process. Among the many issues it found: a lack of human-factors expertise in aircraft certification and training development.

"Designers, pilots, operators, regulators, and researchers do not always possess adequate knowledge and skills in certain areas related to human performance," the team wrote. "It is of great concern to this team that investments in necessary levels of human expertise are being reduced in response to economic pressures when two-thirds to three-quarters of all accidents have flight crew error cited as a major factor."

The study led to substantive change. A formal FAA human-factors working group was formed and produced a 2004 report that helped shape updates to the FAA's aircraft certification regulations. Among them: FAA Part 25.1302 (Installed Systems and Equipment for Use by the Flightcrew), 25.1309 (Equipment, Systems, and Installations) and 25.1322 (Flightcrew Alerting).

But the new regulations and related guidance did not change some key industry tenets such as assumptions about how quickly pilots would react to certain inflight scenarios. Boeing's reliance on such assumptions—specifically that a crew would identify and react to a runaway stabilizer within 4 sec.—combined with questionable system-design decisions and the FAA's lack of objections helped set the stage for both MAX accidents. As a result, while Boeing works to finalize mandated changes and get the MAX flying again, the agency is being urged to bolster its human-factors expertise and develop better analytical tools.

"While issues in human-machine interaction are at the core of all re-

cent aviation accidents and are implicated in the two B737 MAX accidents, the FAA has very few human factors and human-system integration experts on its certification staff," the JATR says. "The FAA should expand its aircraft certification resources in human factors and in human-system integration to enable the thorough analysis and verification of compliance" with the regulations.

The NTSB, in recommendations made last September, calls for more focused human-factors efforts. The board wants the FAA to "develop robust tools and methods, with the input of industry and human-factors experts, for use in validating assumptions about pilot recognition and response to safety-

has an effect on all related systems and, in theory, their safety assessments. In the MAX's case, Boeing did not update some safety assessment elements, including the MCAS' SSA, even after significant changes.

The MCAS moves the horizontal stabilizer during certain non-normal, flaps-up, high-angle-of-attack (AOA) flight profiles to increase force on the pilots' yokes and provide a reduced pitch-up tendency. Originally designed to operate in high-speed scenarios, such as wind-up turns, Boeing determined in 2016 that the MCAS needed to address some low-speed scenarios. But the manufacturer,

ly assess aircraft safety and influence the aircraft/system design details."

Among the Transportation Department committee's recommendations: a call for SSAs to "better consider human–machine interaction" and be more closely aligned with real-world environments. "Test and evaluation should include multiple failure mode scenarios and involve trained pilots who reflect the anticipated end users of the product. Resulting data should be fed back into the overall safety assessment of the total system. Significant changes to safety assumptions or performance levels should be tracked," the committee says.

Investigations of the 737 MAX's certification have spotlighted deficiencies in how the FAA works and how Boeing served in a role on behalf of the regulator.

CHANGES THINGS

SHORTCOMINGS FLAGGED > COMPANIES, NOT REGULATORS, "ULTIMATELY ACCOUNTABLE"

significant failure conditions as part of the design certification process."

Another likely outcome from the MAX saga: changes to the safety assessment process. Manufacturers are required to demonstrate that their designs comply with the FAA's regulations. Most opt for using a complex SAE International-standard procedure, outlined in FAA Advisory Circular 25.1309-1A, that includes a functional hazard assessment, preliminary system safety assessment, and system safety assessment (SSA). The outcomes provide manufacturers airplane- and system-level looks at the risks presented by individual failures and combinations of problems.

Any change to a system—such as Boeing adding the Maneuvering Characteristics Augmentation System (MCAS) flight control software to the 737 family's speed-trim system—

believing the high-speed scenarios were more risky, did not update the MCAS SSA after the low-speed addition was made.

"The SSA and functional hazard assessment (FHA) were not consistently updated, and potential crew workload effects resulting from MCAS design changes were not identified," the JATR says.

Both the JATR and the Transportation Department special committee urged significant changes.

"The safety analysis process should be integrated with the aircraft development assurance process to ensure all safety requirements and associated assumptions are correct, complete and verified," the JATR says. "The FAA should encourage applicants to have a system safety function that is independent from the design organization, with the authority to impartial-

The NTSB urged the FAA to review SSAs that assume "immediate and appropriate pilot corrective actions in response to uncommanded flight control inputs" and factor in possible effects from alerts and warnings that could delay pilots' responses. The U.S. should collaborate with certification experts at the European Union Aviation Safety Agency (EASA), Transport Canada, the National Civil Aviation Agency of Brazil, the Civil Aviation Administration of China and the Russian Federal Air Transport Agency to ensure the global fleet is covered.

Regulators working under bilateral agreements rely on each other's work to maximize resources and minimize duplicative efforts on projects such as certifying a new aircraft. Global regulators are already demanding more from the FAA as a result of the MAX's certification failings, with some

conducting independent reviews on aspects of Boeing's proposed flight control computer software and training changes. It is a sign that the FAA's findings, once accepted as ironclad, will now be more carefully scrutinized.

"Right now, there are things we don't look at at all, [but] there are things that we want to be involved in," EASA Executive Director Patrick Ky told Aviation Week last November (*AW&ST* Nov. 11-24, 2019, p. 26). "I think in the future there will be a gray area of issues in which we want to be involved but not as fully as if we were the certifying authority. We need to discuss this with the FAA but also with the Canadians and the Brazilians," who, together with the U.S. and Europe, comprise the industry's four major aircraft certification entities.

JOE WALKER

Major changes to the FAA's certification standards likely will take years to finalize, but differences in how foreign regulators assess the U.S. agency's work will come more quickly.

More international perspective is expected to come via the final report on Ethiopian Airlines Flight 302, which crashed in March 2019 and triggered the global MAX grounding within days. A preliminary report from Ethiopia's Aircraft Accident Investigation Bureau pointed to an MCAS-related malfunction as a key factor in the accident; Indonesia's National Transportation Safety Committee reached a similar conclusion in its JT610 final report (*AW&ST* Nov. 11-24, 2019, p. 24). The most-watched area of the FAA's certification evolution is likely to be its Organization Designation Authorization (ODA) program, which designates qualified individuals to act on the FAA's behalf. It also could be the most difficult to change.

Designees have been used for decades and are recognized as an increasingly essential resource.

"With strict FAA oversight, delegation extends the rigor of the FAA certification process to other recognized professionals, thereby multiplying the technical expertise focused on assuring an aircraft meets FAA standards," the Transportation Department committee says.

The JATR concurred but also pointed to fissures in the process that the MAX crisis has helped expose.

"[In] the B737 MAX program, the FAA had inadequate awareness of the MCAS function, which—coupled with limited involvement—resulted in an inability of the FAA to provide an independent assessment of the adequacy of the Boeing-proposed certification activities associated with MCAS," the JATR says.

Both reports recommend changes to ODA, including ensuring that the FAA has "increased direct . . . involvement in safety-critical areas of ODA certification projects," the JATR says. "Direct involvement may include the FAA retaining approvals, conducting real-time oversight or implementing other procedures." Both the Transportation Department committee and the JATR also cited a need for more consistent information flow from designees to FAA experts.

Congress has more sweeping changes in mind. Driven by the perception that a system in which companies have significant involvement in approving their own products is flawed, and emboldened by the MAX disasters, lawmakers are targeting delegation as ripe for reform.

"The authorized representative, under the current system, is supposed to represent the public safety interest and the FAA, and clearly, in [the MAX's] case, they did not," says U.S. Rep. Pete DeFazio (D-Ore.), chair of the House Committee on Transportation and Infrastructure that is investigating Boeing and the FAA. "So the system is broken, and I'm determined that we're going to fix that system. We will not rest until we have enacted legislation to prevent future unairworthy airplanes from slipping through the regulatory cracks and into airline service."

Legislation may change the FAA, but delegation's success relies far more on industry than the agency. A 1984 U.S. Supreme Court decision codified what many in aviation have long understood: In the U.S., the FAA's role is to verify compliance with its rules, not ensure it.

"The FAA certification process is founded upon a relatively simple notion: The duty to ensure that an aircraft conforms to FAA safety regulations lies with the manufacturer and operator, while the FAA retains the responsibility for policing compliance," the court wrote in United States v. Varig Airlines. "Thus, the manufacturer is required to develop the plans and specifications and perform the inspections and tests necessary to establish that an aircraft design comports with the applicable regulations; the FAA then reviews the data for conformity purposes by conducting a 'spot check' of the manufacturer's work."

Changes at the FAA such as adding staff—its Aircraft Certification Service employs 1,300 people, fewer than Boeing has in its ODA unit—and limiting delegation are possible. But no new law or FAA initiative can replace industry's role in determining delegation's effectiveness.

"Delegation must survive," says consultant Mike Borfitz, a former Boeing flight-test engineer and FAA aircraft certification office manager. "It has to be driven home to all companies that they are ultimately the ones who are accountable."

Check 6 *Aviation Week editors discuss whether the FAA certification process is broken:* **AviationWeek.com/podcast**

Airbus Canada Prepares More A220 Integration and Cost Savings

> SUBASSEMBLY PRODUCTION WILL MOVE TO MIRABEL

> MORE ORDERS ARE NEEDED TO SUSTAIN RAMP-UP

Jens Flottau Frankfurt

From Bombardier's perspective, the company's complete exit from the former C Series program bought it time to sell off its rail division and ultimately relaunch as a business aviation specialist. For Airbus, being the only industrial shareholder in the A220 opens up more opportunities to drive down costs and integrate production.

"The biggest change is the move of aerostructural work from Saint-Laurent to Mirabel, [Quebec]," says Airbus Canada CEO Philippe Balducchi. "Our dream of a mini-Toulouse is coming true."

Airbus and the government of Quebec agreed Feb. 13 to acquire Bombardier's stake in the A220. The OEM paid $591 million and also released Bombardier from future funding requirements for Airbus Canada, which it had agreed on when the partnership was set up two years ago. "Bombardier has always been a good shareholder, but the shareholding was unbalanced because of its financial situation," Balducchi says. Its departure "simplifies the structure and makes my life a bit easier."

As part of the deal, Airbus subsidiary Stelia Aerospace bought the A220 cockpit and rear fuselage production from Bombardier. The cockpit and fuselage production is currently based in Saint-Laurent, Quebec. After a period of around three years, the work will be transferred to the Mirabel site north of Montreal, where the A220 final assembly line is situated. Stelia already has a facility at Mirabel, but it will build another hangar adjacent to its current base for the work.

"That is very good news for us," Balducchi says. "Aerostructures is Stelia's core business. They are the ideal supplier to us because they know the Airbus way of doing things as a part of the group." A330 work packages are also included in the transaction.

Consolidating Canadian production at Mirabel is the first element of Airbus' transition plan. The second one has to do with the aircraft itself. "What changes can we make on the aircraft to save costs?" asks Balducchi. Airbus is at the beginning of a process of design to cost, already an important element in other programs, now about to be exported to the A220.

Also, Airbus has already been able to cut supplier costs by a double-digit percentage, according to Balducchi, but it needs to continue with another double-digit reduction to reach its savings target of around 20%—cited when it initially took over the program. "A number of discussions have been concluded with suppliers," Balducchi says. "The visibility in the program is now better."

Production ramp-up is the other key target. Since the takeover in 2017, Airbus has tripled A220 output to 48 aircraft in 2019. It plans to triple deliveries again by the middle of the decade, while not giving precise time frames or unit numbers. However, in the short term, the ramp-up is not steep and will also not be accelerated as a result of the Bombardier exit. In 2020, Airbus plans to deliver 55 A220s, among them the first handful of aircraft from the Mobile, Alabama, final assembly line.

Mirabel has a capacity of 10 aircraft per month, while Mobile can build four per month once the site is up and running at full capacity. Delta Air Lines will be the first carrier to receive an A220 from Mobile this summer, and several more aircraft will be delivered from the U.S. facility by year-end. Mirabel production will remain "more or less stable," Balducchi says.

The first six Mobile-built A220s will be assembled in the A320neo hangar. Production will then move to a dedicated facility that is under construction.

Balducchi says the priorities are to get to single-aisle reliability, and stabilize the supply chain and Airbus' own production while getting to the maximum output of 14 aircraft per month as soon as possible. "We also still need to get more orders," he says.

Since the entry of Airbus, the A220 program has received major commitments, including from Air France (60), Air Lease Corp. (50), Delta (95), JetBlue Airways (70) and Breeze Airways (70).

AIRBUS

Air Canada became the latest operator of the Airbus A220-300 in January. The airline has ordered 45 of the aircraft.

Proposed 'Remote ID' Rule Rattles Drone Community

> BROADCAST AND NETWORK METHODS ARE PROPOSED

> HOBBYISTS AND BUSINESS USERS FACE REGULATION

Bill Carey Washington

Upward of 10 times more respondents have commented on the FAA's draft rule for remote identification of drones compared to the number of individuals and organizations that weighed in on its proposed regulation for commercial unmanned aircraft systems (UAS) in 2015.

The public comment period for the so-called "Remote ID" notice of proposed rulemaking (NPRM) closed March 2 with around 53,000 responses counted by the regulations.gov website. When comments closed in April 2015 for the FAA's Part 107 draft rule governing the commercial use of drones weighing less than 55 lb., there were 4,597 responses.

The differentiator this time is that the FAA has floated a rule that would apply to the vast majority of small drones flown in U.S. airspace, both commercial and recreational. At latest count, the agency reports that 1.1 million hobbyists have registered online to fly drones for recreation. There are 436,836 registered commercial UAS.

Thousands of comments on the Remote ID draft rulemaking are thought to be "copy-and-paste" responses based on templates from organizations including the Academy of Model Aeronautics (AMA) and the MultiGP Drone Racing League, which urged their members to weigh in.

In the past, Congress prevented the FAA from regulating drones and model aircraft flown for recreation. But the FAA reauthorization bill President Donald Trump signed into law in October 2018 repealed that protection and extended remote ID requirements to hobby aircraft—a response to concerns advanced by federal security agencies.

The Remote ID draft rule describes a framework for identifying small drones and model aircraft in flight by requiring them to transmit a serial number or alphanumeric code as well as positional data to the ground.

Under the proposed rule, a "standard" category drone must be capable of connecting to the internet and transmitting data to a Remote ID UAS Service Supplier (USS), in addition to broadcasting its identity directly from the aircraft to receiving devices on the ground. A "limited" category drone would only be required to connect to the internet but would be restricted to operating no more than 400 ft. from its control station.

BILL CAREY/AW&ST

"Help Save Our Hobby" activists gathered at FAA headquarters in Washington.

Persons operating drones that are not equipped for remote identification, such as amateur-built aircraft, would have to do so within visual line of sight at an FAA-recognized site established by a community organization.

Complaints over the NPRM center on its requirement that standard-category drones be capable of both network and broadcast means of transmitting identity, the costs associated with a cellular data plan and subscribing to a USS, the limitation of operating within 400 ft. of a control station and relegating nonequipped drones to FAA-recognized flying fields. Sharing information with a Remote ID USS on a network also raises privacy issues, critics say.

Avid hobbyists view the Remote ID draft rule as an existential threat. Activists with the "Help Save Our Hobby" campaign gathered Feb. 28-29 at FAA headquarters to protest the NPRM before the comment period closed. They described themselves as belonging to a "skateboard culture" of do-it-yourself drone builders, first-person view (FPV) enthusiasts who pilot their aircraft using goggles or video monitors and small business owners in the field.

One protester was Tyler Brennan, owner of RaceDayQuads (RDQ), of Orlando, Florida, an FPV racing supply shop that employs 25 people and sells prebuilt drones and components such as frames, motors, batteries and props. It would be severely affected by the Remote ID rule as proposed, he predicts.

"I would say almost certainly RDQ would go out of business" if the rule becomes final, Brennan says. "Then it would be just a trickle-down [effect] to the whole industry—most of the manufacturing is in China, and 70% of their business is in the United States. So, it will effectively destroy the hobby."

Protesters say drones are prohibited at some AMA fields, which negates the option of flying nonequipped aircraft there. In its comments to the FAA, the 180,000-member academy proposes that a distinction be made in the rule between traditional model aircraft and "advanced UAS" that can be flown beyond visual line of sight.

"The AMA—I'll say it: They've failed us," says Troy Naquin, CEO of Quad Standard Labs of Austin, Texas. "Some of them honestly are just afraid of [drones]: They spend thousands of hours on some of these replica planes that cost thousands of dollars. The last thing they want is for some guy to come out of nowhere and not pay attention to the field rules."

Meet Howmet Aerospace, a New Megasupplier to A&D

- FROM THE ASHES OF ALCOA SPINOFF ARCONIC RISES HOWMET AEROSPACE
- THE A&D-CENTRIC HALF OF CARVED-UP ARCONIC WILL BE LED BY THE SAME CEO

Michael Bruno Washington

One of the storied names of 20th century aerospace and defense (A&D) suppliers is set to make a dramatic comeback around April 1, and with it could come a new era of price increases for OEMs and better technology as industry seeks more sustainable approaches.

As soon as next month, Arconic—itself born just a few years ago as a spinoff from Alcoa—will divide into two public companies, both with A&D-related work but with far more of it based in Howmet Aerospace. The Howmet brand harks back to Howmet Castings, which Alcoa bought in 2000.

Howmet will be what Arconic was, including a forgings and castings company, but without its Global Rolled Products aluminum sheet and plate division.

While the names are changing, many faces will remain the same for A&D customers. Arconic Inc. Chairman and CEO John Plant will keep the reins of the new aerospace-focused Howmet Aerospace, becoming executive chairman of the critical supplier and co-CEO alongside Tolga Oal.

ARCONIC

Arconic designed a 3D-printed aerospace bracket that helps take weight out of aircraft.

As a result, Howmet's business approach is expected to focus on lean manufacturing, stricter contracting with industry customers and price increases. Technologically, the company plans to leverage its intellectual property and research abilities to provide high-temperature-tolerant materials for aero engines as well as ways of making aircraft lighter and more fuel-efficient as commercial aviation seeks to ward off climate-change criticism.

Plant kept his intentions quiet until the Feb. 25 announcement. When he appeared at a Cowen investor conference Feb. 12 and again at a Barclays conference Feb. 19, he sidestepped questions about where his future lay. Still, he expounded on what characteristics he was looking for in leaders.

"It all comes down to . . . focusing on our commercial arrangements, and with that goes price," he continued. "Also, all the aspects of cost management, [starting] from [looking at] our corporate costs. And I think there's still a little bit of amazement that we can operate two future public companies with lower corporate costs than has been the current Arconic Inc. cost."

Plant talked about his management approach of narrowing focus. When he moved from the boardroom to the corner office at Arconic a year ago—firing then-CEO Chip Blankenship—he told company managers that they needed to focus on no more than five goals—and then articulated a "very long list" of things on which they will not concentrate.

"It comes from a belief that great companies and improving companies largely define their success by the things that they are clearly not going to do and to focus on those things that really matter," Plant said.

Plant listed three tenets for the new Howmet: to outpace the rate of growth in aircraft manufacturing, to do so with top-quartile operating margins and to provide shareholders a free-cash-flow conversion rate of at least 90% of the company's net income. He further promised a "disciplined capital allocation strategy."

Howmet will count four business segments: engine products, which achieved $3.3 billion in 2019 revenue; fastening systems, $1.5 billion; engineered structures, $1.3 billion; and a $1 billion forged-wheels unit that also supplies the automotive industry. Howmet formally is targeting almost $7 billion in 2020 revenue.

Analysts at JP Morgan were cautiously optimistic Howmet could reach that target, but they noted several headwinds, including what Plant acknowledged was a $400 million cost due to the Boeing 737 MAX halt as well as that OEM's declining widebody production rates. The analysts further noted that about 20% of Howmet's aerospace sales derive from the aftermarket, and that sector is only beginning to figure out how the COVID-19 crisis will damp repair work with fewer airliners flying.

As Howmet becomes a standalone business, it will compete with peers including Allegheny Technologies, Meggitt, MTU Aero Engines, RBC Bearings, Rolls-Royce, Safran and the pending merger of Woodward and Hexcel. But Howmet will look to apply its high-technology materials know-how across A&D, executives told a Feb. 25 investor briefing.

For instance, Howmet will be the sole provider of the highest-temperature sections of the Pratt & Whitney F135 engine for the Lockheed Martin F-35 Joint Strike Fighter. The fighter's engine runs at about 3,600F, while a CFM International engine for a Boeing 737 will operate at around 2,500F. With commercial aerospace looking to boost efficiency in part to become more sustainable, however, next-generation engines are expected to have to operate at a higher temperature. So Howmet will look to flow its high-temperature technology from military into commercial engines.

Plant will remain in his roles at least through March 2023, a move many analysts find reassuring. "Plant's decision to remain CEO for three years is a plus, given his great track record, and should temper concerns that recent cost/cash initiatives may have been made for short-term incentives at the cost of the firm's long-term standing," Cowen analysts say.

While Howmet Aerospace will become a name again in industry, the Arconic brand will not exit the sector. Arconic's Global Rolled Products segment produces polished fuselage sheet and wing skins, according to Fitch credit analysts, while its aluminum extrusions predominantly supply both Airbus and Boeing. It also makes all the metallic wings for Boeing's commercial aircraft.

FAST 5

Maxar's Dan Jablonsky

MAXAR TECHNOLOGIES

Dan Jablonsky is president and CEO of Maxar Technologies, based in Westminster, Colorado, which delivers satellites, robotics, Earth imagery, geospatial data, and analytics to customers including the Pentagon and intelligence community. After roughly one year into the job, *Aviation Week* interviewed Jablonsky in Mountain View, California.

When do you expect the Missile Defense Agency (MDA) deal to close? The markets have responded well to news of the sale, but how does this help your business going forward? It will close pending regulatory approval, which we expect to happen sometime in the first half of this year. We'll provide more details as soon as we know what the agencies are thinking about the applications that have been submitted.

When I took over as CEO in January of last year, we did a full strategic review of what were sort of the biggest opportunities for us and what were the best customers we had. We also had a challenge with the financial situation of the company at the time. Part of the strategy became to make sure we deliver and move our bond maturities out and start paying them down fast. With the MDA deal, we're able to pay down our bonds faster, which saves us a lot of interest payments. And the cash generation from MDA versus the amount of interest we were paying is almost, but not quite, a wash.

It makes our business simpler and allows us to focus more, very critically, on the places we're best.

How was it to win a trio of awards at the beginning of 2020? If you notice, one of the ones we announced was for a commercial [geostationary] communication satellite. We're the world leader in that type of technology. Other things that we announced were for robotics programs, and we're the world leader in robotics in space as well.

Those are very much on par with our strategic objectives and where we can be best in place in the market for customers. We've been doing very well across the defense and intelligence establishment of the U.S. and other nations. We announced the Netherlands SecureWatch contract. And that's a fairly material contract for providing online access to analytics and imagery services, so data and analytics in an online format.

How does the development of the WorldView Legion satellite constellation allow Maxar to remain competitive in a dynamic market for high-resolution imagery? We're the world leader. The fun thing about it is it will triple the 30-cm [12-in.] capacity [and] sub-30-cm capacity we have in orbit. We'll be able to hit places on the planet over 15 times a day with current and future constellations. So that amount of data opens up entirely new use cases for analytics, machine learning and artificial intelligence algorithms, and 3D modeling.

For example, if you want to do a 3D model of Kabul, [Afghanistan], overnight, we can do it with accurate 30-cm satellite imagery, in a 24-hr. time frame. Nobody in the world can do that today.

If you're trying to track change detection, object detection, feature extraction, land use, land cover, things that are really hard to find and unpredictable [such as] mobile missile launchers, this suddenly gets easier and more accurate.

What services can Maxar offer the Pentagon's Space Development Agency? Any of the space-related agencies can be customers, and it depends on what it is they're trying to accomplish at that time. If they're trying for some emerging technology, we're definitely very happy to play in that space, like a DARPA or any type of robotics program. But the Space Development Agency and others are very interesting as well. Our job is to do the stuff we do really well—really fast-moving commercially innovative technologies and developments at good price points. And when the government decides it wants to work with us, we're happy to put proposals in.

What opportunities does Maxar envision to grow its space services business? We'll continue in [California in] Palo Alto, Pasadena and San Jose. We have very robust capabilities—world-leading robotics in Pasadena, world-leading space manufacturing design development for power propulsion and communications in Palo Alto/San Jose—and we're going to stay pretty close to home in those areas. I'd like to start with [knowing] who we are. We know what we're really good at, and the R&D investments we're making are along the lines of that type of infrastructure. On the edges of that there are really cool technology developments happening. [For example,] we're a world leader in solar electric propulsion. If you're moving things between vast distances in space, solar electric propulsion is the most efficient way to do it.

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> U.S. COMPANIES WANT TO FLY 58,000 SPACECRAFT BY 2030

> BETTER TRACKING NEEDED TO MANAGE SPACE TRAFFIC

Irene Klotz Washington

The way OneWeb founder Greg Wyler sees it, collisions in the increasingly crowded beltways circling low Earth orbit (LEO) are only a matter of time, but that is not stopping his company from staking a claim in the nascent industry of broadband small satellite communications.

"It's going to happen," says Wyler. "Launch is getting cheaper. Satellites are getting cheaper, and that means more satellites. More satellites means there are going to be more collisions. To me, it feels like we're now in the moment before an accident, when everything is going in slow motion."

Crashes in orbit have happened before. On Feb. 10, 2009, the decommissioned Russian military satellite Cosmos 2251 and the active Iridium 33 communications spacecraft smashed into one another 490 mi. above Siberia, adding more than 2,000 pieces of large debris fragments to the growing swarm of objects circling Earth.

Ground-based radar systems are tracking more than 23,000 objects in Earth orbit larger than 4 in. (10 cm) in diameter. Only about 2,200 of those objects are active satellites. NASA estimates the population of particles between 0.4-4 in. is approximately 500,000. The number of particles larger than 0.04 in. exceeds 100 million.

Like the Cosmos-Iridium crash, most of the debris is unintentional, caused by exploding spent rocket bodies, breakups of defunct and failed satellites and upper-stage motors discarded after dispatching their spacecraft into operational orbits.

Thousands more pieces of debris were created by two intentional impacts: China in 2007 and India in 2019 each destroyed one of their own satellites to test weapons systems. (The U.S. in 2008 destroyed one of its own relic satellites, though the impact, which took place at a much lower altitude than China's 2007 strike, was characterized not as a military exercise but to eliminate the chance that the spacecraft, which contained a full tank of hydrazine fuel, would make an uncontrolled reentry over a populated area.)

Increasingly, satellite operators receive conjunction warnings, though the data from currently available space situational awareness systems often does not provide enough detail for flight teams to decide if, when and where to move their spacecraft—if they are maneuverable.

A near-collision happened in January when two defunct U.S. satellites—the Infrared Astronomical Satellite and the Gravity Gradient Stabilization Experiment 4—initially had a 1-in-100 chance of colliding 560 mi. (900 km) over Pittsburgh at 6:39 p.m. EST on Jan. 29, according to California-based LeoLabs, which issued a notice on Twitter three days beforehand.

LeoLabs, which operates its own network of ground-based tracking radars to catalog space objects, later revised the probability of impact to 1-in-1,000. The dead satellites ended up passing about 60 ft. from each other without incident. If they had crashed, computer simulations show an additional 12,000 pieces of space debris could have been created, says Daniel Oltrogge, founder and administrator of the Space Safety Coalition.

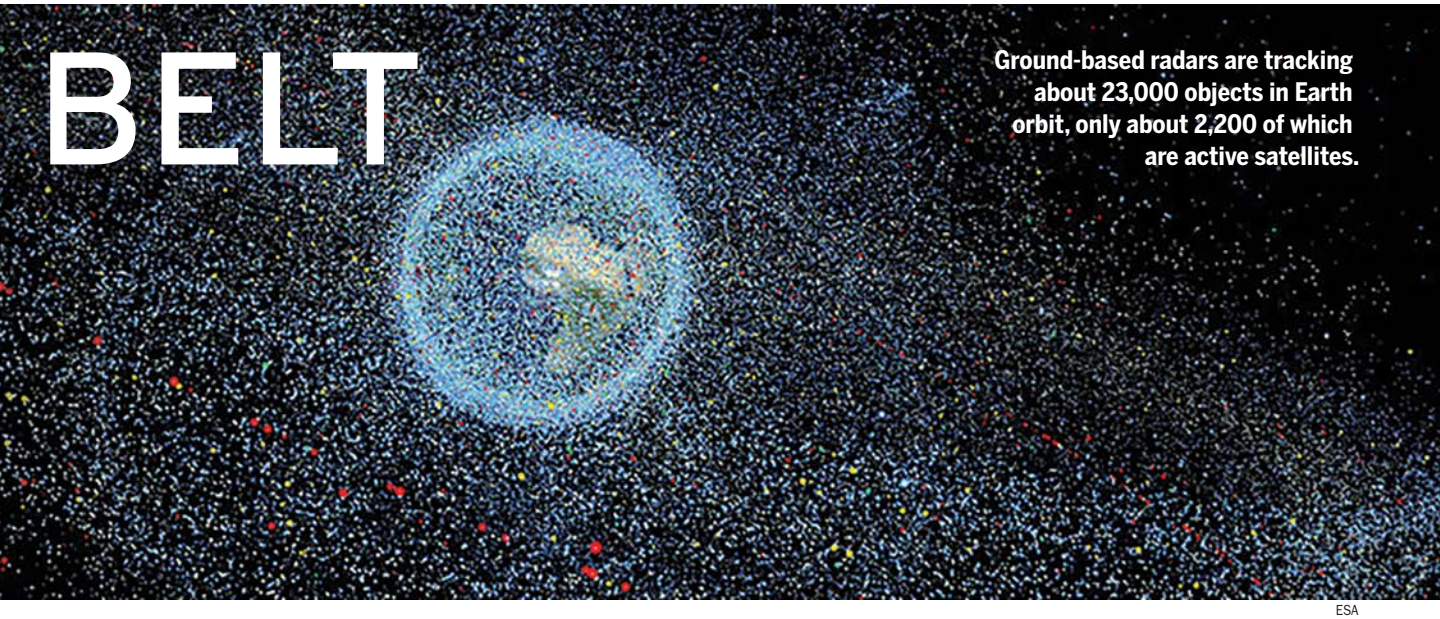
Lucky breaks will likely become more elusive. The same day that the derelict U.S. satellites crossed paths, SpaceX launched 60 more Starlink satellites into orbit, bolstering a network in LEO that could reach more than 1,000 by the end of the year.

In total, SpaceX plans to operate nearly 12,000 satellites in three orbital shells, with the constellation possibly growing to 42,000 spacecraft. Starlink has been cleared for operations in the U.S., with approximately 1,600 satellites in orbits 340 mi. above Earth, approximately 2,800 at 710 mi. and approximately 7,500 at 210 mi. SpaceX is aiming to begin offering broadband internet service in the northern U.S. and Canada this year and to roll out global coverage in 2021, says SpaceX President and Chief Operating Officer Gwynne Shotwell.

They are not alone. A week after SpaceX's Jan. 29 Starlink launch, 34 OneWeb satellites reached orbit, joining six launched in February 2019. OneWeb plans to fly batches of 32-36 satellites monthly through 2021 to build an initial network of 648 spacecraft. Other companies designing or proposing LEO satellite constellations include Canada-based Telesat, Boeing, Amazon, Kepler Communications, Theia Satellite Network, LeoSat and Audacy, among others.

Not all will come to fruition, but predictions of 20,000 new satellites making their way into orbit over the next 10 years may not be far off the mark. Amazon's planned Kuiper constellation alone includes 3,236 satellites in low Earth orbit, with 784 at an altitude of 367 mi., 1,296 at 379 mi., and 1,156 at 391 mi., filings with the Federal Communications Commission and International Telecommunication Union show.

In just the U.S., companies have filed applications to operate 58,000 new spacecraft in the next 10 years—15 times more than any other country and eight times more than all other countries combined, says Oltrogge.

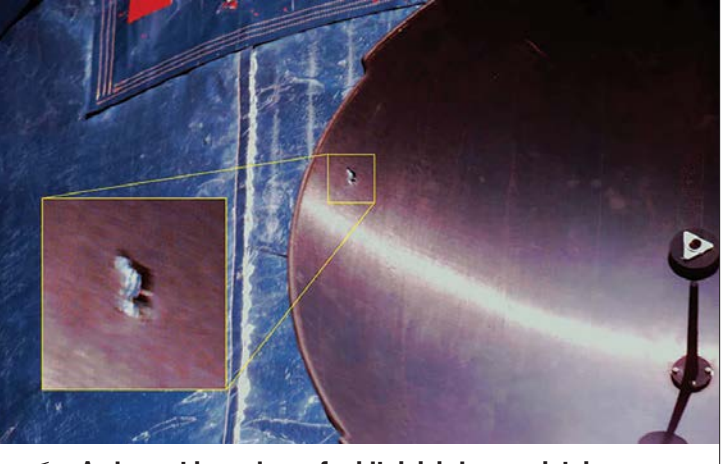


Ground-based radars are tracking about 23,000 objects in Earth orbit, only about 2,200 of which are active satellites.

ESA

"The U.S. is all in on the bow wave of large constellation initiatives, an investment that will lead to socioeconomic and technological progress in agriculture, banking, navigation, communications and Earth remote sensing, so we must ensure the sustainability of space as a vital resource," he says.

The U.S. and other governments are working to create a regulatory environment conducive to the new business ventures while keeping mindful of the potential consequences to economic, national security and human ventures in LEO should the debris environment worsen. If the debris count continues to climb, eventually an irreversible cascade of crashes could occur, posing a threat to satellites.



NASA

An impact by a piece of orbital debris completely penetrated the antenna dish of the Hubble Space Telescope, as recorded by the STS-82 shuttle crew during their 1997 servicing mission.

The Kessler Syndrome, named after former NASA scientist Donald Kessler who is credited with the concept, posits that there will be a critical point when the density of orbital debris leads to random collisions among other pieces of debris. Those crashes, in turn, will generate more litter at a faster rate than the amount of debris falling out of orbit due to Earth's atmospheric drag.

"There is now general consensus among scientists that this critical point has come to pass, and there is enough human-generated orbital debris concentrated in the critical region in LEO, 430-560 mi., to create more debris even if no new satellites were launched," Brian Weeden, director of program planning for the Secure World Foundation, wrote in testimony presented during a Feb. 11 House subcommittee hearing on space and aeronautics.

"Computer simulations conducted by six different space agencies predict that this critical region [LEO] will see additional catastrophic collisions similar to Iridium-Cosmos every 5-9 years," Weeden notes.

Better data is needed to improve understanding of the crowded LEO environment, adds U.S. Rep. Brian Babin (R-Texas). During the hearing, Babin echoed the White House's call for the Commerce Department to take over the role of space traffic management from the Defense Department. That proposal has not passed Congress.

"Orbital debris presents a growing threat to space operations. Debris mitigation guidelines, standards, and policies should be revised periodically, enforced domestically and adopted internationally to mitigate the operational effects of orbital debris," President Donald Trump's June 2018 Space Policy Directive-3 reads.

In addition to updating the country's orbital debris mitigation policy, protocols are needed for the operation of large satellite constellations, rendezvous and proximity operations, small satellites and other classes of space operations, the directive notes.

Since 1988, the official policy of the U.S. has been to minimize the creation of new orbital debris, including removing defunct satellites from operational orbits, either by lowering their altitude so they can be dragged back into the atmosphere or by raising the altitude into nonoperational, stable graveyard orbits.

"The many benefits we derive from space, and the welfare of our astronauts, spacecraft and commercial space industry, are all on the line," says Oltrogge. "Today's U.S. flight-safety capabilities are insufficient: They produce too many false alarms to be considered decision-quality, and the vast majority of lethal objects remain untracked.

"We've been lucky so far," adds Oltrogge. "But the clock is ticking."

Astronomers Sound Alarm Over SpaceX Starlinks

VICTORIA GIRGIS/LOWELL OBSERVATORY

The diagonal lines in this image of the NGC 5353/4 galaxy group are trails of reflected light left by more than 25 of the 60 SpaceX Starlink satellites as they passed through a Lowell Observatory telescope's field of view on May 25, 2019. SpaceX is testing darkening coatings to cut the satellites' reflectivity.

- CONCERNS LOOM ABOUT UPCOMING FULL-SKY SURVEY
- SPACEX NETWORK IS JUST THE BEGINNING

Irene Klotz Cape Canaveral

After the first batch of SpaceX Starlink satellites reached orbit, astronomers soon spotted a glinting, star-like string of pearls draping across the twilight sky as sunlight bounced off the spacecraft train circling 273 mi. (434 km) above Earth.

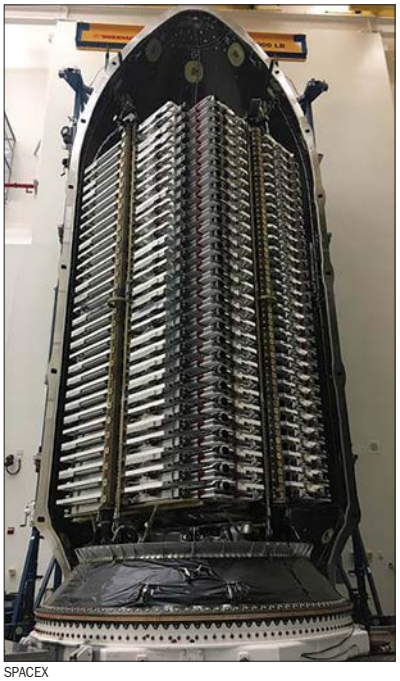
The novelty quickly wore thin. Even after the satellites maneuvered 70 mi. higher to their operational orbits, the bright reflections interrupted scientific studies. Six months later, when the network doubled to 120 satellites, astronomers grew more vocal.

"I am in shock!" Clara Martinez-Vazquez, an astronomer with the Cerro Tololo Inter-American Observatory in Chile, wrote on Twitter. "The huge amount of Starlink satellites crossed our skies tonight. Our [dark energy camera] exposure was heavily affected by 19 of them. The train of Starlink satellites lasted for over 5 min. Rather depressing. This is not cool."

By the time SpaceX launched a third batch of 60 Starlinks in January, one of them had been coated with an undisclosed darkening treatment in an attempt to reduce its albedo. More tests are planned.

So far, SpaceX has launched 300 Starlink satellites into orbit, with more than 700 heading to the launchpad before the end of the year. The company could end up flying more than 42,000 spacecraft to provide global high-speed, low-latency internet services.

Meanwhile, astronomers are still waiting—and hoping—SpaceX will make good on its pledge to cut its satellites' brightness.



SPACEX

Starlink satellites were loaded into the payload fairing ahead of the first launch of 60 spacecraft in May 2019.

A video taken at astronomical twilight on Feb. 23 shows that the dark-coated satellite, nicknamed DarkSat, remains among the brightest Starlinks, says Thierry Legault, an astrophotographer based outside Paris. "We are still waiting for effective albedo reduction measures, and in the meantime the launches continue."

At their final 342-mi.-high altitude, Legault says the brightest satellites are reaching a magnitude of 2.5, which is about as bright as some stars in the Big Dipper constellation. Most of the Starlinks are more like magnitude 4-6, which is much fainter but still visible to the naked eye.

The American Astronomical Society (AAS) is working with SpaceX to come up with a solution. Without mitigation, studies show the bright streaks from passing Starlink satellites could affect about one-third of the full-sky surveys scheduled to begin in 2022 at the Vera C. Rubin Observatory under construction in Chile.

"SpaceX has been very receptive, very proactive in holding roughly monthly telecoms with us," says Jeffrey Hall, director of the Lowell Observatory in Arizona and chair of the AAS committee on light pollution, space debris and radio interference.

"They are on the record as saying that they want to solve the situation for astronomy. We are working to identify the targets they will need to hit . . . and then we'll see what happens," Hall says. "We are making overtures to other companies as well, because clearly SpaceX is not the only player in the field."

University of Michigan astronomer Patrick Spitzer adds: "What surprised everyone—the astronomy community and SpaceX—was how bright their satellites are. We knew these megaconstellations were coming, but based on the sizes and shapes of things currently in orbit, I thought maybe [they would be] eighth- or ninth-magnitude. We were not expecting second- or third-magnitude in the parking orbits, and we certainly were not expecting fourth- or fifth-magnitude in the deployment orbits."

Starlink is just the beginning. U.S. companies alone have asked the Federal Communications Commission to approve more than 58,000 satellites for operations over the next 10 years, with companies including Amazon, Facebook and other tech behemoths looking to develop satellite broadband networks.

Last month, NASA's Space Science Education Consortium launched a citizen science project to help document the population growth of satellites over time. The Satellite Streak Watcher project is open to anyone with a smartphone camera: anecdata.org/projects/view/687

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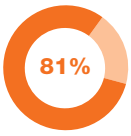

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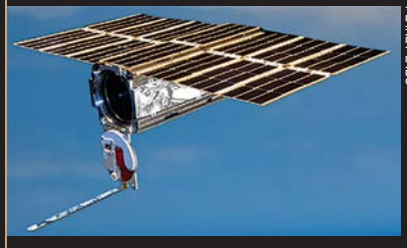
LEO Satellite Bonanza

The U.S. Federal Communications Commission and International Telecommunication Union have cleared the path for tens of thousands of satellites to operate in low Earth orbit, most in constellations intended to provide high-speed, global, low-latency internet service. Here's a look at the broadband, remote-sensing and other tech demos and initial operational spacecraft launched through 2019.

2013


PLANET LABS

APRIL-NOVEMBER
Planet (formerly Cosmogia)
Dove 1-4

JUNE
O3b O3b FM1, 2, 4 and 5

NOVEMBER
UrtheCast UrtheCast-1

2014

JUNE
Spire Global (formerly Nanosatisy)
Lemur 1
Satellogic BugSat 1

2016


GHGSAT

JUNE
GHGSat GHGSat D (Claire)

SEPTEMBER
Blacksky Global
Blacksky Global Pathfinder 1

2017

JUNE
Sky and Space Global Diamond 1-3
Canon CE-SAT 1


GEOOPTICS

JULY
GeoOptics CICERO 1-3

OCTOBER
Iridium Iridium NEXT 100, 107, 119, 122, 125, 129, 132, 133, 136, 139

NOVEMBER
HEAD Aerospace HEAD 1

2018

JANUARY 2018-JULY 2019


ICEYE

ICEYE ICEYE-X1-X5

JANUARY
Telesat LEO Vantage 1
Swarm Technologies SpaceBEE 1-4
Earth-i (built by SSTL) Carbonite 2
(also known as CBNT 2, EiX2, VividX2)

FEBRUARY
SpaceX Starlink
MicroSat 2a, 2b (Tintin A, B)

NOVEMBER
Hiber Global Hiber 1
Reaktor Radio Actives
Reaktor Hello World
Fleet Space Technologies Centauri 1

DECEMBER
Hiber Global Hiber 2
Fleet Space Technologies Centauri 2
Aistech AISTECHSAT 2
HawkEye 360 Hawk A-C
OHB Italia SpA Eaglet-1
Capella Space Capella 1 (Denali)
Myriota BRIO
Astrocast Astrocast 0.1 (Kiwi)
AXELSPACE GRUS-1A

2019

JANUARY
Kepler Communications
Kepler 1 (KIPP)

FEBRUARY
OneWeb OneWeb L1-1-6

APRIL
Astrocast Astrocast 0.2 (Hawaii)
NanoAvionics (partnered with Blink Astro and Lacuna Space) M6P
SatRevolution S.A. KrakSat


SATREVOLUTION

Orbital Micro Systems
IOD-GEMS (IOD 1)

JULY
NSLComm NSLSat 1

AUGUST
UnseenLabs BRO-1

NOVEMBER
Kepler Communications
Kepler 2 (CASE)
KLEO Connect KL-Alpha A and B

DECEMBER
Alba Orbital NOOR 1A, 1B
(Unicorn 2B, 2C)
Hera Systems 1HOPSAT TD
iQPS QPS-SAR 1 (Izanagi)

Source: Bryce Space and Technology

Cleaning Up

TETHERS UNLIMITED

Tethers Unlimited has tested an electrodynamic drag enhancement device to deorbit LEO satellites.

Graham Warwick Washington

ONE IN A SERIES

Will it take a collision or two to make cleaning up space a priority for government and industry? Several approaches to debris mitigation are making progress, and the debate is shifting from technical feasibility to economic viability—arguably a greater challenge.

Space situational awareness (SSA) is improving, revealing the scale of the problem. The U.S. Air Force is close to declaring its Lockheed Martin-developed Space Fence operational. Located on Kwajalein Atoll in the Marshall Islands, this S-band phased-array radar replaces a VHF system decommissioned in 2013. Able to detect smaller objects in low Earth orbit (LEO), the Space Fence expands the uncued detection and tracking capacity of the U.S. Space Surveillance Network from around 20,000 objects to more than 100,000.

A second site was planned in Australia but has not been funded. "Once Space Fence becomes operational, the number of tracked objects confirmed orbiting the Earth is expected to grow significantly. However, with only one sensor site, Space Fence does not have the power or coverage to continuously track and maintain awareness of these small objects," says the latest report by the Pentagon's director of operational test and evaluation.

Russia is improving its automated space-hazard warning system, ASPOS, with space agency Roscosmos adding opto-electronic sensor sites in Brazil and South Africa. Additional sites will be added later this year in Chile and Mexico. ASPOS can detect objects down to 10-20 cm (3.9-7.9 in.) in size.

The Space Surveillance and Tracking (SST) Consortium established by the European Union in 2015 has five surveillance and seven tracking radars, four laser stations and 35 telescopes—mostly in mainland Europe. Rather than providing full autonomy for Europe, the SST is intended to complement the U.S. capability and avoid expensive duplication of effort. "SSA represents a global and shared responsibility, where international collaboration remains a priority," the consortium says.

Europe's SST network is being upgraded. By 2021, the consortium is expected to be able to detect more than 16,000 objects bigger than 7 cm and catalog more than 6,000, including 35% of objects larger than 10 cm. By the 2028 time frame, more than 32,000 objects bigger than 7 cm will be detected by the network, and more than 19,500 cataloged, including 65% of those larger than 10 cm.

One reason the Air Force is rethinking a second Space Fence site is because space traffic management has become a commercial issue—and there is a growing industry providing space surveillance services. AGI has operated the Commercial Space Operations Center since 2014, and in 2016 Applied Defense Solutions (now part of L3Harris Technologies) along with ExoAnalytic Solutions won contracts to provide commercial SSA data to the National Space Defense Center.

ExoAnalytic operates a global commercial network of 275 telescopes and a space operations center that performs tracking and cataloging. It is collaborating with Canadian startup NorthStar Earth & Space, which plans a constellation of 40 satellites equipped with hyperspectral and infrared sensors looking down to observe Earth and optical cameras looking up to track more than 30,000 objects in space.

In November, in New Zealand, startup LeoLabs commissioned the third of its six commercial space radars. The new S-band phased-array radar can detect objects down to 2 cm, compared with 10 cm for the two UHF radars in the U.S. It can track 250,000 objects, up from 12,000. LeoLabs will add a fourth radar this year near the equator to improve coverage of low-inclination orbits, while the fifth and sixth radars will increase accuracy and revisit rates.

LeoLabs' radars are shining new light on the risks. "We are putting out alerts of debris-on-debris conjunctions," says CEO Dan Ceperley. "These have never been tracked before, and there is a lot more of them than functional satellites. We see a very risky close approach every week." A recent close approach, within 50 m (165 ft.), involved an object in an elliptical orbit. A collision "would have created debris all through LEO," he says.

In addition to providing greater accuracy and faster updates that reduce the

LOGO:ARTHOBBIT/UDEFINED UNDEFIND/WASTESOUL/MARYLOOGETTY IMAGES

false alarms satellite operators must respond to, Ceperley says LeoLabs' data allows regulators to monitor operators' compliance with their licenses. It can also help with the emerging problem of satellites going unidentified and unclaimed when multiple smallsats are deployed on a single launch.

With the limited battery capacity of cubesats, operators have only days to establish communication and deploy the solar panels before a satellite is lost. "Good tracking from Day One is critical," Ceperley says. With multiple deployments, it can take up to a month to establish a good track on an individual satellite. Radar data can help the operator pick out and connect with the correct satellite, he adds.

There is discussion within the space community on requiring new satellites to be fitted with beacons, in the same way that aircraft and ships are equipped to self-identify. Small U.S. businesses NearSpace Launch and Tiger Innovations plan orbital demonstrations this year.

NearSpace has developed the Black Box, a 5-oz. "patch" that attaches to the outside of a satellite and has a GPS receiver, solar panel and low-data-rate radio. The company's space-proven EyeStar radio communicates via the Globalstar constellation at 1,400-km (870-mi.) altitude—above most of LEO. This provides 24/7 connectivity with a latency of seconds, NearSpace says.

The Black Box can provide a backup downlink for critical spacecraft data and continues to function after the satellite ceases to operate, even if it is tumbling. "So a long time after it dies, you know where it is and you don't have to map out big tubes in orbit," says Matt Voss, vice president of operations.

NearSpace has been working with the Air Force under small-business research contracts, and four Black Boxes are manifested for launch in 2020. The company is looking for commercial customers, and the space insurance industry "has shown a lot of interest," Voss says. "We are hoping something will be mandated. It would solve a lot of the orbital debris problem."

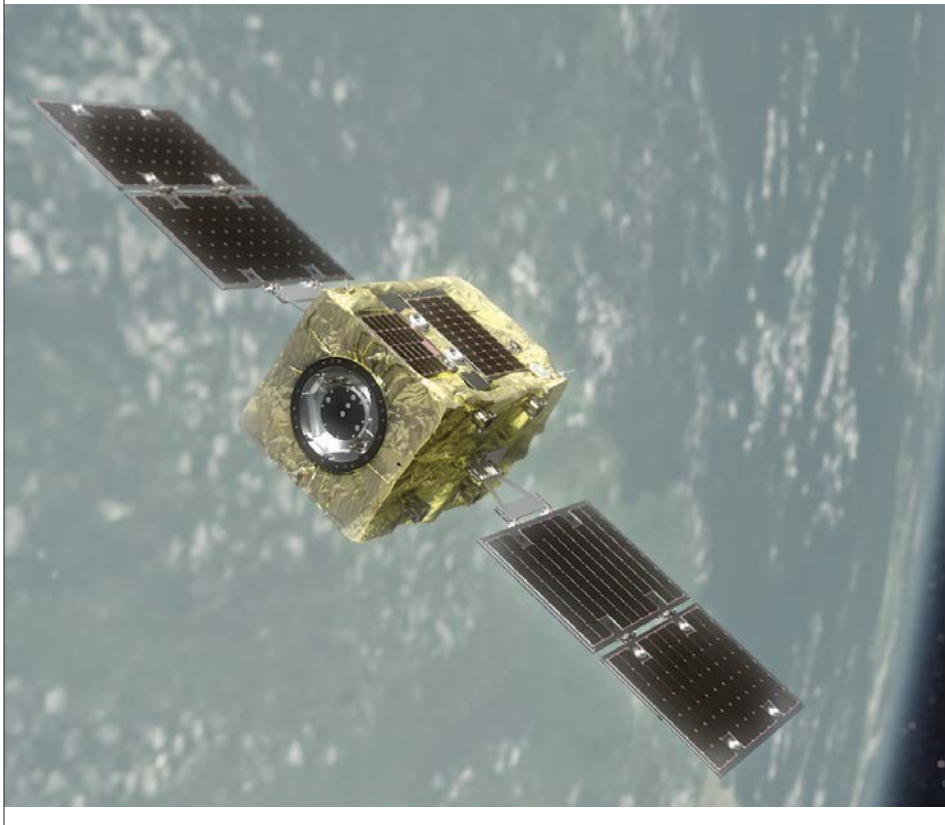
Partnered with Keplerian Technologies (KTi) and supported by DARPA, Tiger Innovations is developing the Space Object Automated Reporting System (SOARS) beacon. SOARS is lightweight, compact and self-powered and can be integrated onto almost any space object to provide both explicit identification and position information up to 1,800-km orbits, Tiger says.

In its response to the U.S. Federal Communications Commission's ongoing review of rules to mitigate orbital debris, KTi urged that commercial spacecraft be required to implement independent onboard transponder and tracking capabilities to "facilitate applications and analytics that mitigate collisions, improve satellite operator efficiency, and lower insurance premiums across the industry."

In September 2018, the team deployed and tracked SOARS on two high-altitude balloons. Tiger also provided a beacon for the first launch by California-based launch vehicle startup Astra under the DARPA Launch Challenge. The orbital demonstration was to be a key milestone toward SOARS commercialization, planned for the end of this year, says Jen Atkin, Tiger's executive vice president of operations. The challenge ended on March 2 without a launch. What happens next "will depend on Astra's plans," she says.

While most of the new megaconstellations use satellites with propulsion systems that can be used to deorbit the spacecraft at the end of their lives, there are options for those that fail or lack propulsion and are in orbits from which they will not reenter within the 25-year post-mission limit now in place. These range from passive deorbiting devices to active debris removal.

Passive deorbiting of objects in low orbit typically involves increasing their drag so they reenter more quickly. Tethers Unlimited's (TUI) Terminator Tape deorbit module uses both aerodynamic drag enhancement and passive electrodynamic drag to accelerate removal of a satellite from orbit.



Weighing less than 2 lb., the module was attached to the Prox-1 cubesat launched in June 2019 under a U.S. Air Force Research Laboratory nanosatellite program. In early September, TUI says, an automated timer on the Prox-1 activated the module, which deployed a 230-ft.-long conductive tape.

"We can see from observations by the U.S. Space Surveillance Network that the satellite immediately began deorbiting over 24 times faster," TUI CEO Rob Hoyt said in January. As a next step, TUI is collaborating with smallsat maker Millenium Space Systems, launch integrator TriSept and launch provider Rocket Lab on a LEO flight experiment called Dragracer.

This will compare two identical satellites, one using Terminator Tape.

An EU-funded research project, E.T. PACK (for Electrodynamic Tether Technology for Passive Consumable-less Deorbit Kit), is developing the Low Work-function Tether. This is a long conductive tape that enables the spacecraft to deorbit or reboost using reversible in-space propulsion free of consumables. The specially coated tether interacts passively with its environment to exchange momentum with the Earth's magnetosphere. The three-year, €3 million ($3.3 million) project is coordinated by Madrid's Universidad Carlos III and involves Spain's Sener and Fraunhofer of Germany.

Astroscale will inspect a spent rocket upper stage under JAXA's commercial debris removal demo.

ASTROSCALE

Airbus Defense and Space is developing a commercial device based on the prototype Innovative Deorbiting Aerobrake System (IDEAS) tested by French space agency CNES on the MicroSCOPE satellite. The 12-kg (26-lb.) IDEAS was activated at the end of the minisatellite's mission in September 2018, deploying two sail-equipped inflatable aluminum booms. Imaging by Fraunhofer's TIRA space radar confirmed their correct deployment at a specific alignment angle to maximize drag.

The Orbital Test Bed (OTB), a 140-kg satellite built by General Atomics and launched in June 2019 carrying payloads for the Air Force and NASA, is fitted with a drag-enhancing device, called Roc Fall, developed by U.S. high-strain composites specialist Roccor. Roc Fall is a rolled-up sail that unfurls under the strain energy stored in its composite spar. The OTB has two devices.

"It is not motorized," says Roccor CEO Chris Pearson. "It is made to be scalable. We can tune the area of the sail by changing the length of the composite tube." He sees a market to equip "ESPA-class" small satellites in elliptical orbits where there are two ways to deorbit: expensive integration of a propulsion system or installation of a drag device with minimal impact on the rest of the satellite.

A different deployable device is offered by Vestigo Aerospace, a spinoff from Purdue University. The Spinnaker is a dragsail, and two versions are in development. Spinnaker3, a flat sail with 3-m-long booms, is in ground testing for launch this year on the first Firefly Alpha rocket, and Spinnaker1, a pyramid sail with 1-m booms, is expected to be ready late this year.

Spinnaker1 will be used on Purdue's Aerodynamic Deorbit Experiment, a 1U cubesat to be deployed into geostationary transfer orbit from a Centaur upper stage on a future Atlas V launch. "The expected orbital lifetime is 50-250 days following deployment of the drag device," says CEO David Spencer. "With no drag device, a standard 1U cubesat would remain in orbit for approximately 2,500 days."

The European-funded RemoveDebris mission was intended to deploy a dragsail to accelerate reentry on completion of its on-orbit demonstration in March 2019. The inflatable boom failed to deploy, but the focus was on active debris removal (ADR). The mission successfully demonstrated vision-based navigation for rendezvous and proximity operations, as well as both net and harpoon capture mechanisms.

Future ADR missions are focused on developing commercial services. Japanese startup Astroscale plans to launch its ELSA-d end-of-life services demonstration this year. The 180-kg servicer and 20-kg client satellites will be launched stacked together, then separate in orbit at around 550 km. The servicer will then demonstrate search, inspection, rendezvous and capture of the client, both stable and tumbling. The servicer has a magnetic docking mechanism and the client a docking plate.

Astroscale has been selected by the Japan Aerospace Exploration Agency for Phase I of the Commercial Removal of Debris Demonstration (CRD2) project. Building on ELSA-d and planned for completion by the end of 2022, this project will use a satellite to collect detailed images of a spent H-IIA rocket upper stage. As a precursor to deorbiting the upper stage in Phase II, after 2025, the goal is to show the motion, damage and deterioration of an object that has been left in orbit for a long time with little data available.

The European Space Agency (ESA) has set the spent Vespa upper stage from a 2013 Vega launch as the target for its ClearSpace-1 ADR demonstration mission by Swiss startup ClearSpace. Planned for launch in 2025, the ClearSpace-1 "chaser" will search for and rendezvous with Vespa in 720-km orbit then deploy curved arms to enclose the upper stage. "It's like tentacles that embrace the object because you can capture it before you touch it . . . because if you touch the object on one side, it will immediately drift away," says Holger Krag, head of ESA's Space Debris Office.

Once captured, the upper stage will be secured close to the chaser's body to ensure they make a controlled reentry together. On future missions, ClearSpace intends to remove multiple pieces of debris before the chaser spacecraft burns up, with the goal of making ADR available at affordable cost.

The economics of ADR—in other words, launching a spacecraft to capture a spacecraft—have yet to be worked out. When Iridium deorbited its last functioning Block 1 satellite at the end of 2019, CEO Matt Desch was asked if he would pay to remove the remaining 30 defunct spacecraft from orbit. "Sure, for a low enough cost. $10K each?" he tweeted. "You know at what point it's a no-brainer, but [I] expect the cost is really in the millions or tens of millions, at which price I know it doesn't make sense."

Short of governments mandating self-identification or active removal in the wake of an orbital collision, closing the business case for these technologies with fleet operators such as Iridium is the challenge facing the industry.

20 TWENTIES

TOMORROW'S TECHNOLOGY LEADERS

Lindsay Bjerregaard Chicago

As aircraft become more electric, engines become more efficient and spacecraft seek to conquer new frontiers, the aerospace and defense industry needs fresh ideas from younger generations that grew up with a passion for sustainability and innovative technologies.

Through the annual 20 Twenties program, the Aviation Week Network and the American Institute of Aeronautics and Astronautics (AIAA) recognize young, rising stars within the industry. Top students working to solve aerospace challenges are nominated by universities around the world, and a judging panel comprised of hiring managers, engineers and academics selects 20 exceptional winners. Nominees are evaluated based on academic performance, civic contribution and the value of their research or design projects.

Now in its eighth year, the 20 Twenties program received nominations from nearly 50 schools across seven countries, including 17 new ones. Several winners have served as leaders at their universities in helping students from diverse cultural backgrounds achieve better access to science, technology, engineering and mathematics (STEM) education and opportunities.

As honoree Emily Beckman explains: "One of the biggest problems in the sciences today is that we have a tendency to treat science as inaccessible to certain people. This not only shuts people out from the opportunity for support to pursue science, but also manifests into a culture conditioned to fear science as something that's untrustworthy or incomprehensible."

One area of STEM outreach on which this year's winners are heavily focused is women's representation in aerospace. Not only were more than half of 2020's winners female, but many of the students have volunteered their time with organizations and nonprofits devoted to increasing women's representation and interest in STEM.

In addition to highlighting the importance of diversity in aerospace, this year's group of students emphasized the need for fearlessness and persistence in the face of failure. Winners engaged with other students to advise, mentor and inspire academic resilience, including a student-run initiative at the Massachusetts Institute of Technology dedicated to destigmatizing failure.

"A test failure is not a reason to give up but a reason to take what you've learned and continue forward," says honoree Jane Gillette. "Sometimes, a project gets scrapped. Sometimes, a test doesn't go how you want it to. But that provides motivation to continue, to succeed and to do great things."

According to AIAA Executive Director Dan Dumbacher, new ideas and perspectives from this year's winners will make a mark on the future of aerospace. "We can expect them to bring fresh ideas to the challenges facing us both here on Earth and beyond our Solar System," he notes. "We look forward to following their accomplishments and how they shape the future of aeronautics and astronautics."

The winners will be recognized during the 20 Twenties Awards Luncheon and Aviation Week's 63rd Annual Laureates Awards on March 12 in Washington.

AIAA 20 Twenties Judges

Mary Lynne Dittmar
President and CEO, Coalition for Deep Space Exploration

Kevin Duda
Principal Engineer and Group Lead, The Charles Stark Draper Laboratory

Lori Garver
Founder, Brooke Owens Fellowship

Daniel Jensen
Head of Engineering for Services, Propulsion and Power, Rolls-Royce

Joe Landon
Vice President Advanced Programs, Lockheed Martin

Kurt Polzin
Research and Development Engineer, NASA Marshall Space Flight Center

Timothee Pourpoint
Associate Professor, Purdue University

Laura Richard
Mission Manager, U.S. Air Force Program Office, United Launch Alliance

Craig Willis
Project Engineer, Gulfstream Aerospace Corp.

CLIPOTART/GETTY IMAGES

Emily Beckman

Graduate Student, Aeronautics and Astronautics • Class of 2020 • Purdue University
B.S. Aerospace Engineering • Class of 2018 • University of Tennessee, Knoxville

After two internships at NASA's Goddard Space Flight Center, Beckman was selected as a NASA Space Technology Research Fellow. Her research for the fellowship and her master's degree at Purdue focus on modeling slosh in small-satellite conformal tanks.

During her undergraduate studies, Beckman interned at the NASA Marshall Space Flight Center Space Hardware and Robotics Academy, where she researched future additive manufacturing improvements needed to make reliable 3D-printed replacement parts for the International Space Station's life-support system.

Beckman has volunteered with the Space Public Outreach Team and Letters to a Prescientist Program to improve youth STEM outreach.

Valerie Bernstein

M.S. Aerospace Engineering Sciences • Class of 2019 • University of Colorado Boulder
B.S. Astronomy and Astrophysics • Class of 2017 • Villanova University

During her studies, Bernstein focused on researching how space weather affects Earth and technology in space, including how to improve modeling and forecasting capabilities for atmospheric drag. She was selected for fellowships at the National Science Foundation and Los Alamos National Laboratory.

Bernstein is passionate about promoting science and making it more accessible to the public. To further these efforts, she serves as director for the University of Colorado (CU) Boulder's STEMinar organization to promote interdisciplinary science communication, and she volunteers as a CU Science Ambassador to create space weather-related activities for youth outreach events.

Kate Byrd

M.S. Engineering Sciences • Class of 2019 • Harvard University
B.S. Bioengineering • Class of 2015 • Clemson University

As an associate technical staffer at the MIT Lincoln Laboratory, Byrd is researching miniature antenna designs to enable smaller systems with higher data speeds for Earth-to-space and satellite-to-satellite communications. She received a Lincoln Scholar award to pursue her Master's degree at Harvard and was selected for the National Science Foundation's Graduate Research Fellowship Program and the Draper Fellow Program.

To spread her passion about diversity in engineering, Byrd has mentored freshmen girls through Clemson's Women in Science and Engineering program and volunteered with the Junior League of Boston. She also serves as chief operating officer of Girls Who Build, organizing workshops for high schoolers with topics ranging from photography and music to climate change.

Katherine Carroll

M.S. Aeronautical and Astronautical Engineering • Class of 2021
Massachusetts Institute of Technology
B.S. Aerospace Engineering • Class of 2019 • University of Illinois Urbana-Champaign

With a passion for giving back to the community, Carroll has participated in programs such as Habitat for Humanity and Entrepreneurs Without Borders and mentored engineering students as president of her university's Women in Aerospace organization.

She has interned at SpaceX, NASA's Jet Propulsion Laboratory and The Aerospace Corp. As technical project manager at the Illinois Space Society, she led a team of undergraduate students to design, manufacture and test a sharp-edge detection and suppression device for NASA's Micro-G Next Challenge.

At MIT, Carroll is researching socio-technical system performance and its applications within aerospace and defense.

Sean Devey

Graduate Student, Aerospace Engineering • Class of 2020 • The University of Alabama
B.S. Aerospace Engineering • Class of 2018 • The University of Alabama

In his graduate studies, Devey is using technology inspired by the microstructure of the shortfin mako shark's skin to improve efficiency, controllability and noise reduction of aerodynamic surfaces. He believes future iterations of his microflap prototypes could be integrated into a variety of aerospace vehicles. The project has received funding from Boeing, the U.S. Army and the National Science Foundation.

Devey interned at Boeing and MIT's Lincoln Laboratory and served as vice president for the Tuska UAV team at Alabama, which created open workshops for students on topics such as 3D printing, aircraft design and avionics. He has volunteered with several organizations devoted to renovating or constructing homes for impoverished communities.

Paula do Vale Pereira

M.S. Aeronautics and Astronautics • Class of 2019 • Massachusetts Institute of Technology
M.S. Thermal Science and Engineering • Class of 2017 • Federal University of Santa Catarina
B.S. Business and Management • Class of 2015 • State University of Santa Catarina
B.S. Mechanical Engineering • Class of 2014 • Federal University of Santa Catarina

At MIT, do Vale Pereira has served as mechanical system lead for a deformable mirror demonstration mission cubesat and a folded lightweight positioning system, both of which are aimed at better exoplanet detection methods. She has received the Amelia Earhart Fellowship and was chosen as one of MIT's Graduate Women of Excellence.

She serves as mentoring and outreach director in MIT's Graduate Women in Aerospace Engineering group. She has also developed several nongovernmental organizations in Brazil to help underprivileged students.

S. Reza Fattahi M.

Graduate Student, Aerospace Engineering • Class of 2020
Sharif University of Technology
B.S. Aerospace Engineering
Class of 2017 • Sharif University of Technology

As treasurer of the university's student environmental group, Fattahi became interested in sustainable solutions for aviation such as electric vertical-take-off-and-landing (eVTOL) transportation systems. That led to his master's thesis work: designing a robust control system for urban transportation eVTOLs. As project advisor, he helped lead his team to first place in last year's AIAA Graduate Team Aircraft Design Competition.

He established the aerospace engineering department's student office for aerospace design competitions, where he mentors and pursues company sponsorships for student teams. He has interned at Farsco Aviation Maintenance, Repair and Overhaul Center and works part time as a configuration development engineer at SAMAD Aerospace, where he is helping develop the company's Starling Jet concept.

Kanika Gakhar

Graduate Student, Aeronautics and Astronautics Engineering
Class of 2020 • Massachusetts Institute of Technology
B.S. Aerospace Engineering
Class of 2018 • Texas A&M University

As a researcher in MIT's Gas Turbine Lab and a former Whittle Fellow at Rolls-Royce, Gakhar is working to make aircraft engines more efficient by studying the effects of combustor turbulence on high-pressure turbine performance. She also has researched the aeromechanics of natural flapping flight through the development of a hover-capable robotic hummingbird.

She has interned at SpaceX and Boeing.

Gakhar's passion for mentoring led her to organize workshops at MIT, including an effort to destigmatize failure and inspire academic resilience. She is working to form a startup that uses satellite and UAV-based systems to help provide internet access and monitor climate and health factors in remote and developing areas.

Shannon Gatta

Undergraduate Student, Informatics • Class of 2020 • University of Washington

While serving as an intelligence analyst in the U.S. Army National Guard, Gatta interned at NASA's Johnson Space Center and Langley Research Center, Stratolaunch and Ball Aerospace. At Ball, she is conducting research with United Launch Alliance to create their first mission-capable deployment of a UAV from a rocket payload.

She also serves as an ambassador for Minority Veterans of America and will travel to Vietnam with PeaceTrees this fall to teach how to safely excavate bombs.

Gatta's passion for data science and cultivating youth interest in STEM has led her to volunteer with Girls Who Code, Seattle App Academy and Washington Space Grant. She was selected as the first astronaut candidate for The Out Astronaut Project, which is working to train and send an openly LGBTQ+ person into space.

Jane Gillette

Undergraduate Student, Aerospace Engineering & Mechanics • Class of 2020 • The University of Alabama

Gillette has interned at the Challenger Learning Center, NASA's Science Mission Directorate and United Launch Alliance—where she worked to train the Ascent team to sit on console during the Boeing Starliner Commercial Flight Test and NASA Artemis missions. Gillette also serves as project manager and lead systems engineer for the Alabama Rocket Engineering Systems team, which is designing, testing and building a two-stage solid-fuel rocket to launch to 100,000 ft.

In addition to volunteer work with Habitat for Humanity and Alabama's STEM Path to MBA Program outreach efforts, Gillette has worked with the Tuscaloosa Rocketry Challenge to teach middle school students about space and rocketry.

Alexis Hepburn

Undergraduate Student, Aerospace Engineering
Class of 2020 • Embry-Riddle Aeronautical University

Hepburn initiated Embry-Riddle's first on-campus electric propulsion research, serving as primary researcher to design, manufacture and test a miniaturized, single-stage Stationary Plasma Thruster-type Hall thruster. She has presented her research on the pocket-sized Hall thruster at three international conferences, including the American Institute of Aeronautics and Astronautics Propulsion and Energy Forum.

Hepburn has interned at Honeywell Aerospace, Raytheon Missile Systems, Boeing Defense, Space and Security and the Seattle Museum of Flight, where she volunteered to mentor students and increase young women's interest in aerospace and STEM. She currently serves as an academic mentor with Embry-Riddle's College of Engineering and as a career services and corporate relations peer advisor for the university.

Chloe Johnson

Graduate Student, Aerospace Engineering • Class of 2020 • The University of Texas at Austin • B.S. Engineering Mechanics • Class of 2018 • University of Wisconsin-Madison

Johnson is working to improve understanding of the next generation of eVTOL aircraft through her graduate research, which aims to validate the airworthiness of experimental designs and improve rotor aeroacoustics to reduce noise. She is investigating the performance and acoustics of coaxial, co-rotating rotors for eVTOL aircraft and is sharing the results of her experiments with Uber Technologies—the project's funder—and the U.S. Army Research Laboratory.

As president of the Graduate Ladies of Aerospace and Mechanics organization, Johnson is working to increase diversity in her university's aerospace department. She also has organized a STEM career fair for female students from low-income backgrounds.

Michelle Lin

Undergraduate Student, Dual B.S. Aerospace Engineering Sciences and Applied Mathematics • Class of 2021 • University of Colorado Boulder

Lin's bioastronautics research has focused on the applications of alternative reality technology within spacecraft habitat design. Through a NASA-funded virtual reality project, she readapted gaming software to create an augmented reality habitat and worked directly with NASA to develop a hybrid-reality spacecraft airlock. She is now designing a project to consider the effects of architectural and interior design principles on spatial awareness and perception in spacecraft habitat.

Lin founded the university's chapter of Women of Aeronautics and Astronautics. She received the Women in Aerospace Foundation Scholarship and was chosen for the Brooke Owens Fellowship.

Lin also volunteers with campus STEM outreach efforts.

Julia Mihaylov

Graduate Student, Space Systems Engineering Class of 2021 • Johns Hopkins University
B.S. Aerospace Engineering Class of 2019 • Embry-Riddle Aeronautical University

During her undergraduate research, Mihaylov served as co-lead of the Julia Language Ephemeris and Physical Constants Reader project through NASA's Jet Propulsion Laboratory. Her work directly aided JPL's flight project Psyche and led to a part-time position at JPL supporting the Europa Clipper mission.

Mihaylov was chosen for the Brooke Owens Fellowship—through which she interned at The Aerospace Corp.—and now is an alumni mentor to recent recipients of the fellowship. She served as editor-in-chief of the *Horizons* newspaper at Embry-Riddle, student vice president of Phi Kappa Phi Honor Society and chapter president for the Alpha Xi Delta Fraternity of Women.

Victoria Pellerito

B.S. Mechanical Engineering • Class of 2020
Lawrence Technological University

Pellerito was the lead undergraduate researcher on a project to develop a flapping-wing robot with three different modes of elastic wing-connections. She also participated in two projects through the New Mexico Institute of Mining and Technology, designing an autonomous flight system for exploration of Titan and examining the effects of heated boundary layers found in nature.

She is the captain of Lawrence Technological University's SAE Aero Design Team, which is working to develop a short takeoff-and-landing aircraft with a 10-ft. wingspan while aiming to carry as much payload as possible. In addition to serving as a mathematics and engineering tutor, she promotes STEM as chapter president of the Tau Beta Pi and Pi Tau Sigma honor societies.

Ethan Plaehn

Graduate Student, Aeronautical and Astronautical Engineering • Class of 2022
Purdue University • B.S. Aeronautical and Astronautical Engineering • Class of 2019
Purdue University

Plaehn's passion for developing advanced propulsion concepts grew from an internship at Aerojet Rocketdyne and a lead propulsion role in a Boeing program to research the fundamental properties of detonation propagation under flow conditions present in a rotating detonation engine (RDE). He is working to design a modular RDE—technology with the potential to improve the efficiency of modern combustion devices.

He also has developed and taught classes to high school seniors about subjects such as engineering design, 3D printing and robotics.

Plaehn is a member of the Sigma Gamma Tau honor society and a private pilot.

Simon Shuham

M.S. Aerospace Engineering • Class of 2019
University of Colorado Boulder
B.S. Mechanical Engineering • Class of 2017
Harvard College

During his undergraduate research, Shuham completed a project to design and test a deployable 0.5-m (1.6-ft.) radio antenna dish for cubesats for a small-satellite startup company. He has worked as a propulsion systems design engineer at United Launch Alliance and now is a propulsion engineer at Blue Origin, where he is helping to develop and design the BE-3U engine on the New Glenn rocket second stage.

Shuham serves on the board of the AIAA's Pacific Northwest chapter and on the Seattle Museum of Flight's Future Leaders team. He founded Harvard's chapter of Students for the Exploration and Development of Space and spent a summer cycling across the country with Spokes America to teach STEM courses to hundreds of students.

Gautham Viswaroopan

M.S. Aerospace Engineering Sciences • Class of 2019
University of Colorado Boulder
B.S. Mechanical Engineering Sciences • Class of 2017
University of Colorado Boulder

Viswaroopan is working to develop electric-field (E-field) antennas for spacecraft, including serving as project manager of the cubesat Compact Spaceborne Magnetic Observatory and designing more optimal E-field antennas. He has already completed a rocket deck segment of the Rapid Active Plasma Sounder, which will launch in July.

The challenges of being an international student led him to become an International Ambassador at the University of Colorado Boulder and the international chair of SEDS Earth, where he has grown the organization's international chapters by 26 countries. He is leading SEDS' GravityGames 2.0 initiative, in which international students will compete to design inventions that astronauts could make on a 3D printer aboard the International Space Station.

Laura Yenchesky

B.S. Mechanical Engineering • Class of 2019
Massachusetts Institute of Technology

As an undergraduate researcher at MIT's Space Telecommunications, Astronomy and Radiation Laboratory, Yenchesky led design and analysis efforts for NASA's CubeSat Laser Infrared Crosslink mission, which aims to demonstrate the first full-duplex laser communications crosslink between two nanosatellites in low Earth orbit. Following internships at Millennium Space Systems, Orbital ATK and Aurora Flight Sciences, she now works full time as a mechanical systems engineer at Aurora Flight Sciences.

Yenchesky served as team coach on the MIT Gordon Engineering Leadership Program and as professional development chair for MIT Women in Aerospace Engineering. She was also captain of MIT's Sport Pistol Team, which won the 2019 National Collegiate Championships.

David Zuehlke

M.S. Aerospace Engineering • Class of 2019 • Embry-Riddle Aeronautical University • B.S. Engineering • Class of 2017 • Bob Jones University

Zuehlke's research on optical orbit estimation with small telescopes seeks to provide an inexpensive way to keep track of the growing number of satellites in orbit. That research became a reality through the U.S. Air Force Research Laboratory's (AFRL) Summer Faculty Fellowship Program and played a key role in a cooperative grant started jointly by Embry-Riddle and the AFRL.

He runs an astronomy STEM outreach event for middle school and high school students to enable them to view planets, stars and satellites through telescopes. During his undergraduate studies, he served as software team leader of the Bruins robot team at Bob Jones University.

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Aerospace Calendar

To submit Aerospace Calendar Listings
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March 16-April 30—RTCA Plenary Sessions. Various locations. See rtca.org/content/upcoming-committee-meetings

March 17-19—Global Aerospace Summit. St. Regis Saadiyat Island Resort. Abu Dhabi. See aerospacesummit.com

March 19—Space Summit 2020/*The Economist.* Shangri-La Hotel, Sydney. See events.economist.com/events-conferences/asia/space-summit-2020

March 21-22—Los Angeles County Air Show. William J Fox Airfield. Lancaster, California. See lacountyairshow.com

March 23-25—International Conference on Applied Aerodynamics. Prime Institute (ISAE-ENSMA buildings). Poitiers, France. See 3af-aerodynamics2020.com

March 30-April 2—36th Space Symposium. Broadmoor Hotel. Colorado Springs. See spacesymposium.org

March 31-April 2—Hypersonic Weapons Summit. Key Bridge Marriott. Arlington, Virginia. See idga.org/events-hypersonic-weapons-spring

April 2-3—SEE Universe 2020 (Southeastern Europe Space Conference). Science Technology Park. Belgrade, Serbia. See seeuniverse2020.rs

April 6-8—Aerospace & Defense Supplier Summit. Seattle. See seattle.bciaerospace.com

Aviation Week Network Events

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March 12—Aviation Week Laureates Awards. Washington.

April 1-2—CAPA Airline Leader Summit: Making Money 2020. Dublin.

April 27-28—Urban Air Mobility Americas. Dallas.

April 27-29—Routes Europe 2020. Bergen, Norway.

April 28-29—Military Aviation Logistics & Maintenance Symposium. Dallas.

April 28-30—MRO Americas. Dallas.

May 7-8—CAPA Americas Aviation & LCCs Summit. San Juan, Puerto Rico.

May 12-13—Aerospace Manufacturing Conference. Charleston, South Carolina.

May 19-21—ap&m Europe Summit & Expo. Manchester, England.

May 27-28—CAPA LCCs in Asia Summit. Sentosa Island, Singapore.

June 2—ATW's Airline Industry Achievement Awards. Vienna.

June 3-4—MRO BEER (Baltics, Eastern Europe and Russia). Istanbul.

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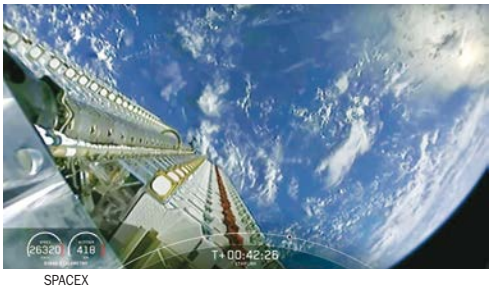
VIEWPOINT

Time for Comprehensive Space Traffic Management

By **Daniel Oltrogge**

In today's complex space operations environment, the benefits we derive from space—as well as the welfare of our astronauts, spacecraft, commercial space industry and general public—are vulnerable. Spacecraft operators are not receiving the decision-quality space situational awareness (SSA) and space traffic management (STM) required to conduct safe operations and ensure space sustainability.



SPACEX

CONGRESS MUST FUND INITIATIVES THAT LEVERAGE EXISTING COMMERCIAL RESOURCES.

U.S. flight safety services freely provided by the Defense Department to commercial spacecraft operators are insufficient, through no fault of the men and women in uniform but rather as a result of the aging legacy tools they are using. These tools produce too many false alarms and miss too many serious threats. False alarms require spacecraft operators to squander precious resources and fuel. The majority of potentially lethal space objects—96%—remain untracked. These shortcomings, compounded by outdated space-tracking algorithms, insufficient quality control and a lack of transparency, degrade flight safety. We have allowed legacy tools and algorithms to dictate the quality of SSA that operators receive. It is high time that we agree on a set of key STM system requirements and "make it so."

In addition, the U.S. is going to great lengths to manage space as a warfighting domain. U.S. Space Command rightly desires to migrate existing SSA sharing and spaceflight safety services out of the Pentagon in order to focus resources on national security.

Complicating matters further is the predicted increase in space traffic. The U.S. commercial space industry has filed applications for 51,000 new large-constellation spacecraft in the next 10 years. While only a portion of these applications will give rise to operational spacecraft, we anticipate the active spacecraft population will be 4-10 times larger within the next decade. This year alone, it is on track to double. Millions of close approaches will occur, and without more accurate SSA, operators will be extremely challenged to take appropriate action.

Decision-quality SSA lowers collision risk. Observing space objects, fusing data, solving orbits, and detecting and characterizing potential collisions enables spacecraft operators to mitigate the threat. The 2009 Iridium-Cosmos collision is noteworthy because it shows what happens when operators fail to receive decision-quality SSA: A planned maneuver was missed, and collision risk was underestimated by 40 orders of magnitude. Large-scale collisions can generate over 100,000 fragments, reverberating through our burgeoning $1-3 trillion space economy, introducing uncertainty and impeding growth.

Left unchecked, these threats can lead to a cycle of cascading collisions known as the Kessler Syndrome, potentially rendering the use of space unsustainable. If we surpass this ecological threshold, there is no return. We've been lucky so far, but the clock is ticking.

Improvements are critically needed and achievable. Commercially available SSA and STM technologies—operating today using advanced astrodynamics algorithms—can provide actionable notifications of impending threats. The U.S. must determine how to incorporate these commercial capabilities into a cohesive set of tools to produce decision-quality SSA.

The U.S. should take the following steps to improve overall SSA and STM:

- Transition public-facing SSA and STM services to a nonmilitary organization.
- Authorize and resource U.S. STM operational initiatives immediately.
- Find ways for the government to nurture and incorporate commercially provided SSA and STM services.
- Provide resources to conduct active debris-removal tests.
- Take a leadership role in developing space traffic management, large-constellation standards and best practices.
- Establish, model and implement rules of the road.
- On this 25th anniversary of the 25-year-orbit lifetime rule, "deorbit" this rule in favor of a more stringent post-mission disposal guideline to better address current and planned large-constellation traffic—and then abide by that rule.

The commercial space community has proactively sought voluntary ways to address flight safety. The Space Data Association provides spaceflight safety services for 30 operators controlling 788 spacecraft that span all orbit regimes. The global Space Safety Coalition develops and maintains an aspirational set of "living" space-safety best practices. Such efforts to promote and enable long-term sustainability are critical to the equation.

Now, Congress must fund initiatives and adopt policies that leverage existing commercial resources to promote spaceflight safety. The long-term sustainability of the space environment, the socioeconomic benefits derived from operating in space and the success of the U.S. commercial space industry are all at risk.

The time for action is now.

Daniel Oltrogge is the director of Analytical Graphics' Center for Space Standards and Innovation, founder and administrator for the Space Safety Coalition and program manager of the Space Data Center.

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