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LETTER FROM THE EDITOR

BEHIND THE SCENES

As part of Aviation Week's sustainable aviation coverage, **Senior Editor Guy Norris** (left) recently flew on Boeing's 777-200ER ecoDemonstrator. His report begins on page 38.

ON THE COVER

Boeing's latest ecoDemonstrator, a company-owned 777-200ER, cruised over the Oregon coast during a recent flight trial, testing technologies targeting at improved efficiency. Senior Editor Guy Norris' report on his flight on the ecoDemonstrator begins on page 38; our broader coverage of a growing industry focus on sustainability begins on page 32. Boeing photo by John D. Parker.

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AVIATIONWEEK & SPACE TECHNOLOGY

Editor-In-Chief
Joseph C. Anselmo joe.anselmo@aviationweek.com
Executive Editors
Jen DiMascio (Defense and Space) jen.dimascio@aviationweek.com
Jens Flottau (Commercial Aviation) jens.flottau@aviationweek.co.uk
Graham Warwick (Technology) warwick@aviationweek.com
Editors Lindsay Bjerregaard, Sean Broderick, Michael Bruno, Bill Carey, Thierry Dubois, William Garvey, Ben Goldstein, Lee Hudson, Irene Klotz, Helen Massy-Beresford, Jefferson Morris, Guy Norris, Tony Osborne, Bradley Perrett, James Pozzi, Adrian Schofield, Lee Ann Shay, Steve Trimble
Chief Aircraft Evaluation Editor Fred George
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Artists Thomas De Pierro, Colin Throm
Copy Editors Jack Freifelder, Arturo Mora, Natalia Pelayo, Andy Savoie
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Contributing Photographer Joseph Pries
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Content Marketing Manager Rija Tariq

Data & Analytics
Director, Forecasts and Aerospace Insights Brian Kough
Senior Manager, Data Operations/Production Terra Deskins
Manager, Military Data Operations Michael Tint

Editorial Offices
2121 K Street, NW, Suite 210, Washington, D.C. 20037
Phone: +1 (202) 517-1100
605 Third Avenue, New York, N.Y. 10158
Phone: +1 (212) 204-4200

Bureau Chiefs
Auckland
Adrian Schofield avweekscho@gmail.com
Beijing
Bradley Perrett bradley.perrett@aviationweek.co.uk
Cape Canaveral
Irene Klotz irene.klotz@aviationweek.com
Chicago
Lee Ann Shay leeann.shay@aviationweek.com
Frankfurt
Jens Flottau jens.flottau@aviationweek.co.uk
Houston
Mark Carreau mark.carreau@gmail.com
Kuala Lumpur
Marhalim Abas marhalim68@gmail.com
London
Tony Osborne tony.osborne@aviationweek.co.uk
Los Angeles
Guy Norris guy.norris@aviationweek.com
Lyon
Thierry Dubois thierry.dubois@aviationweek.com
Moscow
Maxim Pyadushkin mpyadushkin@gmail.com
New Delhi
Jay Menon jaymenon68@gmail.com
Paris
Helen Massy-Beresford helen.massy-beresford@aviationweek.co.uk
Washington
Jen DiMascio jen.dimascio@aviationweek.com
Wichita
Molly McMillin molly.mcmillin@aviationweek.com

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FEEDBACK

HILOSGEN

SMALL MODULE REACTORS

I read with interest "Nuclear Air Force" *(Nov. 25-Dec. 8, 2019, p. 52)*. During the 1960s and early '70s, I worked on the use of small and compact nuclear reactors for applications in space and at remote military and commercial locations. This was part of the SNAP (Space Nuclear Auxiliary Power) program. Over the past decade, there has been considerable work done on developing Small Modular Reactors (SMR) for supplying power to the commercial electric power grid.

While much analysis and design work has been performed on these small reactors, there still exists a lack of test and operational performance on actual operating reactors, which is vital for ensuring a reliable, safe and licensable design. As Adm. Rickover once said, the difference between a paper reactor and real reactor is "corrosion."

To overcome this shortcoming in the lack of operational data on a real reactor, the Defense Department should encourage and work with the Energy Department to site and build the most promising SMR concepts at the Energy Department's complex of remote sites. This would not only provide valuable test and performance data (particularly for advanced fuel types like the TRISO Fuel Pebble for "Project Pele") but also onsite electrical power needs for the department's site complexes, including the Hanford Reservation, Savannah River Site, Nevada National Security Site and the Idaho National Engineering Laboratory.

Electrical power output of about 50 megawatts should be adequate to satisfy the onsite power needs of each location. This operating experience and performance data would also spur the development of SMRs for commercial applications as well, which, as pointed out in the article, has failed to gain traction.

I believe it's extremely important for our country to embark on such exciting projects as SMRs and Project Pele, which will reinvigorate young people to seek careers in the peaceful application of nuclear energy.

Andrew R. Marchese, Las Vegas

A GOOD DEAL

The editorial "A Risky Business" *(Dec. 9-22, 2019, p. 74)* argues that President Donald Trump's success in getting our NATO and Asian allies to spend more on their own defense and increase their payments for U.S. troops stationed in their territory risks their alienation because of his disparaging rhetoric.

The allies, you fear, might build up their own defense industries even though our weapons exports are up. Trump, you say, is so transactional, demanding that they do more or buy more for the protection we provide.

But aren't the allies transactional themselves? The threat to put on uniforms and develop their own defenses unless we are foolish enough to keep doing most of it for them without complaint rings hollow. I bet that they buy a few more planes and put up with the rhetoric to get as much of a free ride as they can. It is a very good deal for them, and they know it.

Harvey M. Sapolsky, Cambridge, Massachusetts

A *NEW* NEW MIDMARKET AIRPLANE?

Richard Aboulafia's "Adieu, NMA?" *(Nov. 11-24, 2019, p. 14)* made me wonder if Boeing would be interested in producing the Irkut MC-21 under license in the U.S., saving it research and development costs. The MC-21 is not your grandfather's Soviet airliner. It seems to be a very modern clean-sheet aircraft. The flight deck is extremely modern, and the cabin is 10 in. wider than the Boeing 737. Maybe it could be the new new midmarket airplane or 797.

I wish Aviation Week would go to Russia and fly the MC-21 and tell us readers what you think of it.

Philip Nackard, Flagstaff, Arizona

LATIN LETTERS IN CHINA

Why do Chinese rockets display Western numbers, such as the DF-17 or DF-41?

Lance Casady, Sterling, Virginia

Editor's note: The most likely reason is that whoever is making the decision considers that the outside world is watching. Anyway, the use of the Latin alphabet ("English," as the Chinese think of it) has a certain prestige in China. Even a barber shop might stick up a sign with its name in Latin letters, just to look cool. The designations with Latin letters sometimes appear in Chinese-language articles, but the original Chinese characters the letters represent are more usual.

CORRECTIONS:

The Defense Systems Data Center *(Dec. 23, 2019-Jan. 12, 2020, p. 62)* should have stated the date range for Fighter/Attack Aircraft Costs and Military Transport Aircraft Costs as 2020-24 and the Five-Year Unit Production measured in billions of U.S. 2020 dollars. The Commercial Aviation Data Center *(Dec. 23, 2019-Jan. 12, 2020, p. 98)* should have stated the date range for Business Aircraft Costs as 2020-24 and the Five-Year Unit Production measured in billions of U.S. 2020 dollars.

These corrections were made to the data features online, in the digital magazine edition and in the Aviation Week 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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COMMERCIAL AVIATION

Canadian Prime Minister Justin Trudeau said initial intelligence points to an Iranian surface-to-air missile as the cause of a Ukraine International Airlines Boeing 737-800 crash on Jan. 8. The flight, PS752, went down shortly after departing Imam Khomeini International Airport in Tehran, Iran, killing all 176 people on board, including 63 Canadians.

Beginning early in 2021, Airbus expects to increase A320-family output at its final assembly plant in Mobile, Alabama. The plan calls for seven aircraft a month, up from the current production rate of five.

Boeing will urge operators to put 737 MAX crews through simulator training before they return to line flying—a reversal triggered by trials that showed pilots were not executing emergency procedures correctly.

David Calhoun will take over as Boeing CEO on Jan. 13 as the company prepares to pause 737 MAX production in mid-January after Aircraft Line No. 7896 rolls off the Renton, Washington, assembly line (page 22).

Fuel distributor Shell Aviation has partnered with biofuel provider World Energy to supply Lufthansa Group with sustainable aviation fuel (SAF) on select flights from San Francisco (page 34).

JetBlue Airways is to offset 100% of carbon emissions from domestic flights beginning in July 2020 and will begin using SAF on all flights from San Francisco under an agreement with Neste (page 36).

China's Comac flew the sixth and last C919 prototype on Dec. 27, achieving an unpublished target that had begun to look doubtful. Comac is aiming at achieving certification in 2021.

The FAA has released its long-awaited proposed rule outlining requirements for drones to transmit identifying information to the ground (page 26).

Toulouse-based aerostructures specialist Latecoere is to acquire Bombardier's electrical wiring interconnection system assets in Queretaro, Mexico, for $50 million in cash.

Safran has joined the Aerion AS2 supersonic business jet program, providing the landing gear and engine nacelles. GE Aviation will develop the electrical power system, and GKN Aerospace is set to produce the empennage and part of the electrical system.

DEFENSE

The U.S. Air Force has transferred the 14th Air Force to the newly created U.S. Space Force. Headquartered at Vandenberg AFB, California, it is now known as U.S. Space Operations Command.

The U.S. Army is to demonstrate an intelligence-collecting system, the High-Accuracy Detection Exploitation System, in an attempt to field a new airborne surveillance fleet starting in five years.

First delivery of Russia's Sukhoi Su-57 fifth-generation fighter could be postponed after an aircraft crashed Dec. 24 about 111 km (69 mi.) from Komsomolsk-on-Amur during a production test flight.

The first Russian missile regiment armed with the Avangard nuclear-armed hypersonic glide vehicle became operational at Dombarovsky AB in southern Russia on Dec. 27, says the defense ministry (page 18).

Israel has begun development of a self-defense laser weapon system for aircraft. The country's defense ministry also plans to perform field trials of a ground-based laser system in 2020 (page 17).

Piaggio Aerospace has signed a $221 million contract with the Italian defense ministry for nine P.180 Avanti EVO turboprops, marking a turning point for the financially struggling company.

VERTICAL FLIGHT

South Korean carmaker Hyundai announced an urban air mobility partnership with Uber and unveiled a full-scale mockup of its S-A1 electric vertical-takeoff-and-landing aircraft (eVTOL).

HYUNDAI

VIEW FROM WASHINGTON

Raytheon's 3DELRR Reign Ends

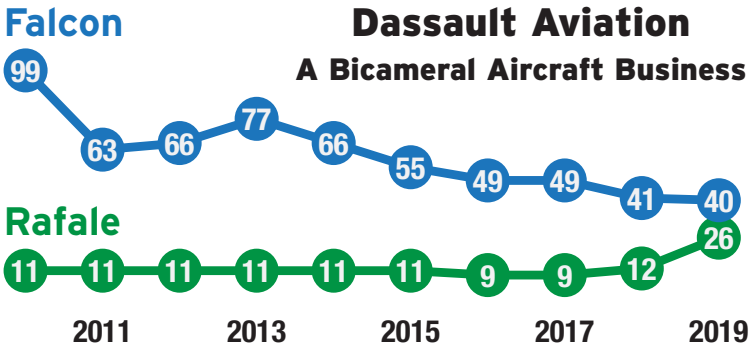
The U.S. Air Force intends to cancel Raytheon's contract for a next-generation three-dimensional long-range radar after facing technical difficulties, but the service will host an industry day Feb. 4 opening the program to other companies.

Raytheon won the contract in 2014 and was scheduled to deliver three production-representative radar systems by November 2020, two years past the Air Force's desired date. The holdup was the result of a lengthy contract protest by Raytheon's competitors, Lockheed Martin and Northrop Grumman. And now, technical difficulties with Raytheon's replacement for a ground-based TPS-75 three-dimensional passive, electronically scanned array have emerged.

Market research shows that alternative technologies can deliver the capability faster. The program office intends to release a solicitation following an industry day at Hanscom AFB, Massachusetts.

A new venture to develop a small, fast short-range eVTOL vehicle specifically for first responders has been unveiled by Carl Dietrich, cofounder of flying car developer Terrafugia.

BELL



Source: Dassault Aviation

From a record high in 2010, Dassault saw deliveries of Falcon business jets decline in 2019 to their lowest level since 1996, while deliveries of Rafale fighters rose to a record high on export orders.

Turkish Aerospace has rolled out the third prototype of its T625 Gokbey twin-engine medium helicopter as it begins to accelerate the aircraft's flight-test program.

Bell has unveiled a revised design for its Nexus eVTOL air taxi, with all-electric propulsion instead of hybrid-electric and four tilting ducted fans instead of six for increased cruise efficiency (page 28).

Leonardo Helicopters has flown the fourth prototype AW609 commercial tiltrotor. The aircraft is fully representative of the final configuration and includes the Collins Pro Line Fusion avionics suite.

EmbraerX, the innovation arm of the Brazilian manufacturer, is to collaborate with U.S. startup Elroy Air to expedite the entry into service of Elroy's Chaparral eVTOL unmanned cargo aircraft.

SPACE

SpaceX has opened what it hopes will be a busy 2020 launch manifest of 35-38 missions with the Jan. 6 liftoff of a Falcon 9 rocket carrying a third batch of Starlink broadband communications satellites.

CALT's Long March 5 heavy launcher returned to flight on Dec. 27, 2.5 years after the second mission failed due to an engine manufacturing flaw, removing a barrier to beginning the third stage of China's lunar exploration program.

The shuttle-derived core booster for NASA's first Space Launch System heavy-lift rocket rolled out from Michoud Assembly Facility in New Orleans Jan. 8 for transport to Stennis Space Center in Mississippi for a key test before launch.

Maxar Technologies has reached a deal to sell its MDA Canadian space subsidiary to a group of private equity investors led by Northern Private Capital for C$1 billion ($766 million).

100 YEARS AGO IN AVIATION WEEK

Our Jan. 15, 1920, cover featured a view from inside the Paris Aeronautical Exposition—now known as the Paris Air Show—which had been held at the glass-domed Grand Palais since 1909. Inside the issue, an advertisement from the Glenn L. Martin Co. of Cleveland (now Lockheed Martin) celebrated a new milestone achieved by one of its military aircraft. "When the Martin Bomber commanded by Col. R.S. Hartz and piloted by Lt. E.E. Harmon landed at Bolling Field, Washington, D.C., on Nov. 9, [1919], it set a new milestone in the aeronautical history of this country—having successfully completed a trip of 9,823 mi. around the rim of the U.S. [and setting] a record for sturdy efficiency that is absolutely unparalleled in the history of aviation," it read.


JANUARY 15, 1920 PRICE 25 CENTS

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Martin noted that the cross-country bomber had also set a new U.S. nonstop record, traveling 857 mi. in 7 hr. and 10 min.

Subscribers can access every issue of Aviation Week back to 1916 at: **archive.aviationweek.com**

UP FRONT
KEN GAZZOLA

Ceasefire

THERE IS A DISCOMFITING SENSE of deja vu with the recent tariff on Airbus exports to the U.S. The subsidy issue has been debated ad nauseum since Jean Pierson headed Airbus, with questionable subsidies on both sides of the Atlantic. In this latest round, the World Trade Organization (WTO) decision is nothing more than a simplistic, one-sided stab at addressing a complex, bilateral issue.

Urgently needed is an equitable resolution to close this anachronistic tit for tat, preferably before the other shoe drops, because you can bet the EU will respond in kind. By now, both sides should have recognized that commercial aviation is too critical to the global economy to allow this dispute to drag on and inflict real damage.

KUZMA/ISTOCK

Time to solve the Boeing-Airbus dispute

Healthy transatlantic relations are essential to the success of Airbus and Boeing, and the huge number of suppliers internationally that support both OEMs—not to mention the overall economies of the U.S. and the EU. It is in the best interests of all parties to resolve the dispute with a mutually beneficial compromise. Hundreds of thousands of jobs are at stake. Except in special cases, tariffs impede free trade, which is key to the success of global aviation. Protectionism is lose-lose.

The U.S. and EU governments, working through their trade representatives, should grant an antitrust exemption to Boeing and Airbus. Then they should send the companies into a room and tell them not to come out until they have devised an equitable resolution that can be submitted to their respective governments for approval. Such an approach would enable the governments to enter into a bilateral treaty, of which they could then notify the WTO.

This would force the two OEMs to prove they want a solution. Without bold action, this sensitive issue will continue indefinitely, and neither Airbus, Boeing nor the industry as a whole can afford this. For that matter, neither can the overall trade relationship between the U.S. and EU. The two sides claim they want to resolve the long-running dispute, so let them prove it.

An added incentive is that an agreement between Airbus and Boeing might actually set a much-needed precedent for other trade disputes under WTO jurisdiction. Taking another look at the 1992 EC-U.S. Agreement on Trade in Large Civil Aircraft might help with the process, since it was an effective bilateral formula.

The tired 15-year-old saga of Airbus versus Boeing—the international equivalent of the legendary quarrel in Appalachia between the Hatfields and the McCoys—arguing who gets what form of government support and whether that constitutes illegal aid has dragged on far too long. Is the leadership of both enterprises so wrapped up in their own self-interest that they lack any ability to see the bigger picture?

An honest reality check at any point along the petty, tortuous path both companies have been following—"honest" being the operative word—would have led them to acknowledge that both rivals historically have benefited enormously from direct or indirect government financial support. That only makes sense, since we're being honest here. Aviation is a strategic industry, and no economically advanced nation would dare risk leaving a sector so critical to its economy exposed entirely to market forces.

The second point is that healthy competition is one thing, but the ongoing bludgeoning both companies inflict on each other has become almost like a blood sport.

Airbus and Boeing leadership need to wrap their minds around the fact that the world is very different today than it was when their disdainful approach to undercutting the other started. Aviation/aerospace is now a truly global industry, with complex networks of supply chains on which both OEMs are highly dependent. But you would never know it based on the way these two industrial leviathans hammer away at each other, with seemingly little regard to the collateral damage. Disrupt those, and the two of them could face far bigger problems.

Another consideration is that Airbus and Boeing will find themselves sharing the reality of a competitive landscape that includes new rivals as fierce and determined to succeed as Airbus was when it challenged U.S. dominance of the commercial aircraft market. They should be laser-focused on this.

The way forward should be clear: One or both of the dominant manufacturers need to take the first step, but that is going to take uncommon leadership. If there was ever a time for uncommon leadership, it is now. Any takers?

Delays help no one and could hurt everyone.

Kenneth E. Gazzola was publisher of Aviation Week from 1987 to 2006.

GOING CONCERNS

MICHAEL BRUNO

Slowing Down

737 MAX grounding hits the supply chain

THE 737 MAX-RELATED LAYOFFS had already begun before 2019 was over. Aviation Week's Wichita bureau chief says smaller suppliers near 737 aerostructures provider Spirit AeroSystems started cutting their workforces around the Air Capital of the World before New Year's Eve, and not because of usual holiday shutdowns.

This was not how the commercial aerospace sector expected to enter 2020. A year ago, suppliers were talking about not being able to hire enough workers to keep up with Boeing's 737 monthly production rate increases, planned to be at least 57 new aircraft by now.

Fast forward, and the specter of layoffs is likely to be a leading topic of conversation around boardrooms and dinner tables, from Wichita to Chicago to Seattle, let alone the countless smaller municipalities that are home to hundreds of suppliers on the halted narrowbody program. With Boeing and Spirit shutting down their respective 737 manufacturing lines indefinitely this month, a nightmare scenario is turning into reality.

Through the holidays, companies have been practically silent, ostensibly because the optics of negative comments were bad, and also due to self-imposed quiet periods before the release of 2019 financial results starting at the end of this month. But they are also struggling to work out exactly what the production stoppage and new leadership at Boeing all means and whether there will be financial aid from the OEM or governments. Nevertheless, industry observers are increasingly clear the impact will be widespread and bruising.

"The suspension of production will have far-reaching adverse consequences for the broad aerospace and defense supply chain," a team of analysts at Moody's Investors Service say in a report issued Dec. 23, the same day Dennis Muilenburg was fired. "Reduced activity related to the 737 MAX—one of the biggest aircraft programs by volume globally—will precipitate lower revenues, earnings and cash flows, and slow the growth in operating profits that we had previously anticipated for 2020 under the former assumption that the MAX grounding would end in January."

CNBC celebrity stock picker Jim Cramer was more blunt a few days earlier. He says production halts suppress the whole aerospace manufacturing sector and likely mean 2020 forecasts across industry will have to be cut or, at the least, weighted to the back half of the new year. "Honeywell? Yes. Spirit, TransDigm, those will be hurt," Cramer opines. "But I think we have to revisit the earnings per share for United Technologies and GE, and these are companies that have been great suppliers to Boeing. I'm waiting for big revisions down."

While the MAX is down, it is not out, and there is still blue sky in long-term forecasts. Yet analysts do not see the commercial aero sector normalizing until 2021 at the soonest. As for 2020, whatever happens, it will be darker than what many expected just a month ago.

A 2020 forecast issued Dec. 18 by Moody's called for 6% profit growth, including Boeing's, but that assumes the MAX's grounding does not last beyond mid-year.

Rival Fitch Ratings also calls the MAX's return critical. "The impact of the MAX suspension should be temporary unless substantial orders are canceled," the credit agency said Dec. 19. "Our rating case assumes the MAX groundings will be lifted in phases by different regions through early second-quarter 2020 and that deliveries in various regions will resume shortly afterwards."

Boeing 737 MAX Supplier Exposure

Company	Shipset* (U.S. $ millions)	737 MAX 2019E revenues: Revenues (U.S. $ millions)	737 MAX 2019E revenues: Percent of total
Astronics	$0.1	$53	7%
Crane Co.	0.2	112	3
Ducommun	0.2	106	15
Hexcel	0.4	224	9
Spirit AeroSystems	6.5	4,056	52
TransDigm Group	0.5	281	5
Triumph Group	0.3	160	6

*The value of an individual bundle of Boeing 737 products delivered to the manufacturing customer.

Sources: Company reports, Canaccord Genuity estimates

However, the long-term impact of the MAX grounding on the aerospace sector is likely to be negative due to growing regulatory scrutiny, the ratings agency adds. New aircraft certifications will take longer and became costlier for manufacturers, while regulatory actions in case of difficulties are likely to be faster and more rigorous.

Others agree that the MAX freeze augurs worse-than-before results for A&D in 2020. "We can expect a negative ripple effect across the aerospace industry in 2020," Accenture Global A&D Lead John Schmidt tells Aviation Week. "This impact is likely to be more significant than prior rate reductions because of the complexities facing suppliers in restarting idled production lines back up to full production rates."

In October—when Boeing still was promoting a MAX return to service by year-end—Schmidt's group had already halved its expected growth forecast for global A&D in 2019 to just 2.5%. Rival Deloitte projects commercial aircraft order cancellations and lower-than-expected new orders in 2019 likely meant total airliner production was cut to around 1,450 units. Airbus and Boeing should issue their tallies imminently. But while the coming weeks should bring a lot more information for the sector, there likely will be even more questions.

INSIDE BUSINESS AVIATION
WILLIAM GARVEY

Signs of the Times
Avfuel serves **one in three**

AS EVERYONE WHO HAS LIVED the experience knows, getting assigned roommates as a college freshman is the luck of the draw. If they turn out to be serious students, but social, funny and good-natured, you win. Get some slovenly slugs who party hard while abstaining from study, and, well, it's a long semester.

For University of Michigan frosh Craig Sincock, the match brought a life-changing surprise, as things turned out. The strangers sharing his new Wolverine den were not just ordinary undergrads, but certified flight instructors (CFI) who were keen to practice their craft on him. And he readily agreed, becoming an avid member of the Michigan Flyers in the doing.

By the time he graduated from the Ross School of Business, Sincock was a committed aviator. Unlike his CFI roomies headed for piloting careers, he put both his degree and pilot's license to good use working in investment banking and corporate consulting. To meet with clients, he would often fly himself to their places of business.

AVFUEL

One was a small, four-person operation begun in Ann Arbor in 1973 to supply fixed base operators (FBO) in Michigan, Ohio and Indiana with Jet A and avgas. Intrigued by the little outfit's potential and its all-aviation focus, Sincock bought the company when it became available in 1983. It proved to be another good match.

At the time, fuel was delivered into aircraft under a variety of brands including Phillips, Shell and Amoco. However, Avfuel's new owner questioned the business sensibility of deferring his company's name to enhance big oil brands. Not long thereafter, Avfuel, when possible, began putting its name above the pumps. That signage proliferation expanded considerably in 1988 when Avfuel acquired Pride Aviation, a West Texas refiner with dealers in Western states, and replaced the Pride signs with its own. Five years later, it repeated that process when it acquired Triton Energy's FBO businesses, located mainly in Texas and the Southeast, and then again when it assimilated Texaco Aviation. Today, the Avfuel sign stands at more than 650 branded FBOs across North America and Europe.

Avfuel is not a refiner; rather, Sincock describes his company as a critical distribution provider that delivers fuel to 5,500 customers including flight departments, airports, passenger and cargo carriers, the military and rotary-wing operators in addition to FBOs, 21 of which it owns. And it does so in 120 countries. In that daily far-flung process, company personnel note customers' pain points and consider whether Avfuel might provide relief.

Over the years, those deliberations have resulted in 31 acquisitions through which Avfuel provides insurance for pilots, airports, distributors and related facilities; designs and installs fuel storage tanks; manufactures and maintains tanker trucks and refueling equipment; offers flight-planning and trip-support services; and leases aviation equipment. In so doing, Sincock says his company in some way touches one of every three U.S. business flights and brands nearly a quarter of all FBOs. He was right long ago about its potential.

The original four-person staff has expanded to roughly 1,000 employees globally, and one notable addition signed on in 2011. An investment analyst for a hedge fund with an MBA and bachelor's in economics from Harvard, C.R. Sincock II easily transitioned into his father's company. After all, while at Harvard he researched and wrote papers on the supply-and-demand economics of jet fuel, price fluctuations in jet fuel during supply/demand shocks and a competitive analysis of Avfuel's position in the marketplace.

Now, as Avfuel's executive vice president, "CR" is in charge of the company's global business strategy, analyzing potential expansion moves and possible acquisitions in the U.S. and internationally.

One of the company's main focuses is on increasing production and distribution of sustainable aviation fuel (SAF) throughout the aviation community. The fuel, which can be blended with fossil-based Jet A, is both expensive and hard to find—there's only one refiner in the U.S.—but the senior Sincock notes that number is increasing both in the U.S. and abroad, and as they come online SAF's current high price should begin to fall.

That progress cannot come too soon as far as he is concerned, because aviation in general, but business aviation in particular, is being branded as polluters (see page 32), its byproduct being carbon dioxide. While SAF will not eliminate that, when compared to traditional Jet A, its CO_2 output is reduced by as much as 85% over its life cycle. And Avfuel, along with its many competitors, is ready and eager to deliver.

Meanwhile, as when he first entered the business world, Sincock, who holds an Air Transport Pilot license, continues to fly to conduct face-to-face sessions with clients, suppliers and to support industry campaigns, only now the former collegiate flying clubber does so most often in his global conglomerate's Citation Citation XLS+ or Dassault Falcon 2000LXS.

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

AIRLINE INTEL

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Recalibrating Emirates

After **Tim Clark retires**, the airline must find a new strategy

DUBAI AIRPORTS

TO GET AN IDEA OF WHAT TIM CLARK and colleagues have built over the past decades, spend a few hours on the terrace of Emirates' headquarters building, adjacent to Dubai International Airport. If security were to allow such a special visit, the best time would be well past midnight.

Observers would see an airport humming with activity as the world's largest fleet of Airbus A380s makes connections and leaves after a couple of hours, or the world's largest fleet of Boeing 777-300ERs returns from "secondary" markets. With people from one end of the globe connecting to places at the other end in the middle of the night, the overcrowded terminals feel like a giant space station full of jet-lagged travelers.

Clark, the president of Emirates Airline who announced his retirement for mid-2020, has the privilege of watching the scene from his office on the top floor. He is one of the primary architects of what has become the world's biggest international hub. There were others who played key roles over the years, most importantly Sheikh Ahmad Bin Sayed Al Maktoum, Emirates group chairman and CEO, and Maurice Flanagan, who was tasked with setting up the airline in 1985 and retired as vice chairman in 2013, aged 85.

Although Clark has been at Emirates almost from the very beginning, he did not stant out as head of strategy. Having just turned 70, Clark is more than 20 years younger than Flanagan, the leading expat executive before him. He became the airline's president in 2003 and was the mastermind behind its rise. The concept: take advantage of Dubai's geographic location to create a hub connecting mainly long-haul to long-haul. Consequently, Emirates does not operate any narrowbody aircraft, while sometimes deploying A380s on the short flight to Muscat, Oman, or similar destinations. Clark once called that "intelligent misuse of capacity."

It's important to note that Emirates did not invent the hub concept. FedEx introduced the idea first in the cargo industry, and KLM Royal Dutch Airlines later adopted it for its Amsterdam passenger hub. But Emirates managed to break into an existing order of established—and often inefficient—legacy airlines in Europe, the Asia-Pacific region and Africa. It showed success is possible outside of the global alliances, which are now being weakened from the inside. Emirates instead has been using an existing hub concept, massive investment and much larger aircraft. The smallest jet in its current fleet, the 777-300ER, is too large for most other airlines. The concept was partly copied by Qatar Airways and Etihad Airways, but neither turned it into a financial success, and Etihad has long dropped the idea of trying to compete with its Dubai rival.

Clark can claim many achievements in 30 years of building the airline empire, including driving aircraft and engine manufacturers to optimize aircraft design. He also played an important role in the improvement of aircraft cabins and inflight entertainment, an important prerequisite in ultra-long-haul flying.

However, Emirates' development appears to have plateaued. International air transport has seen many trends and drivers over time: deregulation in the U.S. and later in Europe, the rise of European and later Asian low-fare airlines and, the rise of Gulf carriers.

Nowadays, rather than trying to copy what Emirates has done, the industry is focusing on other concepts and seems to be successful doing so. Low-cost carriers continue to thrive, although environmental pressures will be a growing threat. On the legacy side, Delta Air Lines and International Airlines Group are the front-runners in successfully building airline groups—an idea Emirates has really never been interested in, apart from an unsuccessful stint with SriLankan Airlines.

Probably more important, the concept of operating very large widebodies is fading. The last few A380s are being built this year, with the last to be delivered in 2021. The 777X program has seen sluggish demand, and even Emirates has cut back its launch order. Instead, technological advances driving development of the Airbus A321XLR, capable of flying true long-haul routes, now favor airlines with hubs nowhere near the size of Dubai.

Emirates already has begun to reinvent itself. It is driving integration with sister airline and narrowbody operator FlyDubai, as demanded by Dubai's government, ordered smaller widebodies and is slowly beginning to reduce its A380 fleet, creating a big opportunity to drive higher yields. The challenge for the next Emirates leadership will be to recalibrate the airline. Thanks to Clark and others, they can do so from a position of strength.

STARLINER STUMBLE

> BOEING CREW FLIGHT TEST ON HOLD

> SPACEX TO DEMO DRAGON INFLIGHT ABORT

Irene Klotz Cape Canaveral

NASA had hoped 2019 would be the year the U.S. restored its capability to fly astronauts into orbit aboard U.S. rockets. But both Boeing and SpaceX, the companies selected in 2014 to develop commercial space taxis in partnership with NASA, faltered, pushing crewed flight tests into 2020.

The latest problem occurred with Boeing's CST-100 Starliner, which returned from its December uncrewed orbital debut just two days after launch aboard a United Launch Alliance Atlas V, having never reached the International Space Station (ISS). Rather than unpacking science experiments and other equipment coming back from the station, Boeing and NASA are unraveling a software glitch that left Starliner's mission elapsed timer 11 hr. ahead of the correct time.

That error cost Boeing the ISS docking, though Starliner's fruitless attempts to correct its orientation gave the propulsion system an unexpectedly robust workout. Boeing salvaged as much of Starliner's abbreviated Dec. 20-22 Orbital Flight Test (OFT) as possible, extending and retracting the docking system, establishing communications with the ISS and navigating in orbit.

Most important, Starliner successfully deorbited, reentered the atmosphere and made a pinpoint parachute landing on the ground—a first by a U.S. human-class capsule. Starliner returned after 33 orbits with a 7:58 a.m. EST touchdown at the White Sands Missile Range in New Mexico on the runway once used by the space shuttle program.

"This did not go according to plan in every way that we would have hoped, but it is also true that we got a lot of really good information so we can keep making meaningful progress," NASA Administrator Jim Bridenstine told reporters after the landing. "That's very good from my perspective."

Even though the docking at the ISS did not occur, Boeing said it expects to glean 85-90% of the expected flight-test data. In addition to the inflight operations and landing systems, the OFT also demonstrated a new configuration and flight profile of the Atlas V, which is needed to certify the vehicle for human spaceflight.

"We have a going design here," says Jim Chilton, senior vice president of Boeing's space and launch division. "We didn't do everything we wanted to do, but we don't see anything wrong with this spaceship right now."

Starliner's Jan. 8 return to its processing hangar at the Kennedy Space Center in Florida set the stage for a joint Boeing-NASA investigation into the misconfigured mission elapsed timer and other potential software issues. The probe is expected to take about two months. In parallel, NASA said it will evaluate the data collected during Starliner's abbreviated flight to determine if another uncrewed demonstration will be required prior to a flight test with astronauts. That assessment is expected to take several weeks.

"NASA's approach will be to determine if NASA and Boeing received enough data to validate the system's overall performance, including launch, on-orbit operations, guidance, navigation and control, docking/undocking to the space station, reentry and landing. Although data from the uncrewed test is important for certification, it may not be the only way that Boeing is able to demonstrate its system's full capabilities," Bridenstine noted in a program

Boeing's CST-100 Starliner spacecraft returned from an abbreviated orbital flight test on Dec. 22 at White Sands Missile Range in New Mexico.

update posted on the agency's website.

The clock is ticking. NASA's current contract for rides on Russian Soyuz spacecraft—the sole system to fly crews to the ISS since the space shuttles' retirement in 2011—expires with the return of the Expedition 63 crew in October.

Before adjourning for the holidays, Congress extended a waiver of the Iran, North Korea, and Syria Nonproliferation Act (Inksna) which allows NASA to negotiate with Russia for additional Soyuz seats. President Donald Trump on Dec. 20 signed ominibus appropriations bills that included the Inksna exemption, which was set to expire at the end of 2020. The waiver now extends to Dec. 31, 2025.

The seats will be expensive—the last price was $82 million apiece—and limited. NASA had hoped either or both Boeing and SpaceX would be flying astronauts by now. Instead, the agency is training Russian cosmonauts to perform spacewalks in U.S. spacesuits and operate the robot arm in case of U.S. station staffing cuts. The ISS currently is staffed by four astronauts and two cosmonauts.

NASA awarded Boeing and SpaceX flight-test and service contracts in 2014 in hopes of restarting human spaceflights from the U.S. by December 2017. Now it is looking at ways to mitigate an increasingly likely gap or cutback in U.S. station staffing.

SpaceX, which conducted a successful orbital flight test and ISS docking of an unmanned Crew Dragon in March 2019, is preparing for a Jan. 18 demonstration of Dragon's inflight abort system. It had hoped to conduct the test last spring, but the capsule was destroyed during preparations for a ground-based static test firing.

The vexing and time-consuming challenges have not shaken NASA's confidence in the Commercial Crew program, nor the public-private partnering approach it intends to expand for the Artemis lunar exploration initiative.

"We will launch American astronauts on American rockets from American soil in the very near future," Bridenstine said. "That is an objective we intend to meet."

BILL INGALLS/NASA

What Happens to Space Tourism if There Is a Fatal Accident?

> VIRGIN GALACTIC'S OPERATIONAL DEBUT SPARKS ACCIDENT ANALYSES

> CUSTOMER DEMAND LIKELY TO EXCEED FEAR

Michael Bruno Washington

Next year is likely to herald the dawn of routine space tourism, with Virgin Galactic anticipating its first commercial launch in 2020. One goal of billionaire-backed upstarts such as Virgin, Blue Origin and others is to make orbital experiences as common for paying passengers as flying on an airliner.

But as the Dec. 20 timer glitch that kept Boeing's Starliner spacecraft from reaching its intended rendezvous with the International Space Station proves, even an unmanned space mission that goes wrong can generate big headlines. So, what happens to a business that provides space tourism if a tragic, fatal mishap occurs, especially in the beginning of operations? Investors want to know and, to a degree, publicly traded and regulated companies such as Virgin Galactic need to have a response ready, because it is a key business risk.

Virgin Galactic has responded, saying balancing risk with shareholder reward is part of the business and investors and customers are being made aware of all the risks (*AW&ST* Nov. 11-24, 2019, p. 47). Of course, Virgin Galactic's supplier Scaled Composites already had had a fatal crash in 2014 in which one pilot died. But that was in a testing phase, and investors want to know about business prospects now as Virgin Galactic prepares for launching commercial service. In turn, financial analysts are weighing in.

Opinions are divergent, with practically all analysts acknowledging that a bad accident with a death toll has the potential to shut down Virgin Galactic. "A major accident could slow or close the business, or cause demand to decline significantly," Credit Suisse analyst Rob Spingarn and his team say.

But not everyone agrees that outcome is likely. Vertical Research Partners analyst Darryl Genovesi and his team look back on the NASA space shuttle and NASA-Defense Department X-15 programs for guidance, as well as niche extreme-adventure marketplaces such as mountain climbing, which serve the same level of wealthy clientele that space tourism companies seek initially.

The Genovesi team believes the 1960s-era X-15 program, the world's first spaceplane, is the best comparison to Virgin Galactic's situation.

"If we assume that the probability of a fatal crash is [about] 0.5% per commercial flight, which is what X-15 actually realized during the late 1950s and early 1960s flying the same mission (one fatal crash over 199 flights), then the probability of Virgin Galactic crashing once over its next 131 commercial flights over the next two years is [about] 48%," the Vertical team says.

By the end of 2020, the company will have completed 16 of the 131 flights. Keeping with a 0.5% per flight likelihood, the probability of Virgin Galactic crashing during 2021 would then drop to around 44%. "We don't estimate a probability of it crashing in a subsequent flight (beyond 131), but we do assume a crash out there doesn't result in a program pause or meaningful loss of revenue subsequently," they say.

Another way to look at the potential effect of a fatal crash on a space tourism business is whether customer demand would evaporate. Here, Genovesi examines space shuttle history for indications.

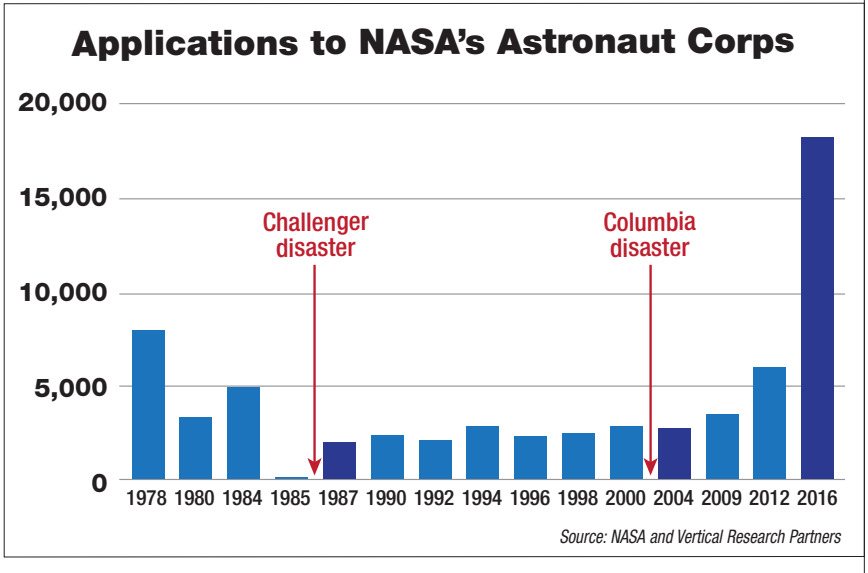
"The shuttle program didn't end after its two catastrophes—and neither did the X-15 program after its fatal crash, and neither did the Virgin Galactic program after its fatal crash," says Genovesi's report. Instead, after the Challenger disaster, NASA built another shuttle.

That was possible due to widespread public support for the space program. In fact, applications to become a NASA astronaut rose after both fatal accidents (see graph).

Analysts believe public support is even more pervasive now. They cite a 2019 Pew Research study that found 58% of Americans polled think human astronauts are essential, while half think human space travel will become routine in the next half-century. More than 40% indicated interest in traveling to space themselves.

Finally, the analysts point to extreme mountain climbers, a niche group of usually highly ambitious and wealthy individuals. They note that around 5% of the roughly 2,000 people who attempt to climb mountains 8,000 m (26,000 ft.) high or more die every year trying.

"Said differently, [about] 5% of the die-hards do literally die," Genovesi wrote. "Everyone who tries knows what he's getting into and chooses to devote significant time and resources to the adventure anyway. Virgin Galactic is counting on a similar commitment from its customers wherein there is some meaningful risk of [a] fatal accident even if they can't exactly quantify it."



Israel Enters Airborne Laser Weapon Market

- ISRAELI EFFORT APPEARS SIMILAR TO THE U.S. AIR FORCE RESEARCH LABORATORY SHIELD PROGRAM
- AIRBORNE APPLICATION IMPLIES PROGRESS ON GROUND-BASED LASERS

Steve Trimble Tel Aviv

Israel has started development of a self-defense laser weapon system for aircraft, sources in the Israeli defense sector say.

The country's defense ministry also plans to perform field trials of a ground-based laser system in 2020 using technology developed by Rafael and Elbit Systems, according to Israeli media reports.

Elbit Systems, which produces laser countermeasures, rangefinders and pointers, is developing the airborne technology demonstrator for manned and unmanned aircraft under a defense ministry contract, sources say. The aim of the project is to provide air superiority and air defense, they say.

A self-defense laser system includes a beam-tracking system to illuminate the target and a high-power laser to intercept the incoming missile with a blast of thermal energy. A podded system includes separate subsystems for power generation and thermal management within the pod. A more advanced system integrated inside an aircraft would require a significant internal capacity for onboard power generation and cooling.

ISRAEL DEFENSE MINISTRY

An image released by the Israeli military depicts a concept for a laser interceptor pod for rockets mounted on the nose of a generic UAV design.

Self-defense lasers for aircraft tend to fall into a power class of 50-100 kW. Elbit Systems' laser technology has transitioned from highly inefficient flashlamp-pumped to solid state, diode-pumped lasers. The change improves overall efficiency from about 1% to about 35%. But a diode-pump laser still requires a power-generation capacity of 150-300 kW to produce a 50-100-kW laser beam, with about 100-200 kW of waste energy, or heat, that must be cooled or vented overboard.

The outlines of the Israeli program appear similar to the U.S. Air Force Research Laboratory's (AFRL) Self-protect High-Energy Laser Demonstrator (Shield) program. In fiscal 2021, the Air Force plans to test in flight a Shield pod, which includes a Lockheed Martin laser, Northrop Grumman beam tracker and Boeing pod system. Last May, the AFRL demonstrated the ability to intercept missiles from a ground-based surrogate for Shield. The AFRL had borrowed the Army's 150-kW High-Energy Laser Weapon System (HELWS) for the ground-based demonstration.

The challenge for Shield is to miniaturize the components for the HELWS so that they can be installed and operate in the smaller and harsher environment of an aircraft.

As HELWS served as a building block for Shield, Israel's investments in ground-based high-energy lasers for air defense likely served as a steppingstone to the Elbit demonstrator. Rafael, Israel Aerospace Industries and Elbit have acknowledged interest in such programs for several years.

Rafael has been the most public. The Haifa-based, state-owned company unveiled the "Iron Beam" concept at the Singapore Airshow in 2014, presenting a system that could intercept rockets, unmanned aircraft systems and ballistic missiles with lasers instead of the Iron Dome's rocket-powered, hard-kill interceptors.

Although Israeli companies decline to provide updates on ground-based systems to outsiders, there is evidence that such concepts have advanced in maturity over the last five years. Israel's leading financial newspaper, *Globes*, reported in 2018 that the Israel Defense Forces launched development of a laser interceptor system in 2016 and was then "on the verge of being ready" for operations. An anonymous source quoted in the article said a system could be ready to enter service by 2021 or possibly earlier, depending on funding levels.

The Rafael-designed Iron Dome now protects Israel from rocket attacks, with a reported successful intercept rate of about 85%. Although Iron Dome has been highly effective, Israel remains concerned about certain scenarios, such as a third Lebanon war. The second Lebanon war in 2006 spurred development of the Iron Dome system, as the Iran-backed Hezbollah group launched thousands of Qassam rockets into Northern Israel.

In the years since, Israel and U.S. government officials have accused Iran of smuggling thousands of unguided and guided rockets to Hezbollah cells in Lebanon and Syria. A 2018 report by the Center for Strategic and International Studies estimated that Hezbollah then possessed a stockpile of 130,000 rockets.

Using the Israeli government's touted 85% success rate for Iron Dome, Israel would have to stockpile at least 155,000 interceptors at a daunting estimated cost of $50,000 each. An interception system based on high-energy lasers, by contrast, would be expensive to develop and field, but the cost per interception would be almost negligible.

As Russia Fields Avangard, U.S. Scrambles to Develop Counter

> INTERCONTINENTAL AVANGARD DECLARED OPERATIONAL

> U.S. SETS LATE-2020S GOAL TO FIELD GLIDE-PHASE DEFENSE

Steve Trimble Washington

As Russia fields an intercontinental-range missile with a nuclear-armed Avangard hypersonic glide vehicle (HGV), new details show the U.S. Missile Defense Agency (MDA) is focused in the near term on developing a capability to intercept shorter-range threats.

RUSSIAN DEFENSE MINISTRY

A new era of maneuvering, hypersonic weapons began when Defense Minister Sergei Shoigu (left) notified President Vladimir Putin on Dec. 27 that the first Avangard regiment was ready to stand on nuclear alert from southern Russia.

Defense Minister Sergei Shoigu informed President Vladimir Putin on Dec. 27 that UR-100N intercontinental ballistic missiles tipped with nuclear warheads inside Avangard HGVs are ready for combat duty at the Dombarovsky launch site in southern Russia.

The fielding of Avangard closes a chapter in Russia's decades-long pursuit of an operational HGV, a weapon designed to evade U.S. missile defenses by maneuvering below and around the MDA's space-based and terrestrial tracking systems. Russia's investment evolved from the 1990s-era Project 4202 to a series of launch demonstrations of the Yu-71 HGV starting from the middle of the 2000s. Putin renamed the project Avangard in a March 1, 2018, speech that identified the HGV as one of several so-called "super weapons" in development by Russia.

Leaked U.S. intelligence reports obtained by CNBC cast doubt on Russia's ability to mass-produce Avangard HGVs, suggesting it is no more than a silver-bullet capability. But the operational declaration by Shoigu also means Russia has taken the early lead in a global race to field maneuvering, hypersonic weapons.

Unlike Russia, the U.S. and China appear to be focusing on shorter-range HGVs with conventional, rather than nuclear, warheads. By the end of 2020, the U.S. Air Force plans to conduct the first air launch of the Hypersonic Conventional Strike Weapon (HCSW), which if successful may demonstrate a limited operational capability with a prototype design. The HCSW could be followed into service by two more air-launched weapons, the AGM-183A Air-Launched Rapid Response Weapon and the Hypersonic Air-Breathing Weapon Concept, by 2022. The Army's ground-launched Long-Range Hypersonic Weapon is scheduled to arrive by 2023, followed by the Navy's sea-launched Intermediate-Range Conventional Prompt Strike HGV a year later.

China, meanwhile, described the HGV-armed DF-17 missile displayed during the National Day parade on Oct. 1 as an "operational" system, but it is not expected to be deployed until later this year. The dimensions of the DF-17 indicate a regional capability, likely aimed at neutralizing U.S. and allied bases in the Pacific at the beginning of any regional conflict.

The MDA has spent more than $160 billion to develop the Ballistic Missile Defense System since 2002, but U.S. officials acknowledge its sensors and interceptors have little inherent ability to shoot down HGVs maneuvering within the atmosphere.

So the agency plans to spend more than $600 million over the next five years to develop a counter-hypersonic capability. In the near-term, the agency's Hypersonic Defense Weapon System (HDWS) program is evaluating adaptations of terminal-phase weapons, including the Lockheed Martin Valkyrie and the Raytheon SM-3 Hawk concepts. Two more glide-phase missiles—Lockheed's DART and Boeing's Hypervelocity Interceptor—also are being studied. Finally, the MDA is considering Raytheon's proposal for a directed-energy intercept system. The five concept-refinement studies are due to be completed by May.

In parallel, Aviation Week revealed in early December the MDA's plans to perform a demonstration called the Regional Glide-Phase Weapon System (RGPWS). An industry day was held in Huntsville, Alabama, with the HDWS candidates and others, including Northrop Grumman, in attendance. The RGPWS is open to traditional, kinetic interceptors, along with options using directed-energy or high-power microwaves, the MDA says. A technology will be selected for a risk-reduction phase, likely using existing test ranges and facilities.

The flight experiment results will be used as background for the MDA's plans to field a follow-on operational interceptor. "Depending upon congressional support and funding, the RGPWS demonstration program will inform system design for a future glide-phase weapon system to be fielded in the mid-to-late 2020s," the MDA says.

European States Plan for Hypersonic Defense

- TWISTER HAS BEEN GIVEN BACKING BY AN EU PESCO INITIATIVE
- MBDA IS INVESTING IN ENGAGEMENT PLANNING FOR UNPREDICTABLE TARGETS

Tony Osborne London

European countries have linked arms to develop a counter to the emerging threat of hypersonic weapons and enhance their ballistic missile defense (BMD) capabilities.

The Timely Warning and Interception with Space-based TheatER surveillance (Twister) project, led by France and supported by Finland, Italy, the Netherlands and Spain, is one of 13 new multinational programs that were given the backing of the EU's Permanent Structured Cooperation (PESCO) initiative in November. It says it aims to develop a European system that can "detect, track and counter" more complex missile threats and give member nations a "self-standing ability to contribute to NATO's ballistic missile defense."

Currently, only a handful of European nations can counter ballistic missiles, including European users of the Raytheon Patriot (Germany, Greece, the Netherlands and Spain), as well as France and Italy with the Eurosam SAMP/T. But none of those systems is ready to deal with the new generation of threats emerging from Russia and China, including hypersonic gliders, hypersonic and high-supersonic cruise missiles, and maneuverable next-generation combat aircraft.

The U.S. has also begun examining technologies through its Regional Glide-Phase Weapon System (RGPWS), disclosed by Aviation Week in December, and the Hypersonic Defense Weapon System.

"We have seen the hypersonic threat coming," says Rainer Stockhammer, team leader for Twister at European missile manufacturer MBDA. "Over the last five years we have performed studies into these new threats, which are new in terms of both novelty and maneuverability, and now we are in a position to answer this PESCO call."

MBDA is now positioning itself for a role in developing the endoatmospheric interceptor that could be the backbone of the wider Twister system in the 2030s, describing the future system as "disruptive" and "technologically demanding."

The company will not discuss what architecture it is studying for the future interceptor, but Stockhammer says MBDA's experience with the Aster family of vertically launched surface-to-air missiles and the Meteor air-breathing, beyond-visual-range air-to-air missile has given it a "good position . . . to be able to develop a solution."

The company's artist's impression depicts a missile clearly equipped with air intakes, which would suggest the use of a ramjet like on the Meteor.

Use of a ramjet would provide not only more range and speed, but also more energy in the final stages of an engagement to maneuver against hypersonic gliders and other maneuverable reentry vehicles.

"We know what kind of accuracy and range we need from the sensing part," says Stockhammer. "Now we will look at a way to manage the unpredictability and look at engagement planning. . . . This is where we are investing."

MBDA has also been looking at the command-and-control mechanisms required for such a system and how it would interface with existing and future sensors.

Individual governments will ultimately decide how they will equip with the future interceptor, but MBDA expects it to arm ships and a ground-based air defense system, with the expectation the system may have to squeeze into existing launch boxes and vertical launch tubes on surface ships.

Securing the nod from PESCO is a major step forward for the program. The next step will be for the five nations to begin hammering out a concept and a high-level requirement.

MBDA

The complex nature of intercepting hypersonic weapons may predicate air-breathing propulsion technologies to provide additional range, speed and energy.

MBDA officials say they are working toward a timeline of the 2030s to produce an operational system.

By working through PESCO, the five nations are hoping this will enable them to secure development funding from the European Defense Fund (EDF), which is expected to provide €13 billion ($15 billion) to support collaborative defense projects in 2021-27. It is unclear how much a program such as Twister could receive from the fund.

Money will also be provided by national governments involved in the Twister program.

Although MBDA lobbied in France for European nations to pursue an evolution of European BMD capabilities, prompting Paris to take a lead in what became Twister, the company is unlikely to be the only player in the program.

The interceptor will be just one component of Twister. The PESCO initiative also calls for space-based early warning, but no details have emerged about the European industry approach to this yet. PESCO and EDF rules call for cooperation between industry, particularly small and medium-size enterprises, as well as between member states.

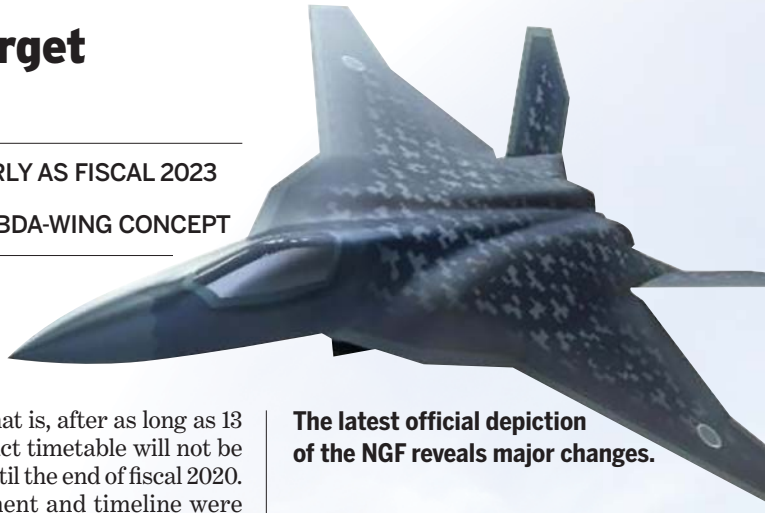
"We would need to build an industry consortium that is clear, but it is too early to talk about how this might look," notes Stockhammer.

Japan Sets Fiscal 2021 Target for Partner To Join NGF

> FULL-SCALE DEVELOPMENT COULD BEGIN AS EARLY AS FISCAL 2023

> MINISTRY PUBLISHES RADICALLY CHANGED LAMBDA-WING CONCEPT

Bradley Perrett Beijing



The latest official depiction of the NGF reveals major changes.

JAPANESE DEFENSE MINISTRY

Things are moving with Japan's plan to develop a fighter for the 2030s: Seven days after the government for the first time allocated specific funding for the program, the defense ministry set a target to begin working with a foreign partner in the fiscal year beginning in April 2021.

The ministry also published a new design for the fighter, suggesting an even greater emphasis on range and payload. The design, not confirmed as preferred, appeared as the ministry detailed total funding of ¥28 billion ($260 million) for the fighter and related technologies in fiscal 2020.

A program name change from the Future Fighter to the Next-Generation Fighter (NGF), mentioned by Defense Minister Kono Taro on Dec. 17, is confirmed in the ministry's Japanese-language budget report for fiscal 2020.

Meanwhile, a U.S. think tank has urged Japan to choose an adaptation of the Lockheed Martin F-22 Raptor with avionics from the F-35 Lightning and a larger wing. Japan's alternatives include developing an entirely indigenous design with help from BAE Systems, Northrop Grumman, Lockheed Martin or Boeing, the latter an undeclared but presumed candidate. Japan could also participate in the British Tempest program with BAE, picking and choosing from available design elements.

Full-scale development of the NGF could evidently begin as early as fiscal 2023, since the ministry plans three years to nail down what it wants to create. "From fiscal 2020 to 2022, the concept of the Next-Generation Fighter will be examined," the ministry says. "By end of fiscal 2020, the contents of international cooperation will be clarified, and the overall plan of the development project will be formulated."

The "contents" will presumably include the foreign partner's identity and role, factors that must influence the schedule. A somewhat ambiguous timeline published "for reference" (and therefore subject to change) showed development finishing at the end of fiscal 2035—that is, after as long as 13 years. The exact timetable will not be determined until the end of fiscal 2020.

This statement and timeline were part of a program evaluation review, a standard ministry document prepared to explain a program before it begins. The ministry published it on Dec. 24, a week after the cabinet agreed to put ¥11.1 billion in the fiscal 2020 budget specifically for the NGF, as distinct from its preparatory technology programs. As the budget was allocated, Kono confirmed Japan was talking to possible British or U.S. partners.

Mitsubishi Heavy Industries (MHI) is the likely Japanese prime contractor, though it and other Japanese companies could jointly take on the role as a consortium. IHI Corp. is the only Japanese company capable of providing propulsion for the big, twin-engine fighter. The specific NGF funding may be intended to pay for industry to start the concept design work; this will clearly be more intensive than the concept work the ministry has undertaken over the past decade. The Eurofighter Typhoon project went through such a concept-tightening stage in 1986-87, following a decade of looser studies.

In its program evaluation review, the ministry says it will develop successive versions of the NGF. Electronic systems will use open architecture for easy upgrades. And "model-based design" will expand opportunities for validation by analysis rather than testing.

The report quotes an anonymous expert reviewer saying that development will cost several trillion yen. Since a production run of about 100 aircraft is apparently planned, such spending works out at hundreds of millions of dollars per aircraft—just on development. Another reviewer emphasized that Japan must decide whether the NGF will be available for export and therefore produced in larger numbers.

The twin-engine NGF is intended to replace the MHI F-2 strike fighter, 94 units of which were built in 2000-11. F-2 retirements are likely to begin around 2035, the ministry says.

Japan will use a U.S. data link for the NGF, the *Mainichi* newspaper reported on Dec. 15. This will presumably be the omnidirectional Link 16 or a successor, unless the U.S. is willing to share the Multifunction Advanced Data Link (MADL) directional system in the Lockheed Martin F-35 Lightning. Directional data links are much less susceptible to detection and jamming.

A Japanese directional data link is part of a networking system the defense ministry's Acquisition, Technology and Logistics Agency has been working on for the NGF. Called Integrated Fire Control for Fighters, it is intended to support cooperative engagement, cooperative passive location of targets and cooperative building of a situation picture.

In fiscal 2013, ministry concept designs began to emphasize range and endurance over maneuverability and speed to keep more fighters on station. A large internal load of long-range air-to-air missiles was part of the formula, too. The latest published design suggests an even greater emphasis on range and endurance. Although the ministry did not indicate this as a preferred design, previous official drawings have accurately reflected progress in refining an ideal configuration.

The new NGF design differs markedly in planform from the previous one, 26DMU, prepared in fiscal 2014. The 2019 artwork shows a fighter reminiscent of concepts for the Tempest and Franco-German Future Combat Air System. Whereas 26DMU had four tail surfaces, somewhat slanted, the new NGF drawing shows only two; they are

mounted at perhaps 45 deg. to the vertical. Eliminating two tail surfaces and especially their edges should reduce radar signature. The DMU23 concept of fiscal 2011 had such an arrangement; later designs did not, perhaps because of flight-control challenges.

The mainplane also is dramatically different from 26DMU's, with seemingly higher aspect ratio (slimness). It has a lambda form: The leading edge is unkinked, as before, but the trailing edges are swept forward inboard and aft outboard. The same choice has appeared in Tempest and FCAS concepts, the unsuccessful McDonnell Douglas submission for the Joint Strike Fighter program in the 1990s and the McDonnell F-101 Voodoo of the 1950s.

Stealth would be improved if the outboard trailing edges were parallel with the leading edges. Instead the outboard sections of the wing are tapered, as jet wings usually are, for lightness. The inboard trailing edges meet the fuselage at about the same point as the leading edges of the tail surfaces, as in a FCAS concept published by Dassault. In the Tempest concept the UK has revealed, the mainplane, with a much lower aspect ratio than that of the Japanese design, is extended as far back as the trailing edges of the tail surfaces.

The Japanese defense ministry has previously associated high endurance and weapon load with a lambda wing, though past designs it has shown had longer outboard sections, perhaps higher aspect ratio and four tail surfaces. A high aspect ratio improves range and endurance at subsonic speeds, although fighter drag is also heavily influenced by fuselage shape. A higher aspect ratio may also permit greater takeoff and landing weights and hense larger fuel and weapon loads.

The 26DMU's wing had an unkinked trailing edge, swept forward, and apparently a lower aspect ratio than in the preceding design, 25DMU of fiscal 2013. In 25DMU, the trailing edge was unkinked and swept backward.

These concepts have been extraordinarily large, bigger than the Lockheed Martin F-22 Raptor—suggesting that Godzilla may be a better project name than Next Generation Fighter. IHI Corp. and the ministry have developed an engine of at least 33,000 lb. thrust, the XF9-1, for the fighter.

The total of ¥28 billion for the NGF in fiscal 2020 is not fully explained. Apart from the ¥11.1 billion for concept work, the budget includes ¥7.6 billion for fighter mission system integration, reduced from the ¥17.7 billion the ministry asked for, and just ¥100 million for work on a drone that would accompany the NGF, down from ¥1.9 billion requested. This leaves ¥9.2 billion of unidentified NGF work in fiscal 2020.

The recommendation for a fighter using F-22 and F-35 elements comes from the U.S.-based Mitchell Institute. With this choice, Japan could field a stealthy long-range fighter with advanced sensor and information-handling systems while avoiding the cost and risk of developing an all-new type, according to a report from the think tank attached to the Air Force Association.

upgrades partly addresses an obvious objection to using systems from that type: They were conceived for service entry in 2008, fully 27 years before Japan's target.

The institute's arguments are likely to appeal to the Japanese finance ministry but not at all to the aerospace industry, which would have a larger program if it began from scratch. In the 1980s, Japan aimed at developing an all-new fighter. It ended up working with Lockheed Martin to create the F-2, an enlarged derivative of the F-16.

The Tempest offer would also limit both costs and indigenous engineering opportunities.

BAE Systems Tempest (top) and Dassault FCAS (bottom) designs feature variations of the lambda wing.

The proposal is in line with what Japanese media have said Lockheed Martin has proposed. Lockheed Martin said in 2018 it was offering a fifth-generation derivative for Japan, wording that could only mean something based on the F-22, the F-35 or both.

Industry officials outside of Lockheed Martin are casually calling the merged design the F-57, because 22 + 35 = 57. Among the cost and risk advantages, F-22 manufacturing equipment could be used, say the report's authors, David Deptula, Douglas Birkey and Heather Penney, noting too that the F-35's avionics have already been developed and are in high volume production. Moreover, Japan could rely on system upgrades for the huge global fleet of F-35s. The potential for following F-35

The report's authors cite the FB-22, a strike-bomber F-22 derivative Lockheed Martin designed around 2002, as an example of what could be done with the F-22 airframe for Japan, they write. As with the FB-22, a large wing could be used, eliminating tail planes, accommodating much more fuel and perhaps reducing the radar signature. The fuselage could be modified to accept more than the F-22's six medium-range air-to-air missiles; anti-ship missiles could also be accommodated internally.

The authors said a big-wing fifth-generation fighter could double the F-22's combat radius of 400-600 nm (700-1,100 km). That is "just under the distance from the Chinese coast to Japan," they noted.

CEO Shuffle

> INDUSTRY WONDERS WHO WILL FOLLOW CALHOUN AS BOEING CEO

> NEW LEADER FACES GROWING LIST OF BIG TASKS

Michael Bruno Washington

David Calhoun, the incoming CEO of Boeing, takes the helm Jan. 13, but the question already on the minds of many industry movers and shakers is: Who will be the next chief executive of the world's largest publicly traded aerospace and defense company?

Calhoun, 62, will take over the corner office in Chicago after he informed former President and CEO Dennis Muilenburg that the Boeing board of directors had lost confidence in its one-time leader. Muilenburg, who was stripped of his role as chairman of the board in October, resigned as CEO and president on Dec. 23, 2019. The reason in one word: MAX.

Calhoun has been on Boeing's board for a decade and served as lead independent director starting in May 2018—filling that role until he became nonexecutive chairman when Muilenburg lost that title. In assuming the chairmanship, Calhoun initially expressed confidence in Muilenburg. But that changed by mid-December when Muilenburg was called before FAA Administrator Stephen Dickson and told that the regulator would determine the Boeing 737 MAX's return-to-service timeline on its own, not to mention that Boeing could do a better job of supporting it.

Calhoun is expected to say more on Jan. 29 when Boeing hosts its teleconference about 2019's fourth-quarter financial results. There will be a lot to cover, including open-ended 737 production halts at Boeing and aerostructures provider Spirit AeroSystems that started this month, as well as charges on Boeing's earnings due to airline customer compensation and other MAX costs. However, several Wall Street analysts and investors may also be listening for clues to Calhoun's longevity as the new top executive—in addition to any other management or board changes.

Several sources tell Aviation Week they believe Calhoun is a relative short-timer, perhaps in office for a couple of years at most while Boeing tries to get back to normal on the MAX—which now may not happen until 2022, if a monthly production rate of 57 or more new 737s is a benchmark.

Regardless, Boeing will need a new, younger CEO to achieve a company turnaround, especially when it comes to reestablishing an engineering-led culture that many observers lament has faded. The company has a mandatory retirement trigger when executives hit 65 years old. Boeing also faces a major decision in the next five years on its next-generation narrowbody family. The engine technology for a 737 replacement may not be mature enough yet, and it would be good to have a new long-term CEO in place to lead that program launch instead of a caretaker.

Industry insiders are already naming names (see list on facing page). According to several senior executives outside Boeing and in the financial community—all speaking on the condition of anonymity—there is a cadre of aerospace and defense veterans who are seemingly capable of taking over Boeing. However, none of them are perfect: For instance, some potential candidates lack diversified commercial and defense backgrounds, while others do not have as much manufacturing or engineering experience. But if Boeing is looking for a younger, Calhoun-like leader—i.e., someone experienced and familiar to industry, regulators and customers, but who comes from outside Boeing—these executives fit the short list.

Part of the challenge for Boeing in finding a leader after Calhoun will be that there was no succession process in place as of Muilenburg's departure. Muilenburg, born in 1964, became CEO in July 2015 and was seen before the MAX crisis as having many more years in office. Among the last five Boeing CEOs dating to 1986, the average length of tenure in office was 6.6 years. A couple of them held the office for as long as a decade.

Industry sources tell Aviation Week that former Boeing Commercial Aircraft head Kevin McAlister was the leading candidate internally for succession, but when he was let go last year in the wake of the MAX crisis that option closed. Boeing may still promote from within, but for now outside observers do not see an obvious candidate.

In the meantime, Calhoun strikes many industry observers as a good replacement for Muilenburg on an immediate basis. "I have confidence in Dave Calhoun, I've known Dave for a long time," Delta Air Lines CEO Ed

BOEING

David Calhoun, Boeing CEO

BOEING CEOs Average Tenure of 6.6 Years

CEO Name	Start of Tenure	End of Tenure	Years as CEO
Frank Shrontz	1986	1996	10
Philip Condit	1996	2003	7
Harry Stonecipher	2003	2005	2
James McNerney	2005	2015	10
Dennis Muilenburg	2015	2019	4
Average			**6.6**

Sources: Jefferies and Boeing Data

Bastian says. "I think he's the right man for the job,"

"We viewed Calhoun as the one logical choice to succeed Dennis Muilenburg after fallout from the 737 MAX, based on past exposure to his management skills and his strong knowledge of Boeing," Sanford C. Bernstein analysts Doug Harned, Caius Slater and George Zhao write in a recent research note.

Jefferies analysts Sheila Kahyaoglu and Greg Konrad agree: "The management change was necessary to strengthen credibility with regulators and customers." Calhoun is a General Electric veteran, counting 26 years at the multi-industrial giant, including time as vice chairman, president and CEO of GE Infrastructure. He had stints in the same positions at GE Aircraft Engines (2000-03) and GE Transportation (2003-05), which included air and rail markets. Following GE, Calhoun became CEO of Nielsen and is largely credited with turning the company around, the Jefferies analysts add.

Indeed, Calhoun has been on a short list of outsiders to lead Boeing as far back as Harry Stonecipher's demise and has been seen as interested (*AW&ST* March 14, 2005, p. 22).

Cowen analysts Cai von Rumohr, Jeff Molinari and Dan Flick understand why critics contend that since Calhoun was lead independent director during all of the MAX crisis, he may not be the optimal choice for CEO. "However, he knows Boeing's customers and suppliers well from six years at GE Aviation and time on Boeing's board, has a strong record in turnarounds of Caterpillar and Nielsen, and has far greater knowledge of the complexities of Boeing's issues than an outsider would," they write.

"Furthermore, as lead director and more recently as board chairman, he has worked closely with [Chief Financial Officer] and interim CEO Greg Smith," the Cowen team continues. "In addition, his initial move to call the FAA and other entities to rebuild relationships and his promises for greater transparency look like the right move. But the decision to suspend MAX production in January cuts the risk of further inventory build at the price of likely additional recovery costs."

Other recent decisions also are adding up. Boeing's most significant nonpersonnel move since Muilenburg's departure came Jan. 7, when it revealed that it would recommend MAX pilots go through simulator training before they return to duty once the model is cleared to fly. The decision came three weeks after a round of simulator trials by pilots from several MAX operators. The sessions presented crews with emergency scenarios that called for following checklists. In some cases, the procedures were not followed correctly, a source with knowledge of the tests confirmed. While no crew failed to recover the airplane, the inconsistent checklist performances have prompted concern at Boeing and helped provide the impetus for the recommendation.

Yet bringing people into the loop appears to be just one major immediate task for Calhoun as he takes office. The Bernstein team sees seven priorities facing him on Day One. In order of importance: 1) stabilize the management team, 2) ensure safe return of the MAX in conjunction with key constituencies, 3) reestablish performance objectives, 4) address next airplane strategy, 5) fully establish new management processes, 6) set Boeing's supply chain and services role, and 7) clarify defense strategy.

"Among those priorities, the challenge for Calhoun will be to ensure the leadership team can bring the MAX back into service and restore confidence in the program, without dropping the ball on other issues," Harned and his associates say.

Potential Boeing CEO Shortlist

David Joyce
GE Aviation CEO and GE vice chair

Scott Donnelly
Textron Chairman, CEO and president

Kelly Ortberg
Collins Aerospace CEO

Bill Brown
L3Harris Technologies chairman, CEO and president

Wes Bush
former Northrop Grumman Chairman and CEO

Tom Gentile
Spirit AeroSystems CEO and president

Midterm tasks likely to face Calhoun include closing the acquisition of 80% of Embraer's commercial aircraft division. While numerous industry insiders now quietly question whether Boeing ever should have done the deal, most who talk with Aviation Week say they believe Calhoun will close on it, in part because he approved it as a leading director.

Opinions also differ—as they have all along—on whether Boeing should pursue the new midmarket airplane (NMA) or jump right to a 737 successor, referred to as the future small aircraft (FSA). Some insiders maintain that Boeing needs another "moonshot" project, and the NMA is a waste of time and money. "NMA does not matter right now; the next program has to be the FSA," says an outside executive. Boeing should start talking in 2021 about FSA as the MAX replacement, the executive adds.

Others believe Boeing cannot afford to cede the midmarket airline sector to Airbus dominance, but with Embraer engineering skills on board, Boeing will be able to meet current mid-2020s plans for delivering the NMA.

Whether it is the NMA, FSA or both, observers increasingly foresee a need for greater research and development spending at Boeing—something Calhoun and any successor will have to explain in light of years that seemingly favored returns to shareholders amid cost-cutting efforts.

"We believe one of the more significant ramifications of the MAX tragedy could be a material reinvestment by Boeing in its commercial product portfolio," says Canaccord Genuity analyst Ken Herbert. "We estimate that Boeing has invested [about] $35 billion in R&D since 2010. While it now appears that Boeing will end up spending [about] $20 billion on the 737 MAX, we believe R&D will increase to potentially [around] $45 billion in the 2020-30 period, depending on the timing of the potential NMA or FSA aircraft.

"While likely not popular with investors, we believe there is growing pressure on Boeing to make a bold move (more moonshots!) with its commercial portfolio to better address the MAX issues and the A320neo family competitive threat," Herbert says.

—With Joe Anselmo and Sean Broderick in Washington and Jens Flottau in Frankfurt

Retrofits Support FAA Data Comm Deployment

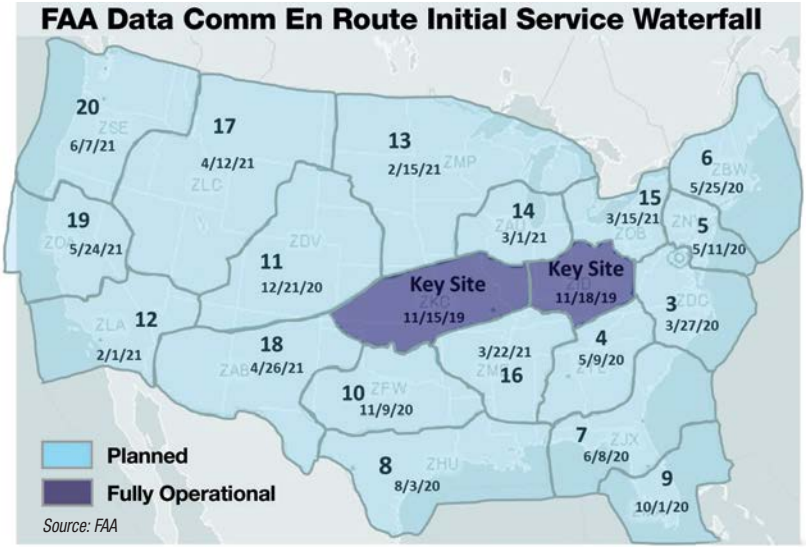
> SYSTEM IS OPERATING AT TWO EN ROUTE CENTERS

> GROUND AUTOMATION FIXES RESOLVE SOME ISSUES

Bill Carey Washington

Airlines are installing updated avionics to support the continued rollout of the FAA's Data Communications (Data Comm) system, which in 2020 will see operations expanded from 62 airport towers to en route centers.

In November, the FAA reached initial operational capability (IOC) of Data Comm text messaging between pilots and controllers at its Kansas City (ZKC) and Indianapolis (ZID) air route traffic control centers, the first two of 20 en route centers it plans to equip through June 2021.



This map of the continental U.S. shows the order by date when en route air traffic control centers will begin text-messaging of instructions between controllers and pilots.

The program was awaiting an in-service decision from the FAA on the two "key" sites and remained on schedule to equip the other en route centers, Data Comm Program Manager Jesse Wijntjes told the Dec. 12 meeting of the NextGen Advisory Committee (NAC).

The FAA and contractor L3Harris Technologies updated the Tower Data Link Service automation system at airports to deliver departure clearances and revised departure clearances by text two years ahead of schedule. But the program's second-phase deployment to en route centers to send transfer of communication, altitude and altimeter settings and other messages using the En Route Automation Modernization (ERAM) system faces schedule risk because of incompatible avionics on some aircraft.

Aircraft must be equipped with Future Air Navigation System 1/A controller-pilot data link communications (CPDLC), transmitted by VHF Data Link Mode 2 radios, to send and receive Data Comm messages. Avionics associated with the CPDLC application on some aircraft have experienced problems processing en route messages, preventing a greater number of airliners from participating in the program.

An FAA and Leidos team responsible for ERAM has developed fixes through software builds to the ground infrastructure that enabled ZKC and ZID to begin Data Comm initial operations, said Wijntjes, who also cited adjustments by L3Harris and air/ground network providers Collins Aerospace and SITA. "All those mitigations that we funded on the ground system allowed . . . those two facilities to go IOC," he said.

But avionics fixes are required to provide enough compatible aircraft to support Data Comm's deployment to other centers, briefers told the committee. A NAC ad hoc working group has met biweekly since the summer to assess avionics update requirements and nail down operator commitments to install updates, says Chris Collings, L3Harris director of business development.

"Data Comm has declared the first two sites as operational. However, in order to have the required number of ops that we need to see, there have been a number of airplanes that have been removed from the operation that we really need back in to support the program's objectives," says Collings. "To do that, we needed several avionics fixes."

Ground automation fixes resolved an interoperability issue with the Honeywell Pegasus 1 flight management system (FMS) installed on Boeing 757/767 airliners, as well as an issue with the Pegasus 2 FMS on the Boeing 747-8 and 787, says Chuck Stewart, United Airlines communications, navigation, and surveillance program manager.

FAA plans called for restricting Pegasus 1-equipped aircraft from participating in en route Data Comm after 2021—the NAC has recommended they continue participating beyond that. It also advised that retrofitting the Pegasus 2 on 757/767s still would not make them Data Comm-compatible without ground automation fixes.

Boeing has informed the committee it is on track to deliver a Block P6 update that resolves an interoperability issue with the communications management system on the 787.

A "Core 16" update to the Collins Aerospace CMU-900 communication management unit (CMU) is expected to be available for installation in March.

Southwest Airlines was testing a "version 523" update to the Honeywell Mk. 2+ CMU on 60 Boeing 737s, also expected by March.

"We're excited about the preliminary data we're seeing in the '523' update from Honeywell on the Southwest trial, and also the Core 16 development work with Collins is looking very good," said Wijntjes.

Alaska Airlines, American Airlines, Delta Air Lines, FedEx Express, JetBlue Airways, Southwest Airlines, United Airlines and UPS provided avionics status reports.

A380 Is in Operational Support, Aftermarket Phase

TARMAC AEROSAVE

> FACING CRITICS ON RELIABILITY, AIRBUS PRIORITIZES "CONTINUITY OF OPERATIONS"

> LESSOR, DISMANTLING COMPANY SEE DEMAND FOR USED SPARE PARTS

Thierry Dubois Lyon, France

Early in 2019, Airbus' salespeople had to accept the harsh reality that the market for new A380s was too slow for production to be sustained beyond 2021. They now seem to have concluded that the secondhand market also is weaker than they thought. And so the program is moving to a phase where the keywords will be "dispatch reliability" and "spare parts," rather than "new operator."

Asked whether Airbus has a target number for placing pre-owned A380s, Chief Commercial Officer Christian Scherer answered in the negative. "We do not see a major role for us in remarketing," he told members of AJPAE, the French aerospace journalists association.

In March, Sunny Guglani, then head of A380 product marketing, had some ambitions for the secondhand market. "We are convinced it will be an opportunity for more carriers to afford A380s, and we are going to support and promote this market," he told French daily *Les Echos* at the time. Lufthansa had just announced it would return six of its 14 A380s to Airbus in 2022 and 2023. The new priority is supporting current operators. Airbus is focusing on continuity of operations, says Scherer. At the least, Airbus executives may want to shore up the aircraft's reputation.

Air France has begun retiring its A380 fleet, and Air France-KLM group CEO Ben Smith was one of the company officials who publicly criticized the aircraft's performance. "This is the poorest operating aircraft in the fleet. We have enormous amounts of delays on this aircraft and this fleet has the highest rate of cancellations," he said in November. "Getting these aircraft out sooner rather than later is going to help the operations at Air France." Though that fleet is only 10 aircraft strong, said Smith, they "drive a lot of decisions."

Scherer emphasizes ongoing investments some are making in their A380s: Lufthansa and Qantas have planned significant cabin upgrades, simultaneous with D checks, he says. Airbus is keeping a close eye on the schedule for the first such 90-day-long overhaul. They will begin soon, as they are done every 12 years. The airframer wants the A380 D checks—a major event in an aircraft's life—to be as smooth as possible.

Perhaps the most worrying evidence about the viability of the A380's secondhand market has been the difficulty Dr. Peters, a Germany-based lessor, has had in placing ex-Singapore Airlines aircraft. Since November 2017, the carrier has returned four. "We have talked to numerous airlines about both a follow-on lease and a sale. . . . The best economic solution turned out to be the part-out route," says Christian Mailly, Dr. Peters' head of aviation. That option was used for two of the four aircraft.

Demand for cheaper A380 spare parts makes a business case for aircraft dismantling.

For the other two A380s, currently in storage, "we continue to seek a viable solution for our investors, which includes leasing out the engines in the interim," he adds.

Another lessor, Doric, in 2018 placed an ex-Singapore Airlines A380 with Hi Fly, a wet-lease specialist based in Portugal.

The outlook for the A380 leasing market is gloomy, according to Mailly. "The A380 market has been challenging for some time and has been aggravated by Airbus announcing the production stop earlier this year; further A380s will be withdrawn from flight operations in the coming years and this will not make it any easier," he says. Scope Analysis, a Germany-based consultancy, says investors cannot expect the high single-digit percentage returns originally projected and will have to make do with lower single digits.

The crystal ball is not as dark in everyone's view. Sebastien Maire, associate director at consultancy Kea & Partners, is relatively optimistic about the market for secondhand A380s. As returned aircraft have now paid for themselves, their cost of ownership has decreased. Combined with the emerging availability of cheaper spare parts, this will make the A380's economic performance competitive with that of newer aircraft, he says.

The dismantling of two of Dr. Peters' A380s is supplying the cheaper components. In Tarbes, in the southwest of France, Tarmac Aerosave has started the final phase of disassembly. In November, it cut down the fuselage of the first one and sorted metals. The second one will follow in January.

This imposing task—Tarmac uses a diamond wire-cutting gantry and sorts nuances of aluminum—came after the removal of those parts that could be sold on the aftermarket. Demand for spare parts was so strong that the number of components Tarmac removed stood close to 6,000 per A380, up from 700-1,000 for an A330.

"We even removed engine pylons for reuse, which is generally not the case," says Gregory Beyneix, Tarmac's vice president for programs and operations. Parts as large as the rudder and flaps were removed, too. The savings from secondhand parts can be considerable, as a new A380 main landing gear is priced at around $25 million, according to Scope Analysis.

As of Nov. 30, Airbus had delivered 240 A380s to 15 operators. The backlog still contains 10, mainly earmarked for Emirates. One will be handed over to All Nippon Airways.

—With Helen Massy-Beresford in Paris

'Remote ID' Proposal for Drones

> FAA PROPOSES INTERNET AND BROADCAST METHODS

> SERVICE SUPPLIERS WOULD PROCESS INFORMATION

DJI

Bill Carey Washington

When the FAA in late December released its long-awaited proposed rule outlining requirements for drones to transmit identifying information, it attracted applause for finally taking a regulatory step but also criticism over details of the rule's implementation.

Published on Dec. 31 in the Federal Register, the notice of proposed rulemaking (NPRM) for Remote Identification of Unmanned Aircraft Systems (UAS) provides a framework for identifying drones and model aircraft in flight that involves both commercial and recreational operators, manufacturers and Remote ID UAS Service Suppliers (USS). The cost of the rule to all parties would be $582 million over 10 years, the FAA estimates.

The NPRM provides for a 60-day comment period; responses are due by March 2.

Reacting to a 319-page unpublished version of the draft rule the FAA released several days before the official publication, the Commercial Drone Alliance said it was "thrilled" to see the proposal, "which appears to open the door for expansion of the billion-dollar commercial drone economy."

But the association—representing companies including Apple, AT&T, Alphabet Wing, CNN, Ford, GE AirXOS, Uber and WarnerMedia—was less pleased with the proposed compliance date for drone operators of 36 months after the rule's effective date. "Our main concern is the implementation period, which is needlessly up to three years," the association stated. "Until Remote ID is implemented, the American public will be deprived of many of the vast safety, humanitarian and efficiency benefits of commercial drones."

Smaller companies and individuals, while professing support for a remote-identification requirement, dislike what the FAA has proposed.

"I believe that recreational pilots, both of drones and [remote-control] aircraft, are not even a consideration as the commercial drone industry moves forward," says "Russ," who narrates the YouTube channel 51 Drones. "The formulation of a data-collection entity that tracks every single move, literally every second that you are in the air, is a deterrent to anyone wanting to fly for fun. Many of us are going to continue to fly as we always have, but by doing so we will voluntarily be surrendering any and all privacy."

Vic Moss, a Colorado-based commercial photographer and policy director of training provider Drone U, says he is "pro UAS Remote ID" and had looked forward to the rule. But he has many issues with the NPRM.

At the International Civil Aviation Organization's Drone Enable conference in November, DJI demonstrated a Wi-Fi-based "drone-to-phone" remote-identification system.

"We as a UAS community, whether hobby or commercial, must come together and make sure this is drastically changed before it ever makes it to any rulemaking committee," Moss writes in a blog. "This is draconian in depth and cost. It will obliterate the compliance numbers necessary to be useful."

With 1.5 million small drones (including 1.085 million registered recreational fliers and 420,340 registered commercial aircraft) counted as of Dec. 10, the FAA has faced mounting pressure from federal law enforcement agencies, Congress, commercial industry and aviation interests—including airports—to enforce some means of detecting errant or unauthorized drones in flight and trace them to their operators.

The FAA released the Remote ID proposed rule amid recent reports of unexplained groups of drones flying patterns at night over northeast Colorado and part of Nebraska.

Adoption of a separate rule that would allow drone flights over people

and at night, published as an NPRM last February, depends on finalizing remote-identification requirements, and Remote ID "is a critical element for building unmanned traffic management capabilities," the FAA says.

In the FAA Extension, Safety and Security Act of 2016, Congress directed the agency to develop remote-identification standards within two years of the law's enactment—or by July 2018. The FAA formed a UAS Identification and Tracking Aviation Rulemaking Committee that met for three months and produced recommendations in September 2017.

Pressed on the delay in publishing an NPRM, the FAA explains it was prevented from regulating drones flown for recreational purposes until Congress gave it that authority in reauthorization legislation that became law in October 2018.

After initiating the rulemaking effort in early 2018, the FAA indicated it would release the NPRM by May 2019. It then postponed the release to July 2019, then to September, then to Dec. 20, citing the rule's complexity. It released the unpublished version on Dec. 26.

The NPRM describes "Standard" and "Limited" categories of remote identification, with a third category for non-equipped UAS.

A drone operated as Standard would be capable of connecting to the internet and transmitting data to a Remote ID USS in addition to broadcasting its identity directly from the aircraft. A Limited drone would be capable of transmitting remote-identification message elements through an internet connection, while being restricted to operating no more than 400 ft. from its control station.

Standard Remote ID message elements would include the drone's identification number—either a serial number or a single-use, randomly generated alphanumeric code known as a session ID; the latitude, longitude and barometric pressure altitude of the aircraft and its control station; a time mark, and an emergency status code that would transmit only as needed.

Message elements for Limited Remote ID would be the same but would provide positional data only for the control station.

"The FAA anticipates that the message elements related to any Standard remote identification UAS or Limited remote identification UAS are publicly available information and may be accessed by any person able to receive a broadcast or who has access to a Remote ID USS," the agency states.

The rule would prohibit small drones from using automatic dependent surveillance-broadcast (ADS-B) "Out" transponders to send identify and position data, out of concern for radio-frequency saturation and lack of infrastructure to receive ADS-B data at lower altitudes.

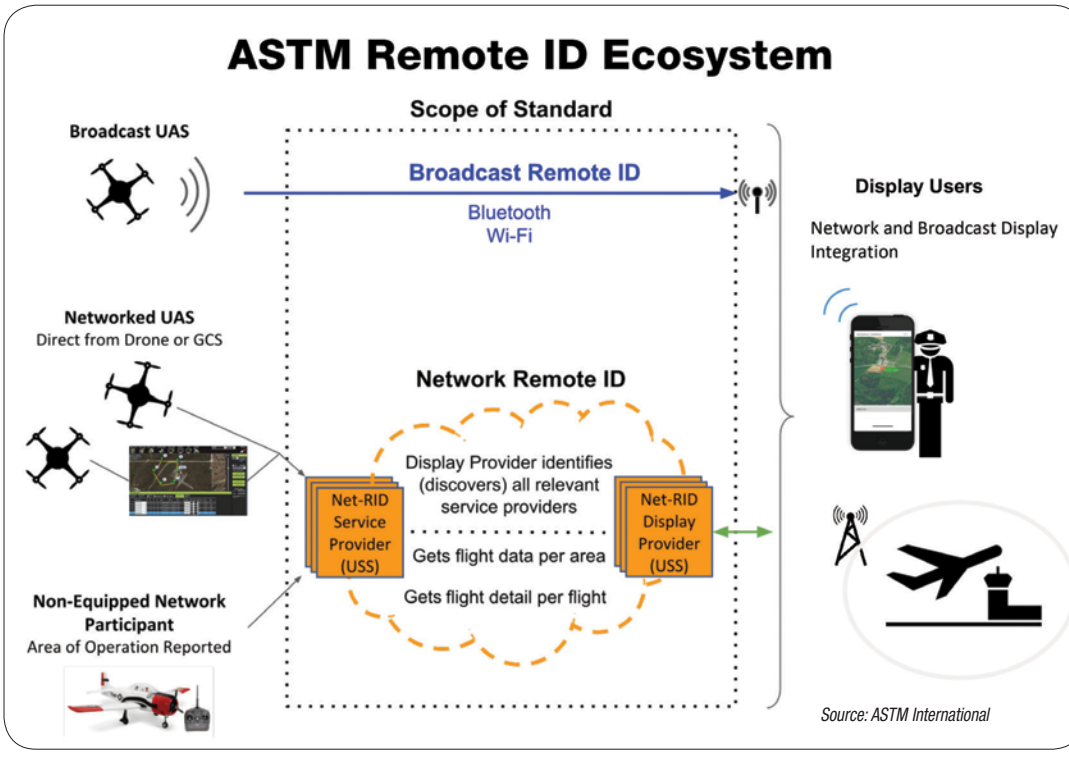
Persons operating drones that are not equipped for remote identification would have to do so within visual line of sight in an "FAA-recognized identification area," the NPRM states, such as a flying site established by a community-based organization.

The FAA envisions establishing a network of Remote ID USS that would collect data from drones in flight under contract with the agency, based on the model established by the Low-Altitude Authorization and Notification Capability used near airports.

Manufacturers would have to design models that comply with Standard or Limited remote-identification performance requirements, issue a serial number for each unmanned aircraft based on the ANSI/CTA 2063-A standard, label the drone to indicate it is Remote ID-compliant and submit a declaration of compliance to the FAA. Manufacturers would have two years to comply after the rule's effective date.

The vast majority of small drones operating in U.S. airspace would be subject to Remote ID requirements, the FAA says. Exceptions would be made for amateur-built drones, unmanned aircraft operated by the U.S. government and models weighing less than 0.55 lb.

The agency proposes revising its current registration regime, which allows hobbyists to register multiple aircraft under a single registration number, to require them to register each aircraft individually.



Source: ASTM International

A new ASTM standard, designated F3411, outlines how drones can transmit identification and location by broadcasting data over the air or sending it over a wireless internet connection.

Bell eVTOL Goes All-Electric

- NEXUS 4EX IS FOCUSED ON SHORT-RANGE INTRAURBAN FLIGHTS
- BELL TAKES MOBILITY-AS-A-SERVICE APPROACH TO UAM

BELL

Graham Warwick Fort Worth

When it took the wraps off its electric vertical-take-off-and-landing (eVTOL) air taxi concept in January 2019, Bell revealed a different approach to urban air mobility (UAM).

Unveiled at the CES consumer electronics show in Las Vegas, the Nexus had six tilting ducted fans and hybrid-electric propulsion providing sufficient range for intercity flights as well as intraurban trips.

In a year, technology and the market have moved on, and Bell has returned to Las Vegas for CES 2020 with a revised design for the Nexus—with four ducted fans and all-electric propulsion.

And beyond unveiling a new full-scale mockup of the five-seat eVTOL, the company is detailing its plans for mobility as a service (MaaS) and its vision of a future smart city ecosystem.

Evolution of the air taxi design into the Nexus 4EX (for four fans, all-electric and experimental) reflects Bell's belief, solidified over the past 12 months, that the short-range intraurban market will emerge first and that to succeed the service must be affordable and accessible to everyone.

The new design has two tilting ducts on the forward fuselage and two at the tips of an aft wing—a configuration closely resembling that of the Bell X-22 experimental aircraft first flown in 1966. The change from six to four ducts improves cruise efficiency to maximize range using batteries only.

The Nexus 4EX will have a range of about 60 mi. compared with 150 mi. for the original design, now called the Nexus 6HX (six fans, hybrid, experimental). "We started with six ducts and hybrid electric because we wanted range," says Mitch Snyder, Bell president and CEO.

Originally, the Nexus was designed to meet two distinct requirements, intraurban and intercity, but the need for more range was compromising the vehicle, he says. The redesigned eVTOL is "propulsion agnostic," Snyder says. "It will fly all-electric, but we can make hybrid work as well."

"If customers need more range they can go hybrid. If they need more hover they can go with the 6HX," says Scott Drennan, vice president of innovation.

The main design changes were driven by the need to increase cruise efficiency to enable all-electric flight. The ducts produce lift in forward flight and, in addition to there being two fewer of them, they are less deep so as to reduce drag in the cruise.

"The more hover flight you have in a mission, the more and deeper ducts you want," says Drennan. "For UAM, the focus is on cruise efficiency because you only have about a minute of hover."

Although there are now fewer ducted fans, there is no reduction in safety, Bell maintains. "Redundancy is only a means to reliability, and reliability is what we design into the vehicle," says Drennan. "We understand where to put critical parts—in the ducts—and where to put redundancy—upstream in the batteries, flight control computers and load paths."

The battery-powered Nexus 4EX has four slimmer tilting fan ducts for lower cruise drag.

For Bell, accessibility equals affordability. "The mix of reliable parts and redundant systems creates the cost equation, for acquisition and operation, and we need to drive that down," Drennan says. The company is aiming to meet commercial-airline safety levels—a 10^{-9} per flight-hour probability of catastrophic failure—and still be affordable.

Redundant battery packs and component reliability will prevent a total power failure he says, but the Nexus will be capable of landing in transition mode, with the ducts partially tilted, or fully tilted in airplane mode on less power than in rotorborne flight.

Safety is one of three key performance indicators Bell has set for UAM. The others are accessibility and sustainability. In addition to affordability, and convenience in terms of vertiport location, accessibility includes the passenger experience, as many customers will be new to urban air transport.

Bell defines sustainability as "quiet, clean and relevant." By relevance, the company means being able to offer the same customer experience in different markets—such as longer regional flights—by using different technologies in terms of payload and range capabilities.

Unveiling of the Nexus 4EX moves Bell a step closer to building a demon-

strator. The company is not putting a timetable on flying this aircraft but is targeting the mid-to-late 2020s for production vehicles and commercial services, Drennan says.

Bell has ground-tested a full-scale duct and rotor, produced an 8-ft.-dia. circular composite duct spar and tested a one-eighth-scale model in the wind tunnel. The company is working on a system integration laboratory (SIL)—"Aircraft 0"—to test avionics, electrics and flight controls.

Flight control computer developer Thales also has a SIL in Canada, and battery supplier EPS is doing some of the integration work, says Drennan. Safran, which would have provided the hybrid-electric propulsion system, is no longer involved. A supplier for the all-electric propulsion system will be announced soon.

Also at CES, Bell is outlining its thinking on urban air mobility as a service. This encompasses not only the vehicles—air taxis and unmanned aircraft for logistics and data-gathering—but also operations, digital and physical infrastructure, and maintenance, repair and overhaul (MRO).

"I removed the bounds from the team and told them to look at every aspect where Bell can be a player," says Snyder. "Can we operate them more safely? Instead of just providing training for operations and MRO, as we do today, can we do it and raise the bar for safety?"

In Bell's approach to MaaS, the service is powered by AerOS, an aerospace operating system the company is developing as a digital backbone for UAM, managing fleet information, monitoring aircraft health and controlling the throughput of people, goods and data.

AeroOS will comprise modular microservices in the cloud such as passenger booking, flight scheduling, route optimization, airspace management and fleet visibility. While Uber will provide these services for its Elevate aerial ridesharing networks, "there will be other customers that do not have them," says Matthew Holvey, operations manager for innovation. "It needs to be a service Bell provides."

To manage high-tempo operations safely, AerOS is to be an autonomous system with human oversight. For example, the system will track which aircraft are seeing deeper battery discharges on longer flights. These reduce cycle life, and AeroOS will adjust scheduling to level out battery utilization across the fleet.

Bell has begun development of AerOS with master scheduling. This models expected traffic demand for each day and prepositions aircraft. "We are using artificial intelligence to predict where people are," says Holvey. As the schedule is executed, and deviations inevitably occur, the master schedule is rerun and the traffic-demand forecast updated to provide a better predictive model.

For Bell, starting development of AerOS now, years before UAM services are expected to begin, is a way to enable the market by offering prospective MaaS providers—whether commercial operators or cities themselves—with an option for the digital infrastructure. "If we don't think about this now, we won't be ready," says Drennan.

ATM Bets On Artificial Intelligence

> EUROCONTROL ORIENTS RESEARCH TOWARD MACHINE LEARNING

> FRENCH ANSP TESTING AI-BASED SUPPORT TOOL

Thierry Dubois Lyon, France

While commercial air transport as an industry is still hesitant about employing artificial intelligence (AI), major players in air traffic management (ATM) are proceeding to operational use from experiments and prototype tools.

Especially in Europe, where insufficient airspace capacity has been a vexing issue, air traffic controllers are likely to see their jobs evolving. The power of AI may be harnessed to reduce the controllers' workload and allow more time for decision-making. AI also may make ATM more effective by freeing up time for controllers to fine-tune aircraft trajectories. Moreover, traffic and delay predictions may become more accurate.

"The ongoing capacity crunch is causing air traffic flow management delays that are 53% above those of 2017," says Eamonn Brennan, director general of Eurocontrol, which is in charge of ATM on the continent, extending to Turkey.

Eurocontrol recently launched the European Aviation AI High-Level Group, which brings together representatives from public and private sectors. The group is committed to "develop[ing] a road map and practical recommendations to accelerate the uptake of AI," Brennan says.

Eurocontrol has launched a recruitment drive for skilled AI operators. A key issue for the agency is to bridge the gap between the people who know their domain and the people who know AI, points out Pierre Andribet, Eurocontrol's head of research and development. "But we need to act now; we can't wait for five years," he stresses.

In flight planning, flow management, safety assessment and conflict prediction, Eurocontrol's early trials of AI have revealed gains of 20-30% in predictability and efficiency. More accurate traffic load predictions will mean Eurocontrol's Network Manager (NM) operators could start to reduce some of the buffers placed into the system as a result of uncertain predictions.

Nevertheless, everything starts with sharing data. Talks with air transport players are underway for NM to share data collected on aircraft and at airports. "What we must demonstrate is that by sharing, all individual actors will benefit more," says Andribet. This would be a cultural change similar to the one Airbus has encouraged with its Skywise digital platform.

Forecasting zone-pair flows is a promising application of AI. To determine exactly how many more flights could be possible between two zones, Eurocontrol's statistics and forecast department contracted with a company to use new machine-learning techniques. "They have brought more input into the calculations than just the GDP data we were using, and the results have been very positive," says Forecasting Manager Claire Leleu.

Eurocontrol tested the AI approach on seven traffic flows across the North Atlantic and found it reduced the median absolute error significantly. Not every idea works on the first attempt, however. An AI-based analytical tool produced disappointing results in an overflight trend forecast.

At its Bordeaux en route control center, DSNA—a French air navigation service provider (ANSP)—has enjoyed success with a new AI-based tool developed with French aerospace research center Onera, in the framework of Europe's Sesar ATM research project.


DSNA

The job of a supervisor in an en route control center may evolve with the use of AI.

Dubbed Sinaps for system-wide information management within integrated network ATM planning services, the tool has been employed since July under an experimental status. Controller team supervisors are so satisfied, they have asked to continue the experiment, according to Isabelle Luxembourg of DSNA's European programs team.

Sinaps uses two kinds of AI to serve two different purposes. In tactical mode, symbolic (i.e. logic-based) AI helps a supervisor plan airspace configuration. In exploratory mode, a machine-learning process imagines new ways to organize sectors of airspace.

The exploratory mode is at the core of the AI revolution. Also referred to as "connectionist AI" or a "neural network," it can be described as an algorithm that infers relations of cause and effect with existing data.

In this mode, some of the proposed configurations may become solutions, but others may be impractical or incompatible with safety standards.

The tactical mode is used to optimize the airspace's configuration. Supervisors in Bordeaux have to best distribute the 38 elementary blocks of airspace for which the center is responsible (see illustration on facing page). The range of combinations is vast.

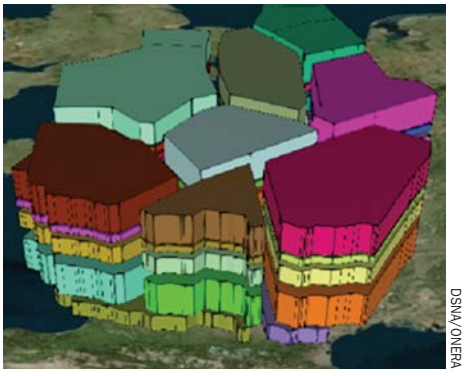
Depending on factors such as a traffic forecast, the controllers' roster, a weather forecast and military needs, an expert creates suitable subgroups of airspace blocks and then allocates them to the control positions that will be staffed in the target period. The work typically is performed between 4 hr. and a day in advance and regularly updated, says Luxembourg.

The Sinaps tool was not designed to do the job in lieu of a human, but it will support decision-making and save

time, Luxembourg explains, adding: "Sinaps provides instantaneous help and offers optimized solutions."

Such assistance may be appreciated every time the situation has to be reassessed—particularly on short notice or in highly constrained situations.

To make the choices manageable, the number of proposed solutions was limited to six (a number that may evolve, says Luxembourg). The use of symbolic AI ensures the solutions are valid, meaning technical and operational prerequisites are met. "Controllers will not be surprised," says Luxembourg.



DSNA/ONERA

Using AI to assemble airspace blocks may save time.

Once a solution is chosen, the controller can look at the remaining workload, which is likely to be complex. Some flight plans may require special attention, and specific action may be decided for a couple of flights. This may avoid a traffic regulation that could cause widespread delay, says Luxembourg.

Conversely, the exploratory mode should be used when considering a longer-term objective. "Connectionist AI will make the most of the available data," says Luxembourg. For this application, Sinaps could be likened to a machine being told "try every possibility; let it go!" she exclaims.

If a proposed solution makes sense and enables an increase in capacity, the center will study it and maybe integrate it into the portfolio of valid solutions.

The request from the Bordeaux en route control center to extend the experiment was welcome. "We made an assessment in October; the prototype was working well . . . . We wanted to demonstrate that the tool cannot create problems and provides appropriate support," says Luxembourg. The long-duration trial therefore was deemed useful.

ATM equipment manufacturer Thales has a web platform in service that also uses machine-learning. Called ECOsystem, it is aimed at finding the best use of airspace and airport resources for ANSPs, airports, airlines and pilots.

"ECOsystem anticipates aircraft delays and offers solutions. . . . It analyzes months of traffic [data] and spots those factors that influence estimated times of arrival and can suggest shorter flightpaths," notes Beatrice Pesquet-Popescu, Thales' director of ATM research and innovation.

Despite the use of the machine-learning variety of AI, ECOsystem provides explainable solutions, according to Pesquet-Popescu. "In traffic prediction, you can explain what parameters influenced the choice," she adds. The controllers can be provided with the explanation, possibly in graphic form, in fly-out windows on their displays.

CLIMATE OF FEAR

> THE AIRLINE INDUSTRY IS UNDER FIRE FROM ENVIRONMENTAL GROUPS

> RISING DEMAND FOR AIR TRAVEL IS OUTPACING EFFICIENCY GAINS

Kerry Reals London

Pressure is mounting on the aviation industry to drastically step up efforts to reduce its impact on climate change. Experts warn that in a business-as-usual scenario, carbon-dioxide emissions from global aviation could rise by more than 80% by 2050.

As a growing list of countries adopt net-zero emissions targets for midcentury, some are questioning whether the airline sector's decade-old pledge to halve emissions by 2050, compared to 2005, should be revised upward.

There is a growing sense of outrage among environmental campaigners over what they perceive as the airline industry getting a free ride while other sectors are forced by regulators to decarbonize. Calls are becoming louder, particularly in Europe, for a more uniform approach to taxing air ticket sales and for an end to airlines' exemption from paying tax on jet fuel.

"The evidence is already there. The very fact that the industry needs Corsia [the International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation] to deliver on its short-term goal [to achieve carbon-neutral growth from 2020] tells us that, in real terms, emissions are going to be much higher after 2020—even with technological advances," says Tim Johnson, director of UK-based campaign group Aviation Environment Federation (AEF).

"All the forecasts suggest that while there will be continuous [efficiency] improvements, the big, radical step-changes in technology are unlikely to happen before 2050," he says.

Johnson acknowledges we will see "modest improvements in efficiency and greater uptake of sustainable aviation fuel" before the middle of the century but says this "is not really going to make much of a dent in the demand trajectory and growing emissions."

Unlike many other industries, aviation currently has no viable, widespread alternative to burning fossil fuels. This makes it a difficult sector to decarbonize. At the same time, global demand for air travel is rising rapidly and outstripping many of the efficiency gains achieved by the industry.

"Once people get to a middle income, one of the things they want to do is fly as much as they do in America and Europe. This could increase aviation emissions by 83% by 2050 in a business-as-usual scenario," Adair Turner, former chairman of the UK Climate Change Commission and current head of the Energy Transitions Commission, told the Royal Aeronautical Society's Greener by Design conference in London in November.

Turner believes the aviation industry's target to halve emissions by 2050 should be doubled to a 100% reduction—a goal he says is achievable without carbon-offsetting. However, this assumes changes to the regulatory environment and much greater use of sustainable aviation fuels—which remain in short supply. As Johnson points out, the total volume of sustainable jet fuel produced in 2018 was only sufficient "to power the global aviation industry for 10 min."

Environmental campaigners have singled out aviation as being a major contributor to climate change, and the pressure is mounting.

Johnson agrees that the environmental goals set by the International Air Transport Association (IATA) in 2009 have become outdated. The targets to achieve carbon-neutral growth starting in 2020 and cut CO_2 emissions by 50% by 2050 "belonged to another era," before today's "net-zero language."

"We find ourselves in a very different world now," says Johnson. "The [UN Intergovernmental Panel on Climate Change] advice is that we need to get to net zero by the second half of this century. This makes [IATA's 50% reduction target] look dated. Now is the time to reevaluate that.

"I'd be very surprised if the industry doesn't have something to say on this [in 2020]. Once airlines start to lead individually with answers, it's not long until the industry bodies catch up," he adds.

John Broderick, a lecturer in energy and climate change at the University of Manchester's Tyndall Centre for Climate Change Research, warns of the consequences of failing to achieve net-zero carbon emissions.

"We need to get to a position of net zero to stop continued global warm-

ing," he says, noting that "approximately one-third of the CO_2 emitted today will still be in the atmosphere in 1,000 years' time."

Broderick says it is time "to stop exempting aviation emissions" from countries' net-zero action plans, a point backed by the UK Climate Change Commission (CCC) in a recent letter to UK Transport Secretary Grant Shapps.

The commission's chairman, John Gummer, is calling on the UK to formally include international aviation and shipping in its plans to achieve net-zero emissions by 2050.

"Aviation is likely to be the largest-emitting sector in the UK by 2050, even with strong progress on technology and limiting demand. Aviation also has climate-warming effects beyond CO_2, which it will be important to monitor and consider within future policies," writes Gummer.

Studies are being carried out to gain a deeper understanding of the non-CO_2 effects of aviation on climate change. These include nitrogen oxide (NOx) emissions, soot and sulphur particles and contrail-cirrus clouds. The latter form when linear contrails—the ice trails left behind by cruising aircraft—converge. It is thought that these clouds could result in an additional warming effect, potentially making aviation's contribution even more serious.

The EU's European Aviation Environmental Report 2019 describes the scientific understanding of these non-CO_2 effects as "very low." However, more clarity could be forthcoming early in 2020. According to Johnson, the European Commission has been "pulling together scientific brains on non-CO_2 effects" and is due to publish its findings in the first quarter.

Gummer also acknowledges in the letter that zero-carbon aviation is "highly unlikely to be feasible by 2050." Therefore, reducing actual emissions from the sector is "likely to require some use of greenhouse gas removals (GGR) to offset remaining emissions."

The UK should "establish a new market" for GGR technology, says the letter, which Johnson interprets as laying down a challenge for the aviation industry to "lead investment in [GGR]."

In addition to GGR investment, the CCC says UK aviation emissions "could be reduced by around 20% from today to 2050 through improvements to fuel efficiency, some use of sustainable biofuels and by limiting demand growth to, at most, 25% above current levels."

This is "very much at odds" with the 60% growth in passenger numbeæærs assumed under UK proposals for expanding the country's airport capacity, says Johnson. "The more capacity we start to allow, the harder it looks that we will be able to constrain demand."

Another possible method of limiting demand for air travel is new taxes. In Europe, efforts are underway to develop an EU-wide aviation tax. In November, nine finance ministers called on the incoming European Commission to look at ways of making this a reality.

"Aviation transport is exempted from excise duties, no [value-added tax] is levied on international flights, there is no coordinated ticket tax and economic instruments to curb greenhouse gas emissions can be strengthened in the aviation sector," the ministers said in a Nov. 7 statement. "We believe that more coordination on pricing of negative externalities of aviation could ensure that the polluter pays a fairer price for the use of aviation transport. To be effective and create a level playing field, we are convinced that EU coordination on this matter is the most effective for all member states."

As countries work toward meeting their Paris Agreement commitments, it is widely expected regulation will play an increasing role in forcing the airline industry to reduce its emissions.

"Airlines need to be honest with their shareholders about the regulations that will be introduced," says Andrew Murphy, aviation manager at Brussels-based sustainable transport lobby group Transport & Environment.

Pointing to carmaker Volkswagen's November announcement that it will invest €60 billion ($67 billion) by 2024 in developing electric and hybrid cars—a decision Murphy says was made "because European laws require

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it"—he warns airlines will likely face similar legislative pressure.

"[The aviation industry's] usual tactics don't seem to be working—they're up against climate science," says Murphy. "The electricity sector in Europe is going greener and there is a huge uptake of electric [road] vehicles, but we will see nothing from the aviation sector. This paints a pretty negative picture for aviation."

But IATA insists the actions it has taken and the emissions-reduction targets it has set are effective. In a Dec. 12 statement, it said carbon emissions per passenger have declined by more than 50% since 1990, and Corsia would "ensure carbon-neutral growth on international flights from 2020 and raise around $40 billion in climate finance."

IATA says the industry will reduce emissions further in the longer term through clean technology, but this will require a "financially sound airline sector capable of funding the significant investments that will be needed to make flying sustainable." It continues to argue vociferously against the additional taxes. "Taxation aimed at stopping people from exercising their freedom to fly will make travel more expensive but do very little to reduce emissions," says IATA Director General Alexandre de Juniac.

"Governments must focus their efforts correctly. Flying drives prosperity. It is not the enemy. Cutting carbon must be at the forefront. And government leadership is needed to incentivize the commercialization of sustainable aviation fuels, drive efficiencies in air traffic management and support research into next-generation low-carbon energy sources."

But such rhetoric will do little to convince critics that the aviation industry is not abdicating responsibility for its contribution to global warming. Indeed, airlines might find demand for air travel waning naturally if the "flygskam" movement, spearheaded by Swedish climate change activist Greta Thunberg, gathers pace and consumers shun air travel to reduce their own carbon footprints.

"Let's see in 2020 what effect the 'Greta effect' is having on demand," says Murphy.

Check 6 *Airlines For America's Nancy Young discusses the industry's work to make aviation cleaner. Is it enough? Listen in and then decide:* **AviationWeek.com/podcast**

Airlines Are on the Defensive, With Industry Targets Seen as Outdated

> EUROPE PREPARES MORE TAXES TO CURB AVIATION GROWTH

> FLEET RENEWAL PRESENTS THE BIGGEST SHORT-TERM OPPORTUNITY TO CUT EMISSIONS

Jens Flottau Frankfurt

Giovanni Bisignani's communications style did not meet with everyone's approval: "*Basta*," he would say to regulators at International Air Transport Association (IATA) events in his native Italian when he wanted to convey "enough is enough." While the former IATA director general and CEO described it as "shouting politely," views differ on just how polite and how effective the approach was.

One of Bisignani's achievement cannot be overestimated, however. He moved aviation into an active position by defining clear environmental targets 10 years ago, when few others inside or outside the industry felt the need to do so. The goal was to improve fuel efficiency by 1.5% per year, achieve carbon-neutral growth starting in 2020 and reduce emissions by 50% until 2050.

Now that 2020 has arrived, and the age of self-proclaimed carbon-neutral growth is supposed to begin, the scene is very different. Aviation, more than any other industry, is under pressure from environmental groups and governments alike to do more about its environmental impact. The International Council on Clean Transportation calculated that aviation emissions rose 32% between 2013 and 2018.

"Even though the aviation sector's emissions make up just 3.6% of global emissions and continued fuel-efficiency gains have partially decoupled CO_2 emissions from expanding air transport services, it is nevertheless one of the few sectors where emissions continue to grow," said Henrik Hololei, the European Commission's director general for mobility and transport, at the International Aviation Club in Washington recently. "This is not sustainable."

Like few other industries, and unlike much bigger polluters, the sector must now play defense and highlight what it considers to be its many environmental achievements to fend off more taxes or even more draconian measures. The proposed measures include a ban on domestic air travel, demanded by more than a few in Germany, or the abolishment of frequent-flier programs, as suggested in a recent study

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Air travel has grown too fast for airlines to be able to cut total emissions.

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Word of the Year

Happy 2020! Instead of creating new year's resolutions, a friend of mine selects a word of the year to serve as a guidepost. Her word this year is *grateful*. If you were to select a word to guide you through the year, what would it be?

If you were to select a word to guide you through the year, what would it be?

A word for the robust commercial aviation aftermarket—pegged at $82.5 billion in 2020 by Aviation Week Network forecasts—could be many things: opportunistic, constrained, innovative, challenging or optimized.

Take "opportunistic" and "constrained". The $82.5 billion market is projected to grow to $106.8 billion in 2029. Over the decade, OEMs will deliver 23,300 new aircraft, and operators will retire 10,765. Engine-makers will deliver more than 46,640 engines and spares.

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The engine market, which represents 42% of total spending, is higher this year, largely due to more expensive shop visits and spare parts. With mature engines staying on wing longer and newer engines coming into the shop earlier, it's creating a traffic jam. James Pozzi does an excellent job examining the capacity constraints and how companies are adapting (see page MRO 12).

Optimizing is a key word for almost everything that happens in this industry, and tools such as data-driven maintenance can help achieve that.

For instance, Emirates Airline has been collaborating with Boeing, using its Optimized Maintenance Program to streamline its 777 maintenance (see page MRO 16). By evaluating Emirates' operational data and considering its unique operating environment, the program has extended both A and C checks. "Like everything else, there's always a tinge of nerves about what surprises it could bring to the operation that we did not take into our calculations," Ahmed Safa, Emirates vice president of engineering and maintenance, tells *Inside MRO*. "But so far, we have not had a single question mark about whether it was a good decision."

While data-driven decisions will make the industry more efficient, Ray Valeika, an industry veteran who has closely followed advancing technologies' impact on aviation, brings up several interesting points in his guest editorial (see page MRO 25), including the question of data privacy, which we all face in our personal lives.

While technology advancements bring many benefits, they also bring challenges. Just the data piece alone poses many—including being in different formats, with much trapped on paper, not to mention security.

As Valeika says, "progress brings challenges."

So in addition to a word of the year, I'd like to propose a quote of the year, too: "You can't stop the waves, but you can learn to surf," says Jon Kabat-Zinn.

—Lee Ann Shay

Keep up with Shay at **MRO-Network.com** *and on Twitter* **@AvWeekLeeAnn**

Highlights

Defense Stocks Led Gains, Boeing Lags

Publicly traded shares of aerospace and defense companies in most of the Western world ended 2019 about 34% above where they began a year ago and 6% above major stock market indices, Wakk Street analysts said in year-end reports.

Looking at the two major components, defense and commercial aerospace, defense stocks roared ahead in 2019 while aerospace stocks were held back by sector leader Boeing, which ended 2019 with its stock essentially flat. Rival Airbus saw its stock gain 55% for the year.

According to Vertical Research Partners, global defense shares were up 40% in 2019 (or 13% above the S&P 500 benchmark), while global aerospace was up 30% (about the same as the S&P). Global airlines rose more than 15%.

In aerospace, Triumph Group led growth with a 120% gain, a notable turnaround from 2018, when it fell nearly 60%. Next came Arconic, up about 80%, followed by TransDigm Group, 65%, and MTU Aero, 61%. Six major companies declined in 2019: Rolls-Royce, down 17%, Embraer, 12%, Senior, 9%, Astronics, 8%, Bombardier, 5%, and Textron, 3%.

Aviatic MRO and IAI in Discussions

Aviatic MRO is in discussions with Israel Aerospace Industries to either partner or establish noncompeting businesses at Siauliai International Airport, which is a civilian and military airport located near Lithuania's fourth-largest city. Neither company would provide details of the discussions.

AVIATIC MRO

Aviatic MRO is a new company opening in Lithuania.

Aviatic is in the process of building a hangar and plans to offer "full-service operations" for Airbus A320s and Boeing 737s—including D checks and asset management—in 2021. As it ramps up, it is offering parking services and small-scale repairs that do not require a hangar.

Aviatic is investing €20 million ($22 million) to create its new MRO services.

AAR in Settlement Talks With Justice Department

Major aircraft MRO and services provider AAR said late Dec. 19 that it is in settlement discussions with the U.S. Justice Department over potential False Claims Act violations the company disclosed in 2018.

"We have recently entered into settlement discussions with the [Justice Department]; we are happy to take a step toward resolving this matter," AAR Chief Financial Officer Sean Gillen said. "However, there is no assurance that any settlement will be achieved. We will keep you updated as these discussions progress."

The potential violations stem from a whistleblower lawsuit over the AAR Airlift unit's work for the Defense Department. The Justice investigation was unveiled July 2018. AAR stressed it has been cooperating.

Gillen gave the update to financial analysts during a teleconference on the company's second-quarter fiscal 2020 results. AAR reported sales of $560.9 million and income from continuing operations of $20.1 million, or $0.57 per diluted share. A year ago, the company reported sales of $493.3 million and $11.2 million, and earnings per share of $0.32.

Contracts

AFI KLM E&M was selected by **Fiji Airways** for Airbus A350 component maintenance.

Aircraft Propeller Service won a five-year **Lion Air** contract to provide propeller maintenance support initially for up to 100 ATR 72s out of Lake Zurich, Illinois. It plans in 2020 to launch a facility in the Asia-Pacific region to handle the account.

C&L Aerospace signed an exclusive supplier agreement with **Thai Aviation Industries** to support the Thai Air Force's fleet of Saab 340s.

Czech Airlines Technic won a **Jet2.com** contract to provide Boeing 737NG heavy maintenance at Prague.

Gol Aerotech was established at **Confins Airport** in Minas Gerais, Brazil, to provide 737/767 maintenance for Gol and third parties out of a 145,000 m^2 (1,561,000 $ft.^2$) facility able to service 80 aircraft per year. Capital Group and DAE are among its first customers.

KF Aerospace won an **Air Transat** contract to provide Airbus A321 and A330 and 737NG heavy maintenance/mods at Hamilton, Ontario.

KLM UK Engineering won a long-term **BA CityFlyer** contract to provide casualty/ad-hoc E-Jet base maintenance at Norwich, England.

Lufthansa Technik (LHT) won a **Novair** contract (as launch customer) to provide Leap 1A maintenance for two A321neos. **LHT** also secured an MOU from **All Nippon Airways** for technical collaboration on Boeing 777X MRO.

MTU Maintenance Zhuhai won an exclusive 10-year **Malaysia Airlines** contract to provide CFM56-7B maintenance/overhaul.

Rolls-Royce won a $1.2 billion contract to maintain AE 1107C engines on Boeing V-22s for the **U.S. Marine Corps, Navy** and **Air Force**.

Contract Source: SpeedNews

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Europe Advances ICA Changes

The European Union Aviation Safety Agency (EASA) has taken the next step in its revisions to instructions for continued airworthiness (ICA) and related parts-marking rules, updating a draft proposal following industry input and presenting it to the European Commission for consideration. The revamped opinion includes a few changes based on industry feedback, but it is likely to leave maintenance providers wanting more.

The rulemaking's most significant proposed change—incorporating the ICA into the applicable EASA type certificates (TC)—remains in place. One change from the draft: The ICA for repair design approvals do not have to be made available right away. "The repaired product, part or appliance may be released into service before the related instructions for continued airworthiness have been completed, but this shall be for a limited service period, and in agreement with the agency," EASA explains.

The regulation will define an ICA as any maintenance information that references airworthiness limitations, the accomplishment of scheduled maintenance—such as the periodic removal of a component for an inspection or test—referenced in the product ICA or when a design approval holder (DAH) specifies information as an ICA.

EASA's definition means some component maintenance manuals (CMM) will continue to be categorized as outside the scope of the ICA—a point that many in the maintenance industry have lamented for years. The Aeronautical Repair Station Association's (ARSA) comments on the proposal elaborated on the issue, arguing that EASA's proposal continues to leave a gap between DAH requirements and those MRO providers must follow. "The Part M and Part 145 requirements are not limited to components referenced in airworthiness limitations or those having a recommended scheduled maintenance interval in the product's ICA," ARSA argued. "They apply to all components."

EASA's response to such comments was that its goal is to improve safety, not address commercial considerations. The rulemaking's next steps are adoption by the EC and final publication, including guidance material. EASA expects the new regulations to be in place by the end of 2021.

—Sean Broderick

Beyond the MAX

The FAA has been under intense scrutiny by U.S. lawmakers in view of the Boeing 737 MAX crisis and its link to product certification. But a recent report ordered by Congress on an unrelated matter has prompted the agency to make changes in how it oversees airlines.

The FAA plans to improve training and guidance for its inspectors to address gaps found by a Transportation Department Office of Inspector General (OIG) audit conducted from August 2017 to October 2019. While the agency and auditors agreed on most findings, they remain divided on whether the outcome of an unintentional violation should be a factor in enforcement decisions.

Originally, lawmakers asked the OIG to examine the agency's Compliance Program (CP), part of its Safety Assurance System that emphasizes training and education, not punitive penalties, for unintentional errors. The audit began as an industry-wide look but became focused on Allegiant Air when congressional concerns were stoked by a CBS "60 Minutes" report spotlighting issues at the Las Vegas-based carrier. The OIG focused on two serious problems plaguing Allegiant: MD-80 engine shutdowns, and mistakes traced to work done at AAR Corp. on Allegiant's aircraft.

NIGEL HOWARTH/AW&ST

Allegiant's engine reliability issues persisted until it retired its MD-80 fleet.

Allegiant experienced 28 shutdowns in 2011-16, disclosing them to the FAA. Despite signs of increased risk, FAA inspectors did not document the issues, "in part because they weren't adequately trained on the new safety assurance system and did not believe the new process required the reports," the OIG found.

While Allegiant's engine issues were not tracked, the FAA in 2016 convened three separate system-analysis teams (SAT) to examine the shutdowns. Corrective actions were agreed upon, but the shutdowns persisted until the carrier retired its MD-80 fleet in late 2018.

"During our review of FAA's records, we could not find documentation or evidence that inspectors consistently tracked the engine risk, which incorrectly suggested that the carrier had successfully mitigated the risk," the OIG's final report says. The OIG also noted that a certificate-holder evaluation process (CHEP) carrier-wide audit was not customized to address apparent risks. CHEPs are done every five years, but in Allegiant's case, it was accelerated.

"According to the national review team lead, the local FAA inspection office had already convened the SAT to address overheated engines, and the team believed the SAT was addressing the issue," the report states. "However, it took more than two years before the SAT could agree on a plan to mitigate the engine risk, and ultimately the risk was not mitigated until Allegiant Air

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retired the fleet."

The AAR incidents were more eye-opening. The FAA discovered that an overhaul on an elevator component done by AAR in 2016 did not follow mandated procedures. A cotter pin was not reinstalled, and AAR did not conduct a required secondary inspection designed to catch such issues. This incident, combined with similar issues, prompted local inspectors to recommend a 30-day suspension of the applicable AAR repair station certificate. A review by regional FAA officials, done under CP, overturned the suspension recommendation and ordered it closed.

"The disparate proposed actions in this case occurred because FAA did not use a process to address disputes between FAA offices," the OIG says. "According to FAA's independent team assigned to review this case, the regional office lacked sufficient interdependence because it failed to consult inspectors responsible for oversight of Allegiant and its maintenance provider to gain insight into the maintenance provider's compliance posture, willingness, and ability to implement an effective corrective action plan."

The OIG also concluded that "the seriousness of this case raised questions within FAA about the effectiveness of the Compliance Program and whether the decision to address the severity of the violation with nonpunitive action was consistent with FAA's safety policy." An independent FAA review found AAR "demonstrated patterns of behavior and performance that represented an unacceptable risk to safety," the OIG said. Despite these findings, the FAA did not take enforcement action. The agency closed the cases in March 2017.

The OIG's report includes nine recommendations—most focusing on improving inspector training and ensuring that information gleaned from certificate-holder oversight is shared across FAA offices and factors into possible enforcement actions. The FAA has pledged to address eight of them by the end of October. The OIG's ninth recommendation calls on the FAA to revise its inspector guidance so that "severity of outcomes" is a factor in whether to proceed with CP or enforcement actions.

"The FAA disagrees that severity should be a key factor in this determination," the agency replies to the OIG. "Certain behaviors, such as intentionally acting contrary to the regulations or reckless behavior, represent the highest risk to safety, regardless of the severity of a particular violation."

The OIG counters that the agency's 8900.1 CP guidance calls on inspectors to consider enforcement when they detect "conduct that creates or threatens to create a significant risk to safety" and urges the FAA to reconsider.

The FAA plans to update its guidance but not its philosophy. "We do recognize that clarification of this aspect of the compliance and enforcement policy is necessary in light of the draft report findings, and intend to update that guidance by Oct. 31, 2020," the FAA says.

—Sean Broderick

ARSA UPDATE

The Best and Worst of Times

IF YOU'RE LOOKING FOR EXAMPLES of policymaking at its best and worst, search no further than two of the biggest issues the aviation maintenance industry is grappling with on Capitol Hill.

ARSA's signature achievement of the past two years—creating a new grant program to support aviation technical workforce development as part of the 2018 FAA bill and getting it fully funded through this year's appropriations process—is a great example of how the legislative process is supposed to work. In stark contrast, a union-driven legislative campaign to make it harder for air carriers to use contract maintenance shows what happens when the process is subverted.

POLICYMAKING AT ITS BEST . . .

In recent years, ARSA has heard loud and clear from its members that the technician shortage is the biggest strategic threat to the maintenance industry—so we set about solving the problem. In early 2018, over the course of many conversations about the skills gap, with staffers working for members of Congress from both political parties in both the House and Senate, the idea of a grant program to recruit and train technicians took shape. Eventually, we put pen to paper and came up with a concrete proposal. Then we started reaching out to other aviation industry stakeholder groups—including labor organizations—to build support for the idea.

Once the concept had passed the laugh test with our industry peers and we had a coalition (which eventually grew to more than 40 groups), we worked with our partners to identify four senators and four representatives (two Democrats and two Republicans in each chamber) willing to introduce legislation. After the bills were introduced, ARSA coordinated dozens of coalition meetings with congressional offices to educate lawmakers about the maintenance industry technician shortage and pitch the grant program as a solution.

Slowly but surely, more members of Congress joined the bill as co-sponsors. Before long, a quarter of the Senate and more than 20 representatives had signed on. Because of that bipartisan support, the grant program was included in the FAA bill and eventually signed into law and legally authorized. Over the past year, ARSA has continued to lead the coalition and pressed Congress to provide full funding. The hard work paid off: In December, Congress fully funded the program at $5 million for fiscal 2020.

. . . AND AT ITS WORST

Contrast that story with recent events surrounding the Safe Aircraft Maintenance Standards Act (H.R. 5119), a bill making its way through Congress that would hurt repair stations, commercial and general aviation operators and aerospace manufacturers.

Although unions representing airline mechanics were essential allies in our grant program campaign and an important part of our coalition, they've been fighting contract maintenance for decades. Repair stations are highly efficient and have helped airlines reduce maintenance costs while improving their safety records. Today, there are six times more technicians working at U.S. repair stations than there are mechanics at airlines. Contract maintenance is no longer a trend; it's the way business is done. Rather than embracing that new reality, labor organizations are still fighting to force air carriers to bring the work back "in-house" and prevent them from using repair stations outside the U.S.

H.R. 5119 is a new front in that ongoing war. It would impose unnecessary restrictions and requirements on foreign repair stations and their employees, create burdensome reporting obligations for airlines and their maintenance vendors, and prevent the FAA from certificating new repair stations outside the U.S. All that would almost certainly lead to retaliation against the more than 1,500 U.S. repair stations with foreign approvals and make it more difficult, or impossible, to serve international customers.

The unions have a strong ally in House Transportation & Infrastructure Committee Chairman Peter DeFazio (D-Ore.), a long-time contract maintenance critic, who introduced H.R. 5119 on Nov. 15 and rammed it through his committee five days later. There were no hearings, no outreach to industry and no attempt to build consensus.

In ARSA's press statement when the bill passed committee, I called it "policymaking at its worst." I stand by that statement. No-huddle offense may win football games, but it's a loser when making policy, particularly in a heavily regulated sector like aviation safety.

In response to the threat posed by H.R. 5119, ARSA is leading another coalition to fight the bill, and as 2020 gets underway, the association is preparing to expend considerable resources defending industry (resources we'd rather devote to addressing the skills gap). We're going to engage with both sides of the aisle in both chambers of Congress, explain the facts, dispel the myths and build consensus that H.R. 5119 is bad idea. In other words, we're going to do it the right way. Hopefully lawmakers will recognize that's the best way to make policy.

Christian A. Klein is the managing member of Obadal, Filler, MacLeod & Klein, overseeing the firm's policy advocacy practice. He is executive vice president of the Aeronautical Repair Station Association.

Alitalia

Alitalia's engineering and maintenance division is adding capabilities and hopes to fully implement new technology projects this year. Vincenzo Quaranta, head of marketing and sales for engineering and maintenance, discusses Alitalia's MRO plans with Lee Ann Shay.


ALITALIA

Alitalia Fact Box

FLEET SIZE: The airline has 113 aircraft: 22 A319s, 38 A320s, seven A321s, 14 A330s, 12 Boeing 777s, 15 E175s and five E190s

NUMBER OF AIRPORTS SERVED: 33 airports are directly served by Alitalia maintenance personnel, and 60 are served with supervision

MAINTENANCE AND ENGINEERING STAFF SIZE: About 1,200 qualified engineers and certifying staff

MAINTENANCE BASE LOCATIONS: Fiumicino Airport, Rome

What is Alitalia's maintenance strategy for its own fleet, in terms of insourcing and outsourcing?

The maintenance strategy for the next year is to continue mixing insourcing and outsourcing. We are targeting maximizing heavy maintenance savings while keeping a high level of flexibility. Next year we are going to insource some Airbus A320 heavy maintenance because our long-term agreement with our provider allows us to process a certain number of heavy maintenance checks per year. We've done that in previous years. Unlike our narrowbody contract, our widebody contracts aren't exclusive. Each year we plan to outsource MRO for our long-range fleet, the A330s and Boeing 777s. For some A330s, we have also recently insourced some C checks.

How far in advance do you have to book slots?

We prefer to book one year in advance but, at the latest, not less than six months before, because it's very hard to find slot availability, especially in the Far East and Middle East. If you book longer than one year in advance, the costs, of course, increase.

We do insource some long-range aircraft, particularly the A330, but not too many, in order to preserve slot availability for third-party customers.

Are most of your heavy maintenance contracts for only one year? Who are your providers?

We don't have one-year contracts, but single-check contracts or aggregate contracts for a few checks for the long-range fleet—the A330s and 777s—as well as the regional fleet. We use the same provider—Atitech in Naples—for heavy maintenance on the A320, which is our biggest fleet and for which we have a long-term agreement, and for the Embraer regional fleet, for which we have single-check agreements. We choose the same maintenance provider for our Embraer aircraft for logistical reasons and because there aren't many heavy maintenance providers for Embraers worldwide.

For long-range aircraft, we use Joramco, Singapore Airlines Engineering Co., GMF AeroAsia, Etihad Airways Engineering and Haitec in Germany.

Are you considering adding any new in-house capabilities?

We already have a huge in-house capability, augmented by the certification recently gained for the IL check for the 777-300s because we are going to do two heavy maintenance checks for a third-party customer at the beginning of the year. We are also considering gaining approval for the A330 IL check and the 12-year check on A340. Recently, we obtained the 6-year check capability for the A330.

We now have full in-house capability for the A320 up to D checks and for the A330 up to 6-year checks. We don't operate the A340 but have in-house maintenance capability for it because we have third-party customers who operate the aircraft. Capabilities are added based on our customers' requests and on our business development plans.

How much third-party maintenance work does Alitalia perform?

We do about 60% for third-party customers and 40% for Alitalia.

What are your third-party maintenance near- and long-term plans? Are you happy with that mix?

We are happy with the mix for 2020. We are planning to keep the portfolio that we developed in the past few years and to gain some new acquisitions for base maintenance. For line maintenance we are planning to increase the business at stations in Italy and Germany. For the longer term, it depends on the new owner of Alitalia. Given that the company is up for sale and the sale should be finalized this year, future strategies will depend on the new shareholders.

What is the latest news on the sale?

The next milestone for the presentation of a binding offer is the end of May.

Alitalia started tearing down aircraft to balance heavy check costs and spares prices. How many aircraft do you plan to tear down this year, and what type will they be?

We don't have any planned for 2020 because our fleet will remain stable until the sale. But if in the future we decide to retire some older A320s, we could consider tearing them down.

Is Alitalia tearing down third-party customers' aircraft, too?

Yes, we are tearing down an ATR 72 now, and this year we plan to tear down A320, ATR 72 and older Boeing 737 aircraft. We have several customers asking us to perform these services.

When Alitalia tears down aircraft, do you also repair and certify the components?

Yes, we have a huge in-house capability, so we can remove and recertify components for which we have in-house shop capability—especially for the A320. Some components, however, we just tear down and return to the customer in as-removed condition.

Alitalia has performed some drone tests. Do you have any technology investments planned for 2020, or is that on hold until the sale?

We aren't planning any new investments for 2020, but we are going ahead with the e-logbook project, in which we already invested during 2019. It will be finalized very soon. For drones, it's the same concept: We invested in it last year and recently awarded flight licenses to maintenance engineers so they can fly them. We have also gained Italian Aviation Authority certification as a drone operator and flight school. To certify the inspections in accordance with the approved documentation (AMM, SRM, etc.), we need to obtain an equivalence statement for the drone inspections and approval from the local aviation authority. That process is ongoing.

When do you think you'll receive the regulatory approval for that?

We hope to get it in 2020. We are ready to start—we just need the final approval from the authority.

Which drones are you using?

The DJI Mavic.

Can you tell me more about the e-logbook project?

We are experimenting with e-logbooks at our out stations because we perform line maintenance at 33 stations worldwide. We will start this year with widebody aircraft. There are some problems with the GSM connectivity on-site, but we are continuing to do pilot tests to be ready early in the year.

At some stations, especially at New York's John F. Kennedy International Airport, we are having problems because the GSM signal isn't available in parking areas and aprons, where we sometimes have to perform maintenance activities. We are solving such problems with the line maintenance duty managers of local stations because our target is to have the e-logbook available wherever we need it. Some stations don't have GSM fields at all airport areas.

Another challenge we are facing is the cultural change associated with moving to paperless documentation.

Full Shop

The engine aftermarket is booming, but with demand outstripping supply, MRO shops are adjusting their strategies

James Pozzi London

The end of 2019 saw a commercial aviation aftermarket buoyed by record MRO spending but one still skeptical that its well-documented capacity constraints will be alleviated in the near- to mid-term. The engine segment, which accounts for 42% of the market according to Aviation Week's Fleet & MRO Forecast 2020 data, is evidence of this. While overall commercial MRO spending reached $24.3 billion for last year and is expected to jump to $34.7 billion in 2020, the surge in shop visits has left many providers running close to capacity for 12 months a year at shops worldwide.

The narrowbody engine segment, mainly the CFM56 and V2500, which account for more than half of the market combined, is particularly lucrative at present. Demand for these engine types is strong, with shop visits for their newer engine variants—the V2500-A5, CFM56-5B and CFM56-7—are all expected to peak by the mid-2020s. However, their successor engines, the CFM Leap and Pratt & Whitney's PW1000G, have seen technical issues over the past few years, meaning the expected influx leading to the phase-out of older engines hasn't materialized very quickly. As it stands, many in the industry believe the CFM56 and V2500 will be operating well into the 2030s.

Other mature engine programs have also shown longevity, which has had some detrimental effects on capacity. "Demand for services for older legacy engines, such as the CF6-80C2, has continued longer than expected—thanks to low fuel prices and air transport demand, where demand for aircraft and engines is faster than delivery rates," says Martin Friis-Petersen, senior vice president for MRO programs at MTU Aero Engines. "Also, new-generation engines are entering the shops earlier than originally anticipated and will ramp up in the next decades. All this has led to our shops and many others being fully loaded worldwide."

On top of these issues, a more recent development has been the technical woes that dogged the Boeing 737 MAX program last year. With the aircraft yet to return to service, the expectation is that this situation will continue well into the year, likely increasing demand for older aircraft and their engines. While retirements could provide relief for the used serviceable material shortages that are prevalent, any potential return to service of the 737 MAX could be key to driving that trend, says Mike Stengel, senior associate at consultancy Aero-Dynamic Advisory.

"Fleet demographics certainly suggest that a wave of retirements is coming. However, if the teething problems on the new-engine models continue, then older aircraft may remain in service longer than expected. The return to service of the MAX will also influence retirement rates in the coming years to replace the last generation of narrowbodies," he says.

Stengel believes that the current environment has pushed MROs into adding capacity out of necessity. "MROs are somewhat backed into a corner in this regard, and one of their most effective options is to expand capacity," he says, pointing to several suppliers announcing expansion plans, both for engine shop visits and component repairs. For airlines with in-house engine

SANAD AEROTECH

Sanad Aerotech in Abu Dhabi will soon begin to overhaul the GEnx as well as several Leap models.

shops, he cites the decisions of American Airlines and United Airlines to insource some engine work, with the former bringing CFM56-5B in-house in late 2018 while the latter brought some V2500 engine services in-house. "This allows them to control their own destiny to a degree rather than relying on third-party capacity," Stengel says.

Holger Lipowsky, principal at consultancy Roland Berger, believes that while the current climate is challenging, it presents a good opportunity for well-resourced companies to grow capacity. "It's the perfect time for investments and especially for large OEMs with the financial power to build capacity and are expected to use this opportunity to strengthen their position for the coming years," he says.

A recent example of an OEM doing this is Rolls-Royce, which in November 2019 confirmed several changes to its global aftermarket network as it looks to prepare for the growing number of its engines undergoing shop visits over the next decade. Its Rolls-Royce Deutschland site in Dahlewitz, Germany, is to transition into a services hub with capability for widebody engine overhauls from early this year.

Meanwhile, its Rolls-Royce Canada facility in Montreal will also introduce widebody engine overhaul services later this year, with a start date projected for the fourth quarter. As well as acknowledging capacity as being a driver behind the moves, Rolls-Royce says it also made the changes as a way of reducing the impact on customers handling in-service issues with the Trent 1000. This followed adjustments to its maintenance center (AMC) network of shops. U.S.-based MRO Standard Aero joined as an AMC for RB211 repairs at the beginning of 2018, followed by Delta Tech Ops becoming an AMC for the Trent 1000 and Trent XWB, which power the Boeing 787 and Airbus A350 respectively.

MTU Maintenance has also invested heavily in ramping up capacity. Expansions have occurred at shops in Hannover, Germany, and in Zhuhai, where it overhauls CFM56 and V2500 engines, along with its Berlin facility where demand for mature engines such as the CF6 remains high. Its Vancouver facility, which has specialized in the V2500, is also due for relocation.

The company factored in Leap and GTF engines into these expansions, with scheduled shop visits expected to begin between 2021 and 2022, to be followed by restoration shop visits. A new Poland-based joint venture with Lufthansa Technik, operating as EME Aero, was scheduled to induct its first GTF engine in late 2019 and will eventually build up to a capacity of 450 engines per year. MTU also plans to open a site in Serbia focusing on parts-repair services.

In the Middle East, the main capacity challenges have been workforce-related. This has been a focus for Sanad Aerotech, which was renamed from Turbine Services & Solutions last year, in a move combining its engine, finance and energy divisions.

The year 2019 saw the Mubadala-owned company sign several large-scale engine repair deals with OEMs, in moves set to add capacity demands at its Abu Dhabi-based facility. Starting in January, it will begin overhauls on the GEnx, with more than 300 engines expected over a 15-year period. It will also handle the Leap-1A and -1B, with the engines representing a new product platform in its portfolio. This will start in 2021, as a 10-year agreement, and will see more than 200 engines inducted over that time frame. With these new agreements in place, building a workforce to add capacity is one priority.

"With these new agreements, we've had to look at increasing our manpower and capacity in terms of production

space," says Sanad Aerotech's CEO Mansoor Janahi. "In terms of numbers, we are looking to add around 400 employees across the aerospace business, taking us to between 550-600 employees over the next two years to deliver this" additional production capability.

While larger companies boasting greater resources have sought several solutions to address capacity concerns, smaller MROs have had to

ROLLS-ROYCE

Rolls-Royce is expanding its capacity to handle overhauls of both new-generation and legacy engines.

be more agile and creative to adjust. Nevertheless, the roles of these smaller, boutique-style independent engine repair providers could also expand in the next two to five years. GT Engine Services, which offers specialist repair services from its facility close to London Stansted Airport in the UK, is one company that sees itself as an alternative option to operators sending their engine into an overhaul shop.

Greg Macleod, the managing director, says the company was previously a seasonal business but changed strategy a few years ago in order to spread its workload year-round while adding further repair capabilities. Given its work for airlines and lessors, this means the shop is routinely full, while the allocation of manpower and resources is a constant challenge, Macleod says. "This year we have just increased our workshop space by a third," he says. "We also have a constant recruitment drive and a growing apprentice program." Specifically, he identifies materials for the Rolls-Royce RB211 engine as being tricky to acquire.

Like many repair providers, Macleod foresees further alignment with OEMs, as companies like GT Engine Services position themselves to take on the overflow of maintenance work from capacity-squeezed counterparts. "There is a lot of scope to strengthen our relationships with the OEMs, which will benefit all involved," he says. "This is nothing new, we are filling a void where the OEMs and overhaul shops struggle to fill."

Across the pond in the U.S., Global Engine Maintenance (GEM), another independent MRO, provides repair services for CFM56-3, CFM56-7B and starting this year, CFM56-5B engines. Like GT Engine Services, it is running either close to or at full capacity all year round, mostly working from a single bay configuration. When necessary, GEM changes the workspace to a double-bay configuration to add capacity.

At the facility, it sees a strong wave of inductions in the winter and spring months as aircraft operators gear up for the summer travel season. "In terms of engine repair volume, we are repairing almost as many -7B as we are -3C engines," says Jamie Devin, the company's director of business development says of the company's output. "Components and life-limited parts (LLP) for the -3C engines are plentiful, with only a few exceptions. However, these parts and LLPs for -7Bs are slightly harder to procure generally because the operators want performance restorations built up to 10,000 cycles remaining."

Devin says it has looked at other methods of adding capacity at its Miami, Florida, hangar and has identified one area where it can improve its output. "One way to increase capacity is to improve your throughput time—we've added a number of in-house capabilities that would otherwise be sent to outside vendors, thus saving time," he says.

GEM, has also turned to technology to help its throughput time. "Our 3D scanner and high-speed grinder allow us to match grind high-pressure compressor (HPC) and high-pressure turbine (HPT) rotors in days rather than in weeks," explains Devin. "The 3D scanner also aids in detail inspection. What would have taken hours to inspect using traditional methods can now be done in minutes," he adds.

Another independent taking on extra capacity is Aero Norway, a CFM56 specialist focusing on engine overhaul service. Its shop in Stavanger also routinely runs close to full capacity annually, says Rune Veenstra, its chief business officer. It has increased capacity by bringing in more resources, including necessary tooling to grow volumes. Once the CFM56 engine family hits its expected shop visit peak between 2023-24, the cargo market will look to move over to these engine types, Veenstra tells *Inside MRO*.

Latin America MRO Investment Surges

Possibilities and potential abound, but there are questions as well

Gol Aerotech initially will support Boeing 737s and 767s in two maintenance hangars and a paint hangar, plus six workshops.

GOL

Henry Canaday Washington

Brazil and Mexico will be among the top 10 emerging aviation markets by 2038, according to the International Air Transport Association (IATA). In Mexico, trips per person will grow 4% a year over the next two decades, with trip frequency in Brazil increasing even faster, at 5% annually, IATA estimates.

Add population growth and other smaller—but growing—economies in Latin America, and there should be plenty of demand for aircraft maintenance. Jonathan Berger, managing director of Alton Aviation Consultancy, puts the current MRO market in Latin America at about $4 billion a year, and expects it to double over the next 10 years, growing 6.3% annually. That number does not include outsourced work for North American carriers.

MROs in the region are responding to growth opportunities. Aeroman in El Salvador is the largest airframe MRO in Latin America, and Berger says it "continues its impressive growth by building new hangars and adding widebody capacity." Brazil's Gol Airlines recently announced it will enter the third-party MRO market and will begin insourcing new customers at its facility in Confins, Minas Gerais. Panama's Copa recently finished a hangar in Panama and has begun performing more work in-house. Azul Airlines will open a hangar this year, bringing maintenance in-house.

Other moves suggest future possibilities. "With Delta's recent investment in LATAM, it will be interesting to see if they elect to pursue MRO collaboration and integration efforts between Delta's maintenance division, Delta TechOps, and LATAM," Berger says. United Airlines is also investing in Avianca.

Possibilities and potential may be the key words, for there are questions as well. Berger notes that political unrest and instability continue to challenge the ability of airlines to grow and thrive in Latin America. Such conditions remain problematic in Venezuela, Argentina, Colombia and Chile. This uncertainty has hampered the ability and desire of investors to finance major infrastructure investments in airports to support traffic growth and in MRO facilities. Berger also asks, "Will countries such as Brazil soften their airline foreign-ownership rules, which could spur new investments?"

But growth continues. Gol's new Aerotech venture will initially offer support for Boeing 737s and 767s in two maintenance hangars and a paint hangar, plus six workshops. These facilities could service up to 80 aircraft per year.

The new competitor has solid experience. Carlos Alberto Costa, Aerotech's maintenance director, says Gol started in 2006 doing maintenance for the airline itself. "After 13 years of experience, Gol decided to create Gol Aerotech to offer its services to all airline companies," he notes.

The MRO plans to expand its portfolio. Aerotech already has FAA certification for Boeing 737-700s and -800s and soon will have it for the 737-8 MAX, Costa says. "We are now working to certify Aerotech for the Airbus A320 family in 2021, and Embraer 170s and 190s in the year after. Within 3-5 years, we will have Boeing and Airbus widebody certification as well."

Aerotech is seeking third-party revenue of more than $30 million in 2020. But Costa says it is too soon to estimate future third-party revenue. "GOL Aerotech has a structure prepared to expand or decrease according to market demand, and that makes our projections variable."

At the moment, C checks are the service most in demand by airlines. Beyond C checks, Aerotech offers painting services, general parts repair, engine services, wheels and brakes, electric/electronics and metallic structure repairs.

To meet or beat the competition, Costa says Aerotech can offer the best labor costs per hour in the current market, "with almost 99% on-time delivery." The MRO is strategically located near airport hubs such as Guarulhos, Rio Galeao and Brasilia. Aerotech will specialize in labor and material transaction maintenance, not flight-hour support.

For engines, Pratt & Whitney and Brazil's Industria de Aviacao e Servicos (IAS) have just opened an overhaul center in Belo Horizonte, Brazil, for the PT6A and PW200 engines for business and general aviation, smaller regional aircraft and rotorcraft. This extension of IAS existing facility will add 1,800 m^2 (19,375 $ft.^2$) of shop floor with 900 m^2 of test cell area. Pratt & Whitney is creating 50 new jobs and growing to about 100 people in Brazil, a representative says, and "is looking at Belo Horizonte to potentially overhaul PW127M engines for ATR 72-600s."

Emirates' Customized 777 MRO

Boeing's Optimized Maintenance Program tailors services to carrier's environment

JOEPRIESAVIATION.NET

Sean Broderick Dubai and Washington

Ask anyone in the MRO business for a list of the hottest industry trends, and data-driven maintenance is sure to be near the top. Much of the emphasis is on aggregating large datasets on specific aircraft or engines from multiple operators and using it to glean insight on when disruptive events such as a failure of a specific part may happen. But increasingly airlines are reaping benefits from their own data, which can be used to customize their efforts based on unique operating environments.

Among the most ambitious of such projects is Emirates Airline's collaboration with Boeing on the OEM's Optimized Maintenance Program (OMP) offering to streamline its 777 maintenance. Early returns suggest it will be one of the more successful as well.

"Like everything else, there's always a tinge of nerves about what surprises it could bring to the operation that we did not take into our calculations," Ahmed Safa, Emirates vice president of engineering and maintenance, tells *Inside MRO*. "But so far, we have not had a single question mark about whether it was a good decision."

Emirates committed to OMP in early 2018 following several years of evaluation. The first step was applying Boeing's OMP modeling to Emirates' fleet data and finding initial opportunities to adjust task intervals—a process that typically takes about six months, Boeing Global Services Vice President for Commercial Services Mike Fleming says.

In Emirates' case, initial changes have been made to both A check and C check intervals. A checks are now done every 2,500 flight hours (FH) or 500 flight cycles (FC), up from 2,000 FH and 400 FC before OMP. (A separate Emirates project eliminated a calendar-day limit.) The carrier's C check intervals were adjusted 15,000 FH or 1,125 days to 18,000 FH or 1,200 days.

Emirates began transitioning its 154-aircraft 777 fleet to the new program in early 2019, and the process is now about 40% complete, Safa says. Bridging requirements to bring aircraft from the old to the new program means transitioning the entire fleet will take about two years, but positive returns are already evident.

The airline's deep 777 experience—it operates 10% of the global 777 fleet and has flown every variant produced—has helped keep it at the top of dispatch reliability figures, at about 99.5-99.6%, Safa says. Those marks, slightly higher than the global fleet average, are being maintained under the OMP—a clear sign that the adjusted intervals are not compromising operational efficiency.

"If it was not going to work, it would immediately have [had] an impact on our on-time performance and dispatch reliability," Safa says. "But to continue to see the operation at 99.5%, 99.6%—it confirms that what we have put in place is delivering what we anticipated."

The OMP complements bigger-picture optimization efforts that accompany any in-service model. The 777's A check intervals when the model entered service in 1995 were 1,000 FH or 75 days, for instance. While

Emirates is optimizing its Boeing 777 maintenance based on trends identified by its own fleet data.

fleet-level interval changes benefit all operators, tailoring programs for individual airlines requires a more concentrated dataset.

"Take a task that we do every 10 days, as the [Boeing maintenance program] prescribes," Safa says. "Every time we do it, our findings are nil, nil, nil, whereas other operators have some positive findings. We need to be liberated from the shackles of the [portion of] industry that's driving this threshold to a specific time frame."

Longer maintenance intervals are only part of the story, Fleming says: "The number of scheduled maintenance delays is reduced, just by virtue of the fact that you're not opening up the airplane as often. So you get aircraft availability increasing; you get scheduled reliability increasing, too."

Boeing and an operator can set an OMP up in about six months, but fine-tuning it takes years. Boeing will monitor customer maintenance data for five years as part of an OMP package and provide input as needed.

"We look at the effectiveness, whether there have been any findings and whether there are any adjustments that need to be made to the program," Fleming says. "Our team will continue to work closely with the [operator] to make sure the forecasted effectiveness that we targeted is actually achieved."

Intervals can also be further expanded. Boeing and Emirates are evaluating whether to increase the C check time interval to 1,375 days, for instance.

Boeing has about 2,500 customer aircraft with 24 airlines under OMP programs, including several with multiple fleet types.

"No two customers are exactly alike or operate in the same environments," Fleming says. "That combination of data-sharing with our software applications and algorithms can create customized programs that continue to conform to regulatory requirements-but have the elasticity to be uniquely suitable for a customer's needs."

Industry as Focused on ADS-B 'In' as 'Out'

American Airlines will start installing ADS-B In systems on its A321 fleet this year

Bill Carey Washington

With the arrival of the Jan. 1, 2020, compliance deadline for automatic dependent surveillance-broadcast "Out" (ADS-B Out) functionality in the U.S., airlines are shifting to the promise and requirements of ADS-B In: the capability to display and exploit aircraft targets on the flight deck.

After years of trials involving several U.S. carriers, ADS-B In is no longer aspirational. In January, American Airlines plans to begin installing the SafeRoute+ ADS-B In retrofit system on its fleet of 319 Airbus A321s, an expected 4-5-year process. The airline completed certification flight tests on the narrowbody at Phoenix Sky Harbor International Airport (PHX) in September and October.

L3HARRIS

Pilots and engineers with American Airlines and L3Harris conducted certification flight tests of the SafeRoute+ ADS-B In system on the carrier's Airbus A321 at Phoenix Sky Harbor International Airport.

Originally as US Airways, with which it merged in December 2013, American has worked with SafeRoute developer ACSS—the joint venture of L3Harris and Thales—for nearly a decade to achieve ADS-B In functionality.

"It's pretty exciting," ACSS President Terry Flaishans says of the system's entry into service. "All of the installation has been checked out, we've done our flight test, we've gotten the STC [supplemental type certificate] for the system, and we will start to install these in 2020. It's going to be a very exciting time because immediately we will start looking for benefits [from] the ADS-B In system."

SafeRoute+ is an upgrade to an aircraft's ACSS TCAS 3000SP or T3CAS surveillance processor that avoids panel modifications on the flight deck by using the existing multifunction control and display unit and primary flight displays, with the addition of a small ADS-B Guidance Display (AGD). ACSS estimates the upgrade takes three days to complete.

The system currently supports five ADS-B In software applications: Enhanced Airborne Traffic Situational Awareness, Interval Management-Spacing (IM-S), Cockpit Display of Traffic Information, Assisted Visual Separation (CAVS), and In-Trail Procedures and Surface Area Movement Management.

ACSS first installed SafeRoute on UPS Boeing 757/767s in 2007, then provided applications for Delta Air Lines, JetBlue Airways, US Airways and American Airlines. Early versions of the system made use of Class 3 electronic flight bags (EFB) located to the side of the main instrument panel as the platform for display and control of the ADS-B In applications.

With the increasing adoption of tablet computers as EFBs instead of costly Class 2/3 mounted or installed units, ACSS moved to develop the SafeRoute retrofit solution. Adoption of integrated electronic standby indicators freed up panel space for the AGD.

The forward navigation displays present nearby ADS-B traffic for situational awareness; the graphical AGD supports more complex ADS-B In applications such as CAVS. A visual approach procedure, CAVS allows pilots to maintain separation during challenging visual conditions by presenting the differential ground speed between a lead and own-ship aircraft on the electronic display.

Expected benefits are reduced time on approach within 25 nm of the runway, reduced need for go-arounds and more efficient use of terminal airspace.

Recent progress in ADS-B In development has been reported on other fronts. In February 2019, the FAA, Honeywell, Alaska Airlines and United Airlines demonstrated IM-based "paired approaches" with lead and trailing aircraft at the San Francisco and Tucson airports using Honeywell prototype avionics.

During a paired approach, the trailing aircraft uses speed commands to maintain precise spacing from the lead (target) aircraft. Pilots are presented with a time-based spacing parameter, called the assigned spacing goal, which represents the desired spacing behind the target aircraft.

Airspace design and engineering company Mosaic ATM developed the experimental instrument-approach procedure, intended to increase the capacity of closely spaced parallel runways during instrument meteorological conditions.

Under the Air Traffic Management Technology Demonstration-1 program in early 2017, United Airlines and Honeywell tested the NASA-developed Airborne Spacing for Terminal Arrival Routes algorithm using EFBs to display the IM application with a chain of three aircraft—a United 737 and Honeywell's Boeing 757 and Dassault Falcon 900 testbeds—at Grant County International Airport in Moses Lake, Washington.

Once its upgraded A321s enter service, American will participate in the ADS-B In Retrofit Spacing project, a two-year FAA demonstration designed to collect operational data and support future ADS-B In development. Benefits of ADS-B In applications will be measured within airspace managed by the Albuquerque air route traffic control center for westbound flights approaching PHX.

"In the past, the FAA and airlines and avionics manufacturers have worked on technical demonstration projects," says Andrew Shutt, with the FAA's Surveillance and Broadcast Services program. "What sets this project apart is that it is using commercially available avionics permanently installed in aircraft on revenue-generating flights, and using a large number of pilots and controllers."

L3HARRIS

The ADS-B In certification test crew with an Airbus A321 at Phoenix Sky Harbor International Airport.

Transponders also will be updated to support ADS-B In. To comply with the ADS-B Out mandate, the FAA requires that operators equip with Version 2 DO-260B Mode S transponders and approved GPS position sources. The Version 2 standard has evolved since its original "Version 0" substantiation in the early 2000s to meet the mandate's performance requirements.

An updated specification—DO-260C—that will support ADS-B In applications is under development. Standards organization RTCA's Special Committee-186 for ADS-B has scheduled release of DO-260C minimum operational performance standards (MOPS) for next August.

DO-260C will correct issues identified since the publication of MOPS for DO-260, make revisions and implement additional information required for advanced Flight Deck Interval Management, according to the SC-186 terms of reference. It will make other improvements to support new ACAS X collision-avoidance logic and to accommodate unmanned aircraft and commercial space vehicles.

Tackling Workforce Needs in Texas

Port San Antonio pursues STEM and innovation growth

Students participate in Boeing's recent STEM signing ceremony.

BOEING

Lindsay Bjerregaard San Antonio

Quietly housed in the meat locker of a former U.S. Air Force base commissary is an assortment of industrial fabrication equipment and historic technology collectibles that will soon serve as part of San Antonio's recipe for future innovation and MRO workforce growth.

The old commissary building is serving as a temporary home for the San Antonio Museum of Science and Technology (Samsat) before it moves to a newly constructed innovation center on the Port San Antonio campus. Once there, Samsat's vast collection of technologies and youth programs will become an integral part of the innovation center's STEM initiatives.

Port San Antonio—a confluence of MRO, defense and technology companies developed on the former Kelly AFB—is hoping to start construction on the innovation center by June 2020 to bring together the campus's stakeholders while attracting future workforce candidates. The facility is envisioned as an intersection of technology showcase, collaboration resources and innovation center with the overarching goal of addressing challenges for local companies, including the growing need for MRO workers.

Companies on the Port campus added approximately 3,000 new jobs this year, many of them at StandardAero and Boeing. StandardAero has hired approximately 300 new employees at this location in the last 2.5 years, a trend it expects to continue. Boeing, which employs around 1,200 people at its Port San Antonio site, plans to double this number in the near future to accommodate growing MRO programs.

While Boeing receives plenty of applicants for jobs on the site, thanks to San Antonio's large veteran workforce, hiring skilled technicians is still a challenge. Jay Galloway, Boeing's San Antonio site leader, says combing through applications to find applicants with the right skill sets is easier said than done.

"In a certain skill that I hired for recently, I went through 1,200 people to hire 180. It's hard to find the right kind of talent—sometimes you have to be patient because it takes a while," he says. "You have to work with places that are developing talent such as trade schools, colleges and universities."

Both StandardAero and Boeing work with local schools such as Hallmark University, University of Texas at San Antonio and St. Philips College, which has a campus right down the street from both companies. Galloway says Boeing San Antonio's eventual goal is to develop partnerships with these schools to create college curricula beneficial to both students and Boeing's workforce pipeline.

For Mark Buongiorno, vice president and general manager of StandardAero's San Antonio site, developing relationships with these schools has been part of its success in recruiting. The company also has a robust internship program, which received 250 applications last summer.

"The one thing we really pride ourselves on is [that] if you come here as an intern, you're going to get real work to do. There's no filing because we're paperless. You'll be working on an engineering project," he says, adding that engineering projects from

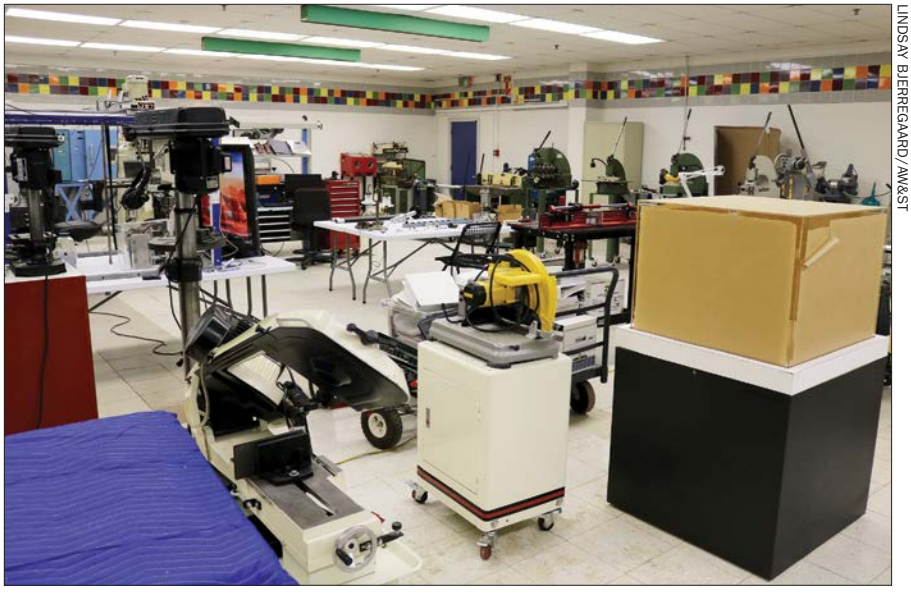
previous interns are currently in use at the site such as engine stands designed by interns last summer.

To encourage students to go into STEM fields, Boeing San Antonio is heavily involved with local initiatives for K-12 students. The company recently participated in the Port's Youth Aerospace Expo, in which it engaged with kids through technology such as virtual reality headsets and 3D printers. Boeing also recently held a STEM signing ceremony for students going into high school or college who were choosing either a STEM curriculum endorsement or career. The company brought 60 students on-site to participate in a sports-draft-like signing ceremony onstage next to a C-17 aircraft.

Aerospace companies at the Port are also engaging with Samsat. Boeing recently provided a $100,000 grant to the nonprofit for mobile STEM programming in lower-income neighborhoods through its Geekbus program. Poised to serve 240 students in 2020, the Geekbus is a mobile "maker space" that travels to different locations to provide STEM educational experiences on topics ranging from drones, rocketry and robotics to cybersecurity and structural engineering.

Aside from the Geekbus, Samsat provides a wide variety of STEM educational programs, many of them focusing on aerospace or related fields. The museum holds multiple space camps every year, typically for underserved youth, that include experiences such as building and launching model rockets with staff from NASA and JPL, as well as exposure to WEX Foundation projects focused on building 3D-printed habitats on the Moon and Mars.

Samsat is in the process of adding 3D printers and laser cutters to its temporary co-working and maker space in the former Air Force commissary, which already features labs for electronics, optics, sheet metal and an assortment of CNC machines. Once Samsat is moved into the new innovation center, Port San Antonio's vision is to make this technology available both for students interested in learning and for companies on-site looking to collaborate and address challenges. The hope is that established companies such as Boeing and StandardAero will not only use the space to collaborate with each other but to work with tech startups on-site such as robotics specialists Reckon Point and Plus One Robotics.



LINDSAY BJERREGAARD/AW&ST

Fabrication equipment in Samsat's temporary maker space.

"What we see is that as the world becomes more connected, and as we move into a systems-based world, you need to start to bring all these capabilities together. Because if you try to solve it in silos, it's just not going to work," says Jim Perschbach, president and CEO of Port San Antonio. He adds that the Port hopes to establish "creative collisions of the right people" at the innovation center, while attracting interest from potential future workers through STEM initiatives and features such as a gaming center and robotics arena.

Perschbach says that the idea is for the innovation center to bring in 150,000 new people who could potentially be recruited into the STEM workforce. "If you get 1% of [them] actually pursuing some of the education programs and actually working with the employers, that's 1,500 people a year going into that pathway [who] aren't there right now to increase that recruitable market."

PORT SAN ANTONIO

Kids gain exposure to tech devices such as VR headsets and 3D printers at the Port's Youth Aerospace Expo.

The E175's Long Run

Large-scale retirements of the E175 after the E175-E2 enters service appear unlikely

EMBRAER

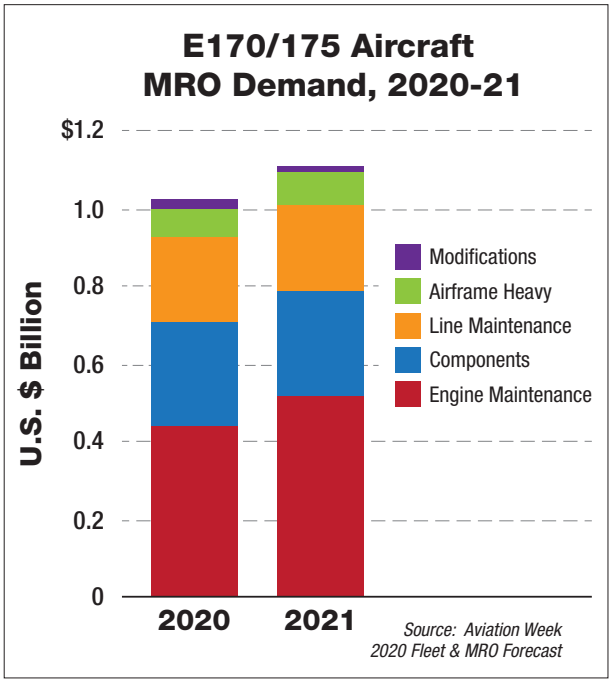
Paul Seidenman and David J. Spanovich San Francisco

With the successful first flight of its new-generation E175-E2 on Dec. 12, some might speculate that Embraer will spool down production of its popular legacy E175 when the -E2 enters service in 2021. But Embraer says that is not the plan.

In fact, the numbers suggest production of the E175 will not end anytime soon, especially if scope clauses in U.S. airline pilot contracts remain in place. Scope clauses restrict regional airline operations—on behalf of their major partners—to aircraft with no more than 76 seats and a maximum takeoff weight (MTOW) limit of 86,000 lb. The E175, with an MTOW of 85,517 lb. and a 76-seat dual-class cabin, now commands 80% of the 76-seat jet category in the U.S., with more than 600 orders since the last scope negotiation in 2012, says Embraer.

Since the E175's 2003 first flight and entry into service with Air Canada in July 2005, 793 have been ordered worldwide, accounting for 612 deliveries and 181 on backorder plus another 326 options, according to Embraer's statistics as of Sept. 30, 2019. More recent data, provided by New York-based Alton Aviation Consultancy, puts the in-service numbers at 625, with 249 on back order. Alton cites the CAPA - Centre for Aviation fleet database as the source.

The U.S. is by far the largest market for the E175, with 521, or 83% of the fleet in service, and U.S. operators slated to receive 242, or 97% of the E175 backlog, reports Adam Guthorn, an Alton Aviation Consultancy director. "The ownership composition of the E175 fleet is very interesting, with 41% leased," he explains. "Of that number, the vast majority are owned by U.S.-based full-service carriers, which lease them to their seven regional airline partners. Only 9% of the global E175 fleet is owned by operating lessors—by far the lowest percentage of regional jets."



The U.S. regional airline market accounts for 83% of the global E175 fleet in service.

With ongoing demand from U.S. regionals and, potentially, Africa, the E175 likely will remain in production.

Guthorn expects the E175 fleet to continue growing, with production and deliveries extending until at least the middle of the decade and minimal retirements over the same period. The fleet, he predicts, is expected to peak around 2024-25. "Embraer is expected to continue E175 production since the U.S. airline scope clauses will not permit the use of the E175-E2 because it exceeds the current contractual weight limit," he points out. "There is no indication yet that scope clauses will be relaxed or that the E175-E2 will become compliant." In 2018, Embraer removed from its E175-E2 backlog an order from SkyWest for 100, which was conditioned on scope clause change.

Asked if any changing market dynamics could affect lease rates and residual values, Guthorn says that based on scope clauses and demand from regional airlines, they will remain mostly stable for 76-seat aircraft, led by the E175 throughout the 2020s. "The [service entry] of the redesigned Mitsubishi SpaceJet (M100), which is scope-clause-compliant and expected to gain more orders, is not expected prior to 2024. This means that the E175, and slightly smaller E170, will be the only available options in the 76-seat regional jet segment once Bombardier stops manufacturing the CRJ 700 and 900," he says. "That would concentrate demand and support lease rates and values of the E170 and E175 in the used market."

Allan Bachan, vice president and managing director

LUFTHANSA TECHNIK AERO ALZEY

Lufthansa Technik Aero Alzey services roughly 30-40 CF34-8E engines for both E170 and E175 operators annually. The MRO expects to see a surge in life-limited parts replacement events for the engine type within the next few years.

for MRO operations at ICF, agrees. "The medium-term values and lease rate outlook for the Embraer 175 looks promising, with no imminent replacement by the E175-E2. Current public availability for the E175 is low, with only two [European Union Aviation Safety Agency]-certified aircraft listed as available for lease in March 2020," he says. "However, there will be more volatility in values if and when the E175 ceases production at a still unknown future date."

Bachan stresses that major North American carriers have an ongoing need to feed their hubs with regional aircraft, so demand for current-production E175s is unlikely to soften soon.

Richard Brown, managing director of the Naveo Consultancy in London, says there is demand from U.S. airlines for another 400-500 regional jets. "And it is this replacement market that both the E175 and the Mitsubishi M100 are targeting," he says.

The M100 is aimed at the 75-seat market, under an agreement to keep the weight under 86,000 lb. for U.S. operators. "The M100, itself, is over the weight limit, but for the U.S. market Mitsubishi proposes offering it with a reduced fuel load, thereby reducing the weight by limiting the perfor-

mance of the aircraft," he explains.

Brown says the E175 will remain in demand by North American operators seeking an existing scope-compliant aircraft. "If scope clauses don't change, the classic E175 remains a viable model, and Embraer will continue to manufacture it, so long as airlines are ordering it."

"Outside of the U.S. we will likely see some demand for the E175. However, the aircraft will likely be limited to niche route operations due to the increased availability of larger regional jets such as the E190/E195, which have only marginally higher operating costs, while also offering significantly larger capacity," suggests Michael Brain, regional sales manager for AerFin, a Cardiff-based specialist in aircraft end-of-life solutions.

Brain cites Africa as a potential growth market for the E175, as operators invest in larger aircraft to support increasing travel demand. "We therefore expect to see an increased number of used and new E175 jets transition into the region to either replace smaller 50-seat jets or for operation on new, emerging routes. The main reason is that the E175's capacity and overall economics are perfectly suited to support growing demand within emerging markets."

MRO OUTLOOK

The bullish outlook for the E175 will translate into a strong MRO market for that aircraft. Alton's Guthorn says combined E175 engine and airframe events are projected to hit $1.2 billion by 2025, up from $850 million today.

MROs are girding for increasing demand, based on the fact that within the next 3-5 years a portion of the E175 fleet in the Americas will be coming out of warranty, according to Marc Bajaj, sales director for the Americas for Spairliners. That will create higher demand for support from the aftermarket at the same time that many regional airlines are still receiving deliveries of the E175. The Hamburg-based company offers component repair programs, asset management and engineering services for the E-Jet family in Europe and more recently in the Americas.

For the E175, says Bajaj, 10-year inspections and landing gear overhauls and exchanges are just a few of the major events that will affect shop capacity.

GE

In early 2020, GE will issue a high-pressure turbine durability package for CF34-8s, under a service bulletin that will provide multiple redesigned HPT parts along with an incentive to adopt this new standard.

"However, airlines typically have the ability to stagger these inspections to minimize fleet downtime," he remarks.

Jochen Mast, head of sales support for Lufthansa Technik Aero Alzey in Germany, reports that the MRO expects to see phase-outs of the E175 fleets with the entry of the E2 generation—in the long run. Nonetheless, in the near-to-mid-term, Aero Alzey, which services the E175's CF34-8E engine, does not see a strong E2 impact on its MRO business for that powerplant, he says. "In the U.S., the market is growing, hence, the demand for CF34-8E MRO services is strong and expected to remain strong for the next few years," he notes.

Aero Alzey services roughly 30-40 CF34-8E engines annually for both E170 and E175 operators, says Mast. "We do expect to see a surge in life-limited parts (LLP) replacement events, driven by large parts of the fleet hitting the LLP limits within the next few years," he says.

Asked about challenges in the CF34-8E MRO market, Mast points to parts shortages—especially the hot-section airfoils—which he attributes to the OEM focus on newer and higher-volume engine types such as the Leap. "This is further amplified by the current high amount of shop events generating high demand for the parts," he remarks. "Also, MRO shop capacity has been an intermittent problem due to high peak demand, and we expect this situation to continue for the next few years."

Mast predicts the peak in LLP events is "yet to come," with a second but smaller such peak expected when the large fleets of E175s—more recently sold in the U.S.—reach their first engine performance-restoration shop visits. The exact timing of that, he says, is hard to predict.

CF34 OEM GE Aviation sees a long time horizon for the E175 fleet. Paolo Bellini, CF34 regional engine marketing manager, says. "The E175 fleet is relatively young, with more than 400 less than five years old, and [is] expected to fly for at least 20 more years," he notes.

GE Aviation continues to invest in the CF34-8, working in the past year to freeze engine configuration, focusing not only on reliability but also on maintenance costs and fleet stability. Early this year, reports Bellini, GE will issue a high-pressure turbine (HPT) durability package, via service bulletin, that will provide multiple redesigned HPT parts, along with an incentive to adopt this new standard. "This configuration will provide clear advantages to the customers with regard to time on wing, maintenance planning, higher engine residual value and lower life-cycle maintenance costs," he explains.

Engine Essentials

Lindsay Bjerregaard Chicago

1. Safer Engine Transport

Company: **Marlin Steel**
Product: Circular Floats
Specifications: Designed to safely transport aircraft engines around MRO facilities, Marlin Steel's new Circular Floats can hold up to 600 lb. while protecting engines and their associated components from damage. The product features a perimeter wall with a neoprene rim, adjustable ratchet straps to secure engines in place and a truck bed liner coating to prevent metal-on-metal contact. The Circular Floats come in 36-in., 48-in. and 60-in. sizes, and the company says they are ergonomic to move around as well as forklift- and pallet jack-friendly.
marketplace.aviationweek.com/product/material-handling-racks-no-metal-metal-contact

2. Environmentally Friendly Engine Washing

Company: **Rochem Aviation**
Product: Ro-Jet-Wash System
Specifications: Rochem Aviation's Ro-Jet-Wash System is designed to easily wash engines in minutes while improving engine gas temperature margins and fuel efficiency. The self-contained system is rolled up to an aircraft engine and operated by a two-person crew, using a patented atomizing system to spray water efficiently in a 360-deg. pattern around the engine inlet. Water and debris are expelled as a mist behind the aircraft and filtered through the system to be reused in its wash tanks or disposed of safely. The system has been sold to carriers including American Airlines, Icelandair and Spirit Airlines.
marketplace.aviationweek.com/product/introducing-ro-jet-wash-system

3. eStore for Engine Stands

Company: **Magnetic MRO**
Product: EngineStands24
Specifications: Launched in 2016 to make the process of purchasing and leasing engine stands quicker and easier, Magnetic MRO's EngineStands24 e-platform enables customers to receive immediate price quotes and lead times on engine stand trades or leases, as well as digitized agreements and invoices. EngineStands24 recently added product offerings for Leap-1A/-1B engines and opened new hubs in Dubai and China to capture market share in the Middle East and Asia-Pacific regions.
marketplace.aviationweek.com/product/enginestands24

4. Quicker Engine Changes

Company: **Hydro**
Product: Cobra Engine Change System
Specifications: Hydro's Cobra Engine Change System has been designed to perform aircraft engine removals and installations 70% faster than with traditional bootstrap systems. Operated via a mobile panel that controls the semi-automated lifting and lowering of the engine dolly and cradle or transportation stand, users can select preset load sheets for various aircraft, engine and stand combinations to mechanically align the system's equipment. Cobra allows engine changes both inside the hangar and on the apron, and Hydro says the system reduces costs by minimizing aircraft downtime.
marketplace.aviationweek.com/product/maximum-safety-cobra-engine-change-system

5. All-Weather Engine Washes

Company: **Lufthansa Technik**
Product: Cyclean Engine Wash
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By RAY VALEIKA

Ray Valeika advises airlines, OEMs, private equity firms and lessors. He was Delta Air Lines' senior vice president for technical operations.

Aircraft Data Rights

With the advanced aircraft and IT evolution, what are the effects on business models and privacy?

Today's aircraft and the power of advancing information and aircraft technologies are changing MRO and superseding yesterday's processes.

As commercial aviation has evolved, many systems were adopted and regulated to create stable, balanced and controllable processes. Basic to this was the maintenance system, which is dependent on a balance between the regulators, manufacturers and operators. This balance could be seen in the way different streams of information were controlled. The airlines were responsible for their operating data, the OEMs for their technical and certification data, and the regulators for their oversight data. It was often referred to as a three-legged stool. For the most part it is still that way today—but for how long? Are we now at a tipping point where operational performance and maintenance requirements are slowly migrating away from the operators?

The more advanced the aircraft, the fewer the technical resources that need to be provided by the operators. What we are seeing is the ability of airlines to operate the latest-generation aircraft safely and reliably with much less internal technical capability than required for previous generations of aircraft. This has led to a transition from dependence on internal capabilities to reliance on external services.

The most obvious examples are power-by-the hour (PBH) engine maintenance agreements, which transfer engine maintenance as well as the record-keeping, operational data and real-time monitoring of operational performance away from airlines. This has given engine OEMs unprecedented insight into an airline's operations, providing more control over pricing, engine maintenance and inventory. Let's look at where else technology and business trends are further pushing this transition.

This shift will disrupt today's aftermarket, seriously affecting independent MROs, parts distributors and airlines.

Both Boeing and Airbus have committed to major expansion in the aftermarket, which will give them more insight and control over activities that airlines perform.

The "connected" aircraft opens up huge benefits for rapid data transfer, easier record-keeping, improved diagnostics, off-aircraft analytics, training and predictive opportunities. But to which entities will they be connected, who will do the analysis, who will maintain operational data, and who will recommend corrective actions? Many of the major Tier 1 OEMs are engaged in sensor installation, predictive services and diagnostics. This will also allow them to provide PBH services across the aircraft component world. More important, like the engine OEMs, they will have significant control over many aspects of the aftermarket, particularly inventory.

Business models and aircraft are all changing, but the most dramatic change is in information technology (IT) itself. Concepts like blockchain and other capabilities will transform aircraft lessors, which today make up nearly 50% of aircraft owners. Until recently, lessors have not committed fully to the benefits available from advanced IT. They have depended on operators for most of the maintenance while under lease and have used maintenance reserves as a revenue source. Today's IT is sufficiently powerful to standardize aircraft maintenance and record-keeping so that aircraft transitions can become much more seamless. Maintenance records will become standardized and transparent. Return provisions will become much less of an issue. With such information more available, even lessors will provide all-inclusive one-stop shops.

In today's digital world, airlines are not the most efficient stewards of inventory. Billions of dollars of component inventory sits idly in airline warehouses, having turn times of less than twice a year. Clearly, this area is an obvious opportunity for big benefits, but who should control it? It's not in the OEMs' financial interest to sell fewer parts. An increase of turn times by one or so means billions less in parts sales. This area is ready for an infusion of technology and new ownership such as that already changing the supply chain in other industries.

These are just a few snippets of how operational dependence is shifting from operators primarily to OEMs and in the future possibly to independent technical information and supply-chain ventures. This shift will disrupt today's aftermarket, seriously affecting independent MROs, parts distributors and airlines.

Perhaps the biggest challenges presented by this transition will be for regulators. As the analysis and monitoring of data moves away from airlines, how will the responsibility for airworthiness be regulated? My concern about this expansion of operational information is the issue of privacy: How do we preserve it? In our social media world and litigious society, will operational data become a source for news items, an opportunity to exploit incidents as a means to litigate or sensationalize? As always, progress brings challenges.

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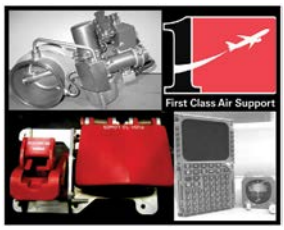

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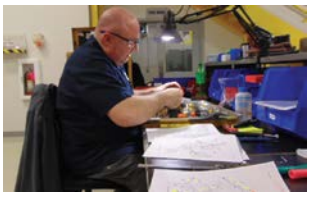

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that looked at unnecessary incentives for flying. And there is a growing movement, originating in Scandinavia, that passengers should be ashamed of flying because of the environmental impact and instead travel by train.

Europe is at the forefront of that drive, as other regions feel less urgency, or none at all, to rein in aviation's growth and impact.

It is clear that airlines have much to do before sustainable aviation fuels become available in sufficient quantities to significantly reduce carbon emissions. Carriers have even more work before new propulsion concepts, whatever they may be, can deliver on their promise over the next several decades.

One major project is Corsia, the Carbon Offsetting and Reduction Scheme for International Aviation. If all goes well, it is to mitigate 2.5 billion tons of CO_2 emissions over 15 years and make available $40 billion in funds for offset projects. But there are questions as to whether the many projects around the world are really effective in compensating for aviation emissions and can be properly supervised. More important, Corsia does not reduce aviation's original emissions output.

"Arguing that Corsia is a sufficient tool is not enough anymore," Hololei says. "I think that the industry has not been able to grasp or understand the changing societal trends and expectations."

The industry as represented by IATA still cleaves to targets defined 10 years ago, even as the events of 2019 and the Paris Agreement calling for net-zero emissions by 2050 show them to be outdated. Some individual airlines have set their own targets—International Airlines Group (IAG) aims at net-zero emissions in 2050 and is offsetting all of its domestic flight emissions starting next year. EasyJet went a step further and announced it will offset all of its emissions. KLM Royal Dutch Airlines is actively asking its passengers to consider taking the train when it is a viable option. Of course, the train is not a threat to the vast majority of its routes, but the message is still significant.

To reach their targets, airlines will have to do much more beyond offsets and sustainable aviation fuels. IAG calculates that with no change to today's technology and processes, 43% of projected emissions will have to be offset to achieve its net-zero target. Biofuels could cut emissions 18%. But there is a large block (39% of the needed emissions cuts) airlines will need to address through operating efficiencies and changes in procedures.

IAG is replacing its Boeing 747-400 fleet with Airbus A350-1000s, and the results from the initial phase of operating its first three A350-1000s are quite stunning: The aircraft are using 40% less fuel on the same routes. This may be an extreme case, but fleet replacement nonetheless presents a major near-term opportunity to cut back on emissions per flight, with aircraft such as the A321neo burning 20% less fuel than predecessors. The problem is that replacing in-service fleets takes a long time, and there often is no economic incentive for airlines to do so.

Lufthansa recently calculated it could well have held on to its fuel-guzzling Airbus A340s for much longer, as they will soon be fully depreciated, without seeing any negative financial impact. It is a sign of greater environmental and political sensitivity that the airline nonetheless opted to order more A350s and Boeing 787s last year. Next on Lufthansa's list is a major narrowbody acquisition this year.

There have already been noticeable performance improvements in commercial aviation's environmental impact. According to Bernstein Research, airlines have improved fuel efficiency by 3% annually in recent years. On average, airlines the analysts cover have grown 6.5% annually since 2021, but emissions have increased only 3.2%. The problem is that there still has been an increase. Bernstein analysts calculated that around one-third of the efficiency gain is due to higher load factors, and two-thirds is due to the use of more modern aircraft.

"Aircraft designs have received substantial, ongoing technology efficiency improvements over past decades, typically offering a 20-30% reduction in energy intensity compared to older aircraft models," the Intergovernmental Panel on Climate Change (IPCC) writes. "Further fuel efficiency gains of 40-50% in the 2030-50 timeframe [compared to 2005] could come from weight reduction, aerodynamic and engine performance improvements, and aircraft systems design."

But IPCC researchers warn that "the rate of introduction of major aircraft design concepts could be slow without significant policy incentives, regulations at the regional or global level, or further increases in fuel prices." In other words, additional taxes the airlines want to avoid at all costs could be a tool to incentivize faster investment, the IPCC says.

The IPCC lists other means airlines have to reduce their carbon footprints: "Retrofit opportunities, such as engine replacement and adding winglets can provide significant reductions. Improving air traffic management can reduce CO_2 emissions through more direct routings and flying at optimum altitudes and speeds. Efficiency improvements of ground service equipment and electric auxiliary power units can provide some additional greenhouse gas reductions."

Bernstein Research analyst Daniel Roeska warns that the pressure to improve environmental performance could shift the balance of power in the industry somewhat, as not all airlines are in the same position. "Airlines that grow fast will likely increase their total emissions faster than technological advances can offset," Roeska writes in a note to clients.

"Airlines with newer technology will face greater challenges increasing their efficiency," he continues. "Both effects will work to the advantage of larger, older and less efficient airlines in Europe. If more regulatory cost is added for all airlines, and fast-growing plus efficient airlines have fewer opportunities to reduce their emissions, the relative cost difference between Europe's low-cost and full-service carriers will narrow—with low-cost carriers being disadvantaged and full-service carriers gaining a relative advantage."

The industry is not following a coherent approach. Even in Europe, where political pressure is the most intense, tactics vary. Air France, like British Airways, plans to offset all emissions on domestic flights starting in 2020. Lufthansa gives passengers the option to offset emissions during the booking process, but it is only an option, not a requirement. Lufthansa does offset all emissions caused by its own staff travel, however.

Ryanair plans to reduce emissions to 60 grams from 66 grams of CO_2 per revenue passenger kilometer until 2030. The airline aims to grow quickly over the same period—up to 70%, according to Bernstein Research estimates—and so its footprint would still become much larger without offsets.

Fueling Momentum

> AIRLINES PLACING CONTRACTS IN BID TO DEVELOP THE MARKET

> PRODUCTION CAPACITY WILL RAMP UP OVER THE NEXT FIVE YEARS

Graham Warwick

Since Jan. 1, fuel suppliers in Norway have been obligated to blend low-carbon sustainable aviation fuel (SAF) into jet fuel provided to airlines at the country's airports. It is just a 0.5% blend initially, but the goal is for it to become 30% by 2030.

Norway is the first country to mandate the use of SAF, but others are expected to follow. Sweden could be next, as a March 2019 government report proposed a mandate beginning with a blend ratio of 1% in 2021 and increasing to 30% by 2030.

In June 2019, the Finnish government announced plans to mandate a 30% blend of SAF by 2035, as part of plans to become a carbon-neutral country by that year. The Netherlands government has stated publicly it wants to achieve a 14% SAF blend by 2030.

Norway's action and its neighbors' plans are among signs that the SAF industry finally may be gaining momentum after a decade that has seen strong technical advances but slow commercial progress.

The past year has seen a steady flow of fuel offtake agreements between airlines and SAF suppliers, and others are expected as more aviation biofuel production capacity comes online. Initial deals have focused on fuel supply to airports in regions, principally California, which have low-carbon fuel standards that allow SAFs to qualify for credits.

The ability to use SAF to reduce offsetting obligations under the International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (Corsia) is another potential impetus. National mandates such as Norway's also will begin to drive demand over the next few years.

Norway already has taken an aggressive stance on the sustainability of aviation, announcing plans for all short-haul flights to use electric aircraft by 2040. Sweden, meanwhile, was first to feel the effects of the "flight-shame" environmental movement, with airport traffic declining in 2018 and 2019.

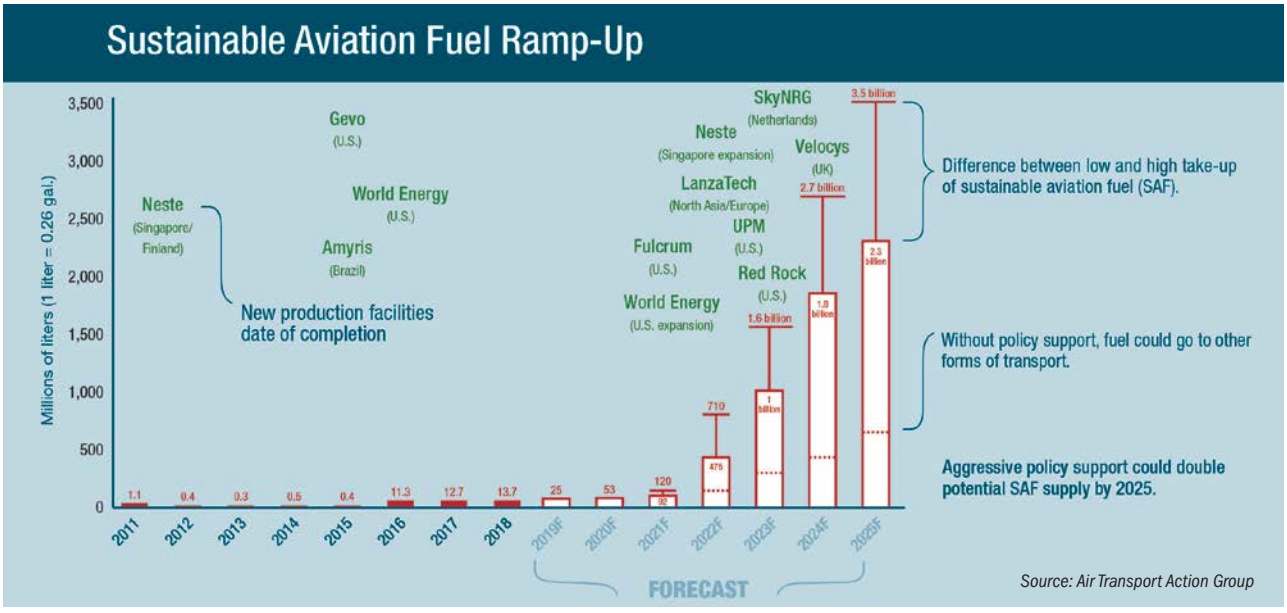
Biofuels can reduce life-cycle carbon emissions by up to 80%. The Swedish government report calculated a 1% blend of SAF would reduce greenhouse gas (GHG) emissions by 0.8% in 2021, increasing to 27% in 2030 when the blend ratio reaches 30%.

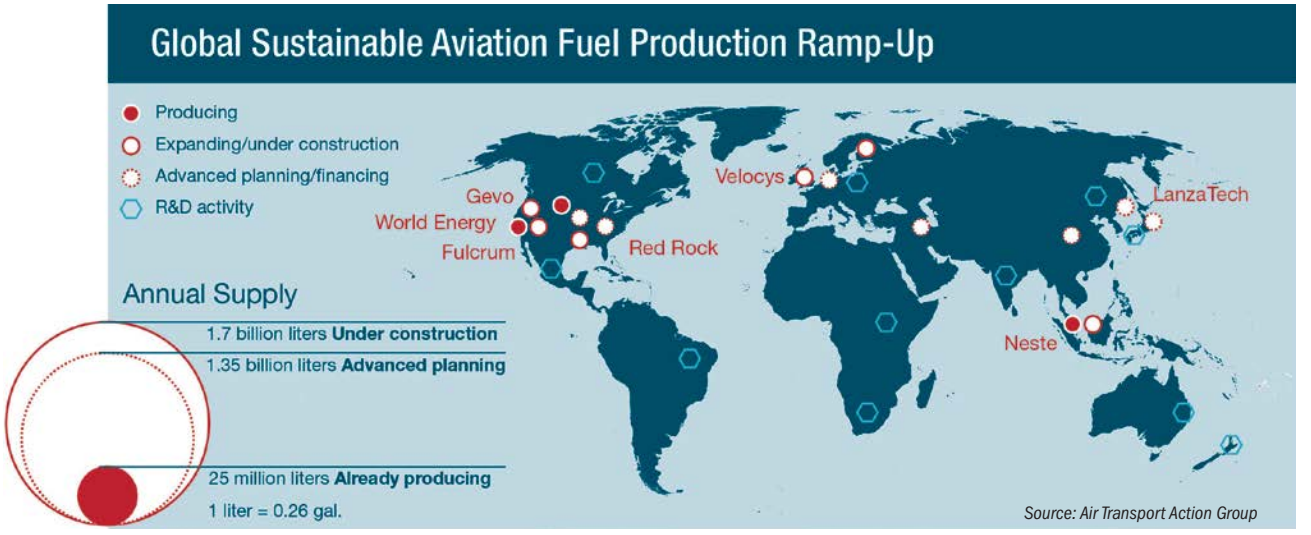
Availability has been one issue holding back growth in sustainable fuel use. Currently, there is only one commercial SAF plant in operation—World Energy's biorefinery in Paramount, California—with Gevo, LanzaTech and Neste producing SAF in pilot plants while they build production facilities.

The FAA-led Commercial Aviation Alternative Fuels Initiative (CAAFI) calculates that just over 1.2 million gal. of SAF were purchased in 2018. Neste estimates Norway's 0.5%-blend ratio mandate will require 1.7 million gal. of SAF in 2020, while Sweden calculates its mandate will require 3.6 million gal. in 2021 and 112 million gal. in 2030.

Such figures are just drops in the ocean compared with the 98 billion gal. of jet fuel consumed globally by airlines in 2019, but the quantities of SAF under contract are beginning to accumulate. In December, Delta Air Lines announced an agreement with Gevo to buy 10 million gal. per year for up to seven years.

In the first days of 2020, JetBlue Airways announced a deal to buy SAF from Neste for supply at San Francisco International Airport (SFO), while Shell Aviation and World Energy began supplying SAF to Lufthansa and Swiss International Air Lines at SFO. The Lufthansa Group has a one-year deal for 1 million gal. of SAF, the largest contracted volume to be delivered to SFO, says Shell. World Energy already is supplying SAF to Finnair, KLM, SAS and United Airlines at SFO, and at Los





Angeles International Airport to KLM, Qantas Airways, SAS and United.

Demand is inching up as substantial SAF production capacity is scheduled to come online. CAAFI estimates there is potential for annual U.S. production to exceed 250 million gal. within five years. World Energy is expanding its total sustainable fuels capacity at Paramount, which includes renewable diesel, to 306 million gal. per year from 40 million gal. Gevo plans to begin supplying Delta in 2022-23 from an expanded plant in Luverne, Minnesota, which is expected to produce 12 million gal. of liquid fuels a year. LanzaTech is scaling up its demonstration plant in Soperton, Georgia, to 10 million gal. per year.

Finland-based Neste produces 3 million metric tons of renewable fuels today, 100,000 metric tons (33 million gal.) of which is SAF. Total capacity will increase to 4.5 million metric tons in 2022 when a new plant in Singapore is scheduled to come online; 330 million gal. will be SAF.

Fuel supplier SKyNRG is building Europe's first dedicated SAF plant in the Netherlands, at Delfzijl, which is planned to produce 100,000 metric tons of fuel a year when it comes online in 2022. KLM has committed to buy 75,000 metric tons of SAF a year for 10 years from this plant. Velocys is collaborating with British Airways and Shell Aviation to build a facility in Immingham, England, which is projected to covert municipal solid waste (MSW) to 26 million gal. a year of jet fuel and naptha.

This expansion is bringing on new players and feedstock options. Most of the SAF used to date has been produced from used cooking oil and inedible corn, but plants now under construction or expansion will broaden sustainable sources to include municipal waste, forest residues and industrial waste gases.

Red Rock Biofuels is building a refinery in Lakeview, Oregon, scheduled to come online in 2020 and produce 15 million gal. of liquid fuels annually from woody biomass. FedEx Express and Southwest Airlines have agreements in place to buy SAF from Red Rock. Also in 2020, Fulcrum Bioenergy's plant near Reno, Nevada, is scheduled to come online producing 10.5 million gal. per year of fuels from MSW. United, Cathay Pacific Airways, Japan Air Lines (JAL) and Air BP have fuel offtake agreements in place.

CAAFI Executive Director Steve Csonka says commissioning of the Red Rock and Fulcrum facilities will validate gasification technology as well as the viability of the supply chain for two major feedstocks—MSW and forestry residues—enabling both pathways to proliferate in the coming decade.

LanzaTech produces SAF from industrial waste gases via an alcohol-to-jet pathway, and plans to have an annual liquid fuels capacity of 100 million gal. from four sites by 2023. Virgin Atlantic Airways, All Nippon Airways and JAL have agreements in place to use SAF produced by the company. SG Preston's first facility is expected to come online in 2021, producing 33 million gal. per year of fuels from waste oils and fats.

Approval of a version of renewable diesel called HEFA+ (high freeze-point hydro-treated esters and fatty acids) is expected "in the near future," says Boeing. This only can be used in a blend up to 15%, compared to 50% for HEFA fuel, but has the potential to unlock for aviation some of the millions of gallons in production capacity already in place for ground transportation fuels. But Csonka is concerned that the incremental cost of fractionating renewable diesel for SAF could be prohibitive for fuel producers.

SAFs are significantly more expensive than petroleum-based jet fuel and are likely to remain more costly because of the costs involved in the feedstocks. Pressure on operators to be seen taking action to improve their sustainability is likely to play a part in SAF adoption.

"I expect business aviation may respond to these pressures in advance of commercial aviation and be a bit more aggressive with SAF acquisition," says Csonka. Business aviation is less price-sensitive and more image-conscious, and several manufacturers already have announced SAF supply deals for their own use.

While ICAO's Corsia will allow airlines to use SAF to reduce their offsetting obligations, it is not expected to be a major driver of airline purchases, says Nancy Young, vice president for environmental affairs at industry association Airlines for America.

"[Corsia] was not intended to incentivize sustainable aviation fuel. There are other things that have to be done to do that," she says, noting fuel producers do not receive the federal government incentives for SAF that are provided for ground-based alternative fuels.

"Airlines will continue to struggle with the affordability of SAF versus satisfying Corsia commitments via offsetting, and will be deliberate in making additional commitments to near-term SAF production," says Csonka, adding that airlines will continue to experiment with ways to offset the incremental cost of SAF.

"We are so far removed from the viability of other advanced technologies that can mitigate GHG growth that the near-term focus must be on offsets . . . while awaiting policy development that supports SAF and continues to make it more affordable," he adds.

Green Gambit

JOHN D. PARKER / BOEING

- LATEST ECODEMONSTRATOR IS FIRST BOEING-OWNED, DEDICATED TESTBED
- 50 TECHS ARE IN TESTING—HIGHEST NUMBER YET FOR A SINGLE PLATFORM

Guy Norris Los Angeles

Cruising in from the North Atlantic at 39,000 ft., the dawn greets the Boeing 777-200ER ecoDemonstrator over Scotland, and a group of engineers gather enthusiastically to look out of the starboard windows.

Far below, the snow-covered Highlands are barely visible in the early morning gloom, but it is not the landscape that enthralls the engineers. Instead, they are looking to check an experiment on the aircraft's right wing. A few hours earlier, as the 777 climbed to cruise altitude over Canada and darkness set in, the fins of three vortex generators (VG) could be seen poking up from the wing surface. Now the morning light reveals they have recessed completely into the skin.

Less than 1 hr. later, as the 777 descends into warmer air toward Frankfurt, the VGs mysteriously reappear and, to the satisfaction of the engineering team, once more interact with the boundary layer. The flight has just proved the basic functionality of thermally active, reconfigurable VGs made from shape-memory alloy. The devices, developed with the NASA Glenn Research Center, deployed only when needed for slow speed and stowed for cruise, and they hold promise to reduce cruise drag and improve fuel burn.

The shape-memory alloy reconfigurable-technology vortex generators (SMART-VG) experiment represents one of 50 new technologies being tested on the company's latest ecoDemonstrator aircraft—the sixth since the first flight-test program began in 2012. However, unlike all the previous rounds, the latest campaign is using a dedicated aircraft bought by Boeing specially for the ecoDemonstrator initiative. The move represents the increasing importance being placed by the company, and the industry in general, on efforts to improve sustainability and operational efficiency.

Aviation Week was invited to join a test flight on the newest ecoDemonstrator, an 18-year-old former Air China 777-200ER that has been extensively modified. As it will amass only a limited number of flight hours compared to its airline life, Boeing could operate this low-cost asset for two or more years. In addition to the 777, Boeing plans to fly other ecoDemonstrators in 2020 and 2021 with leased aircraft.

"In the past, because of how lean we wanted to be, we have always found partners to help us acquire or lease aircraft, but that's when we were doing one per year or one every 18 months," says Doug Christensen, Boeing ecoDemonstrator program technical leader. "Now that we are at almost a yearly cadence, it makes sense to provide our own aircraft and that allows us to do more long-term demonstrations on the airplane. Plus, we do not have to refurbish it when we return it to the operator."

Boeing acquired an ex-Air China 777-200ER as part of its plans for higher-tempo ecoDemonstrator testing.

Before the latest flight tests, the ecoDemonstrator program was used to evaluate 112 discrete technologies on five aircraft, beginning in 2012. Forty, or 36%, have been implemented on Boeing aircraft or partner products; 51, or 45%, have progressed in technical development, while the other 21 have been discontinued. The latest program follows tests using a 737-800, 757-200, 777F and 787-8 from Boeing, and an Embraer 170. The 777-200ER is being used to evaluate another 50 technologies covering aerodynamics, advanced materials and environmental improvements, flight controls, flight decks and avionics, operational efficiency and what Boeing describes as a "smart cabin."

The intrusive nature of the wiring and other changes made for the smart-cabin technology tests also partly drove the decision to acquire rather than lease an aircraft, says Jeanne Yu, director of technology integration and the ecoDemonstrator program. The modification includes an interconnected intelligent-cabin system running on a specially installed network. "We had to have our own platform for that," says Yu. "We will retain the 777 and we have plans next year that include another airplane."

As with tests on previous ecoDemonstrators, those on the 777 are sup-

ported by a variety of government research agencies, aerospace companies and academia such as NASA, the German aerospace research agency DLR, Collins Aerospace, Diehl, Honeywell, Safran and others. Operators also have been keen to back the ecoDemonstrator, and some already are "seeking partnerships to be involved for next year and the year beyond," explains Yu.

The choice of test platform is also partly driven by the key technology focus for each campaign. "We are 'learning by doing' and finding that the asset you choose depends on what tests you want to do and the strategic placement of the technology. It all depends on what asset makes sense for the 'big rocks' and the other 'bigger rock' technologies around that," notes Yu.

Among the 14 technologies evaluated on the 737-800 in 2012 were laminar-flow winglets, which were then adopted for the 737 MAX. The advanced engines of the follow-on 787-8, on which 35 items were tested in 2014, were suitable for evaluating a ceramic matrix composite nozzle. Other items observed on the 787-8 included touchscreen flight-deck displays that will be featured on the 777X.

The 757, which was used to check 20 items in 2015, was a suitable testbed for an active-flow-control vertical tail and wing sections, all treated with special insect-resistant coatings for improved laminar flow. At the end of the flight test, the 757 was dismantled to show how up to 90% of the structure could be recycled. Biofuels and advanced sensors and coatings also were tested. Among the six and 37 technologies tested, respectively, on the E170 and 777F, the latter included trials of a compact thrust reverser that could pave the way for use of a similar design on the proposed new midmarket airplane.

"We set up the ecoDemonstrator to learn by doing in a way that could start to inspire action among our own team as well as throughout the industry. It started as a small ripple, and we are hoping it will continue to become a larger ripple as it passes through the industry," says Yu.

The effort also continues to gather a momentum of its own, notes Christensen. "Now vendors are coming to us and saying, 'We think we have this great idea.' The ecoDemonstrator allows us to work with them and understand how these ideas might work," he says.

While the availability of a flight-test asset helps galvanize new ideas, the process of installing the experiments also helps transform the flying laboratory from a concept into reality.

"People have ideas, but most of the time they don't know how to integrate them on the aircraft," says Yu. "The tests also involve a lot of collaboration so we bring up the state of knowledge for the whole industry. That's vital because to get to sustainable aviation, we need to work together."

The ecoDemonstrator is helping to change attitudes, says Yu. "When people first join the program, they'll give you 10 reasons why something can't be done. But now if someone's on the team for six months, they'll say, 'Hmmm, let's look at what the options are.' We are changing mindsets, and that's a huge thing for the sustainability of aviation," she stresses. "For some reason over the past few decades, we've begun to think of constraints as problems rather than as opportunities. We're seeding a shift in mindsets. That's the biggest ripple we are creating."

GUY NORRIS/AW&ST

Cameras were positioned to monitor the performance of the wing-mounted shape memory alloy vortex generators.

The 777 provides ample space for testing a set of connected cabin innovations that form the bulk of the technologies packaged for this ecoDemonstrator program. Stemming from an intelligent-cabin collaboration launched in 2018 with sponsorship of Boeing and Etihad Airways Engineering, the system consists of a dedicated network to monitor and control a series of "smart" interconnected "intelligent" commodities such as advanced galleys, a lavatory and business-class seats, all of which provide digital updates on maintenance status via wireless sensors.

The suite includes Boeing's automatically ultraviolet-light-sanitized Clean Cabin Fresh lavatory, an advanced water-disinfection system and new cabin lighting and displays incorporating organic light-emitting diodes and organic LED displays.

The intelligent cabin system is designed to gather real-time data on the interior features and make maintenance more efficient by flagging failures and even predicting them in a way similar to other aircraft systems.

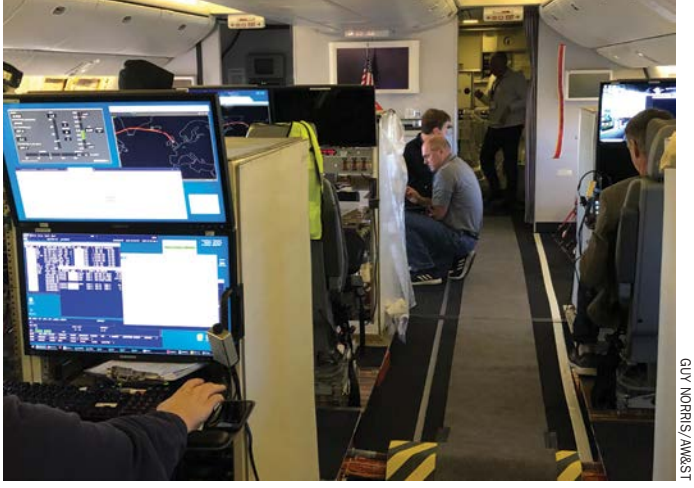
"The airplane should take care of itself, and that's what we are moving toward," says Jeff Roberts, senior manager for cabin and feature development for Boeing. "On the 787, we introduced a lot of airplane health management, but in the cabin not so much. A lot of customers say, 'I make the money in the cabin so help me make sure everything is always working the way it's supposed to'—and that's what this is all about."

The tests also play a role in helping to define a standard protocol that the industry is developing to enable easier interconnectivity between cabin systems. "A lot of companies use different protocols but, just like how your device can connect easily to different networks, we want cabin systems and devices to be able to talk seamlessly to each other," says John Craig, chief engineer for cabin networks for Boeing Commercial Airplanes.

Additional testing includes evaluating a suite of advanced flight deck avionics and improved connectivity features to make operations safer and more efficient. Using a handheld tab-

let (electronic flight bag [EFB]), Boeing crews are testing the Honeywell-developed surface with alerting (SURF-A) and with indications and alerting (SURF-IA) safety system. SURF-A/IA alerts crews to potential traffic conflicts and collisions using automatic dependent surveillance–broadcast data and is being considered for retrofit on older 777s and 737s, which do not have the installed display processing power to show airport maps and surface traffic.

Also under test are potential communications improvements to make trajectory-based operations easier, thereby increasing efficiency. Working with Honeywell, Inmarsat and SITA, Boeing is developing internet-protocol-suite (IPS) technology as a next-generation data link for advanced air traffic management systems such as future air navigation services (FANS) and airline operations control (AOC). The use of IPS is expected to provide wider bandwidth capacity and greater flexibility and to reduce costs.



GUY NORRIS/AW&ST

Advanced cabin and navigation systems made up the bulk of the 50 experiments tested on the 777.

"A big piece of what we are doing is data connectivity," says Al Sipe, chief architect of operational efficiency at Boeing. "The U.S. is implementing FANS domestically, and we are trying to set up using the EFB so pilots can work digitally with air traffic control (ATC) to find better routes.

"We have a Boeing Jeppesen application that allows the pilot to plan a flight, and now we have an experiment application that pulls that data and we can inject weather along the route," explains Sipe. "This app can automatically look for ways around the weather and offer it to the pilot. The new route is sent down to the AOC then over to ATC, and if ATC approves it, then it is passed back via FANS."

Advanced materials and other technologies tested on the 777 to reduce environmental impact include additively manufactured nose landing-gear steering components, lavatory floor mats made from recycled carbon fiber, a primer made a non-toxic non-chromated coating and recyclable carpet tiles that last four times longer than existing types. All of these materials are expected to divert around 8,000 lb. of waste from landfills over the life of a typical single-aisle airliner. The cargo compartment also is being used for key tests of a "promising" fire-suppression replacement for Halon, production of which was banned in developed nations as far back as 1994.

Digital Extra *See more images of and details about Boeing 777's ecoDemonstrator:* **AviationWeek.com/777ecoDemo**

Boeing Flies 777Fs in Formation

Guy Norris Los Angeles

More than 20 years after researchers began studies into whether aircraft fuel consumption could be reduced by emulating the formation flying of birds, Boeing has validated new technology that could help make wake-surfing operationally practical.

Formation-flight tests conducted with FedEx Express using two 777Fs freighters confirm the potential for reducing fuel consumption by up to 10% by flying in the wingtip vortex of the lead aircraft, says the aircraft maker. The test, conducted during Boeing's 2018 ecoDemonstrator program using an aircraft leased from the cargo carrier, follows similar flight trials by the U.S. Air Force, DARPA and NASA.

In November, Airbus also announced plans to explore the potential fuel-saving benefit under the Fello'fly technology demonstrator project, which will involve formation flying with a pair of A350s in 2020. The following year, Airbus hopes to start operational trials on transatlantic flights in cooperation with airlines.

The Boeing-FedEx tests focused on validating the wake-prediction model used to assess the optimum cruise location for the in-trail aircraft. The evaluations also were targeted at the ability of the autopilot to maintain a correct computed position based on input from modified automatic dependent surveillance-broadcast (ADS-B) data link and traffic-alert-and-collision-avoidance (TCAS) systems.

Using precise positioning information and the wake-prediction model, the autopilot flies the aircraft in a zone where upwash inside the lead-aircraft's vortex increases the angle of attack on the trail-aircraft's wing. This rotates the lift vector and, because lift is an order of magnitude greater than drag, the autopilot produces a significant reduction in drag for a small increase in lift.

The work is expected to help lay the foundation for future studies of wake-surfing and potential methods for proving its practical and safe applications in commercial operations. During the 2018 formation flight, which was performed at standard cruise speed and altitude, the two aircraft maintained a 4,000-ft. separation—outside of the predicted vicinity of wake effects but still close enough to gain benefit for wake-surfing. The position of the wake was predicted by constant comparison of the locations of the ecoDemonstrator and lead aircraft, using ADS-B and the ship's own data.

"The autopilot was configured to track a position relative to the wake," says Boeing, which partnered with TCAS supplier ACSS on an updated system that provided additional ADS-B "In" data to the ecoDemonstrator. "This allowed us to improve the wake prediction accuracy. Position relative to the wake and the lead aircraft was also presented to the pilots on a custom flight-test display," adds the manufacturer.

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> ELECTRIC TAXIING IS A BENEFIT OF HYBRIDIZED SINGLE-AISLES

Graham Warwick and **Guy Norris**

Barely a decade ago, most people in the aviation industry doubted electric aircraft ever would fly fare-paying passengers.

Now all-electric aircraft capable of taking 2-4 people on urban trips are on the path to certification. Hybrid-electric aircraft designed for subregional flights with 6-9 passengers are entering testing. And short-range regional aircraft with up to 19 seats and electric propulsion are on the drawing board.

Does this unexpected rate of progress make electrified aircraft propulsion a viable option to improve the sustainability of aviation?

Large commercial aircraft account for about 93% of global annual jet fuel consumption. Some 57% of the fuel is burned by long-range twin-aisles, which are widely considered to be out of reach for electric propulsion—at least for several decades—because of the massive amount of energy required to fly hundreds of passengers thousands of miles.

Single-aisle airliners account for 37% of fuel consumed annually, and regional aircraft 6%. For these classes of airliners, the results of several studies suggest hybridization could, by the 2030s, provide a performance benefit above and beyond that expected from anticipated advances in airframe technologies and turbine engines.

How big that benefit could be depends on the market, the mission, technology and the tradeoffs manufacturers and operators are prepared to make.

When it comes to hybrid-electric propulsion, there are two main choices: parallel and serial. In a parallel hybrid, both a thermal engine and an electric motor drive the same shaft, turning a fan or propeller. The engine runs on jet fuel and the motor on batteries.

In a serial hybrid, only the electric motor drives the shaft, powered by electricity that comes from both the batteries and a generator driven by the thermal engine. In both cases, energy is stored in both fuel and batteries.

Two key research programs are underway that could determine the future of electrified propulsion for regional and single-aisle aircraft. Airbus plans to fly the E-Fan X, a 2-megawatt serial hybrid regional jet demonstrator, in 2021. And in 2022, United Technologies Corp. (UTC) plans to fly Project 804, a 2-megawatt-class parallel hybrid regional turboprop testbed, although changes at UTC might slow the project.

Airbus is working with Rolls-Royce, which is providing the turbine engine and generator, electric motor and controller, as well as the fan. Run by UTC's Skunk Works-like United Technologies Advanced Projects (UTAP), Project 804 brings together the power systems capability of Collins Aerospace with the propulsion engine experience of Pratt & Whitney Canada.

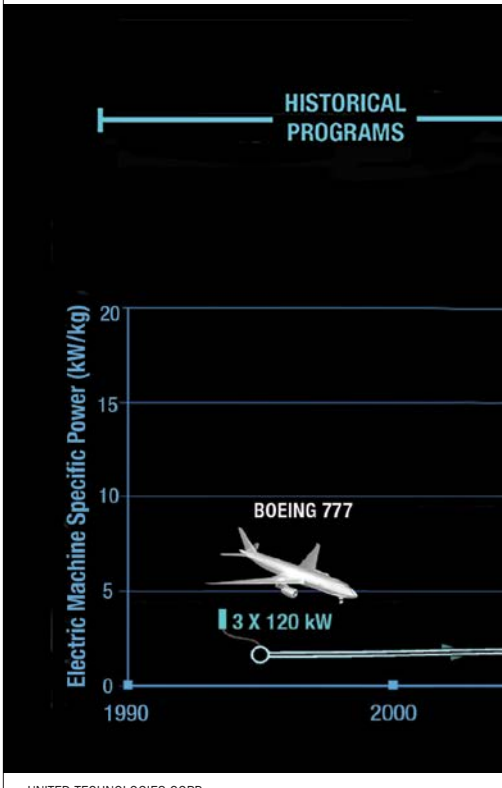
"We see parallel hybrid as having the best near-term potential for incorporation onto large aircraft. We are looking at regional aircraft in the next 5-10 years," says Todd Spierling, director of advanced technologies for UTAP.

Project 804 envisions modifying a 39-passenger de Havilland Canada Dash 8-100 by replacing one of its 2,150-shp Pratt & Whitney PW121 turboprops with a new thermal engine flat-rated at 1 megawatt (1,300 hp) and a 1-megawatt electric motor, both driving the propeller through a combining gearbox. The motor will be powered by a 200-kWh, 1-kv battery pack in the underfloor cargo compartment.

The engine and motor will provide a combined 2 megawatts at takeoff. Electric motor output will reduce during the climb until, in cruise, all the power is provided by the thermal engine. This will operate at its optimum point, producing a constant 1 MW until the crew throttles back to begin the descent.

By using stored electrical energy from batteries charged on the ground to boost takeoff power, the size of the thermal engine can be reduced and its cycle tailored for operation at a constant, optimum point. UTAP calculates this will decrease fuel burn 30%—and overall energy consumption including lower-cost electricity by 26%—on flights up to 250 nm.

Key to this performance is the degree of hybridization. In terms of power, hybridization is 50%, with the thermal engine and electric motor each providing half of the peak power on takeoff. But in terms of energy, hybridization is mild. Batteries provide just 6% of mission energy. This minimizes the weight penalty from the much lower energy density of batteries. Sizing the electric propulsion system to provide half the power on takeoff and a decreasing amount during climb allows the electrical components to be smaller and means a relatively low amount of energy storage is required, in turn requiring smaller batteries.



UNITED TECHNOLOGIES CORP.

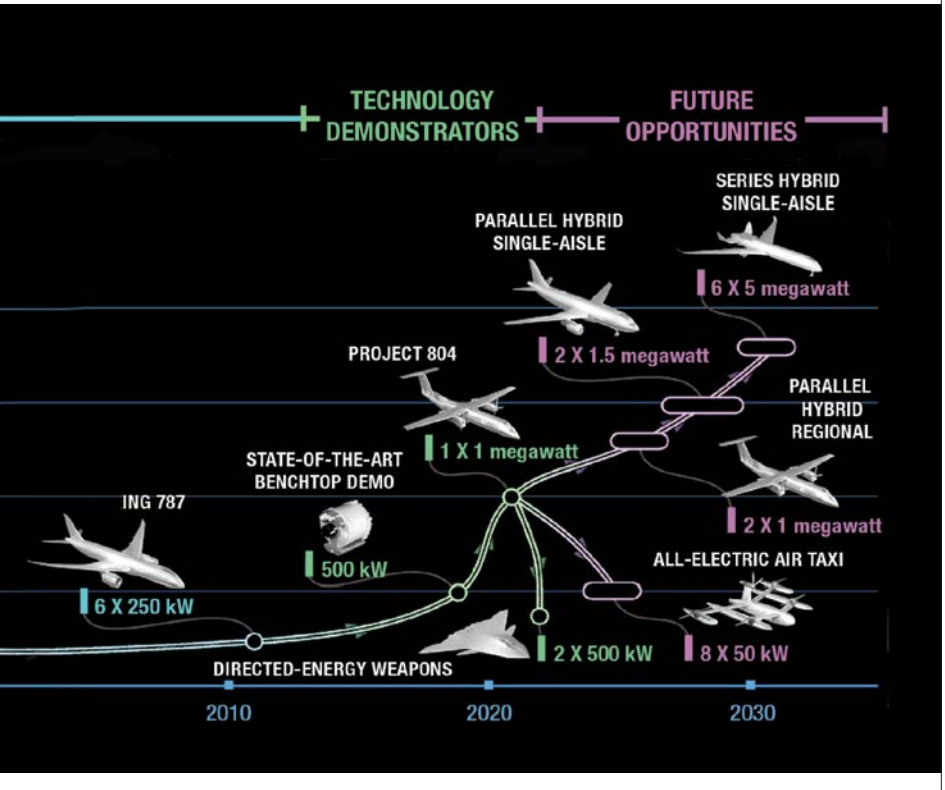
"We are not just replacing fuel with batteries, but doing it in a way that will make both sides better," says Spierling. "We improve the thermal engine while minimizing battery energy and, frankly, until batteries get better, one of our best approaches is not to use them more than we need to."

A production conversion of the Dash 8—replacing its turboprops with two 1,000-hp thermal engines assisted by

two 750-kW electric motors—would require 500 kWh of energy storage. The batteries would weigh 3,099 kg (6,830 lb.) at the 363-Wh/kg pack-level energy density that UTAP is assuming will be available by the mid-2020s.

Other 30-50-seaters, including the ATR 42 and Dornier 328, have similar power requirements and storage volumes. "We are not counting on new airframes," says Spierling.

One reason why regional aircraft are better candidates for electrified propulsion than twin-aisles is the lower efficiency of smaller gas turbines. Where the latest high-power, high-by-



UTC sees the established trend of aircraft electrification continue into propulsion.

pass turbofans have a thermal efficiency exceeding 55%, the Dash 8's turboprops are just 30% efficient.

In cruise, the combustion engine developed for Project 804 will have a thermal efficiency of 40% and a 24% lower specific fuel consumption than the PW121. UTAP is not disclosing details of this engine but says the use of electric boost allows the cycle to be changed and the engine redesigned for efficiency at the cruise point. This avoids the off-design conditions that drove the design of today's engines.

"We don't need the traditional performance of a legacy turbine," says Spierling.

The technologies expected to be available within the next 5-10 years will force some tradeoffs. UTAP is assuming a power-to-weight ratio of 13 kW/kg and efficiency of 97% for the electric motor and 20 kW/kg and 98% for the power electronics. These are the targets of NASA-supported R&D underway at Collins and elsewhere.

For the battery, UTAP is assuming an energy density about twice that available now, based on the goals of the Battery500 consortium. Launched in 2016 and funded by the U.S. Energy Department, this is a five-year effort to develop lithium-metal battery cells with a 500-Wh/kg energy density and 1,000-cycle life.

Using technologies expected to be at a readiness level of 6 by the mid-2020s requires fuel load and mission range to be reduced to accommodate the weight of the electric drivetrain. This will cut the Dash 8's range to 250 nm from 1,000 nm, but UTAP argues this still covers more than half the missions flown by this type of aircraft.

"It will have shorter range and cruise slightly slower, so this is not a free lunch," says Spierling. "But we believe those trades are acceptable in the market . . . [and that] for aircraft with more than 30 seats, parallel hybrid has the better midterm potential."

Project 804 passed its design and business reviews in November 2019, and UTC already is talking to potential customers, says Mauro Atalla, engineering and technology leader at Collins Aerospace. But regional aircraft account for only 6% of fuel used. Can the same approach be applied to single-aisle airliners?

Under a research agreement with NASA, United Technologies Research Center (UTRC) has studied near-term parallel hybrid propulsion for single-aisles in the 2030 time frame. In this architecture, a battery-driven electric motor puts power into the low-pressure spool of the geared turbofan engine, and both drive the fan.

Similar to the Project 804 system, the electric motor is used to boost power for takeoff and climb, allowing the engine to be resized for cruise. Today's turbofans are designed to run at maximum temperature for peak efficiency at the top of climb. This sizes the core but means the engine operates less efficiently in cruise.

By adding external power to the low spool for takeoff and climb, core size can be reduced to increase temperature and efficiency in cruise. In the 154-seat aircraft studied, this requires a 4.5-megawatt electric drivetrain comprising two 2.1-megawatt motors, one on the low spool of each underwing engine, a 1-kv distribution system and a 1,500-kWh battery.

Two 900-nm missions were studied. In one, the aircraft carries only the battery pack mass required to boost takeoff and climb, with all the energy for cruise supplied by fuel. This results in an energy hybridization of just 3.9%. For this mission, reductions of 4.2% in fuel burn and 0.3% in overall energy consumption are predicted.

In the other mission, battery mass is increased to take the aircraft to its maximum takeoff weight and allow electric energy to augment the engines during cruise. This increases energy hybridization to 9.9%, but the extra weight reduces the fuel-burn saving to 2.8%, while energy consumption increases 2.7%, so there is essentially no benefit.

The study does highlight an unexpected benefit. Adding a 2-megawatt motor to the low spool allows the fan to be driven without starting the engine and makes electric taxiing an attractive option, says Chuck Lents, principal research engineer at UTRC. With wheel drive, accelerating the aircraft across an active runway sizes the system. But this is well within the capability of the propulsion motors driving the fans.

UTRC calculates that taxiing out requires 62 kWh of battery energy, both to drive the low-spool motors and to power aircraft subsystems while the engines are off. This is just over 4% of the total stored energy consumed during taxi, takeoff and climb. The batteries are recharged in cruise for taxiing in.

In this study, electric taxi provides most of the fuel-burn reduction from hybridization. "The benefit is mainly coming from e-taxi," says Lents. "There is a slight saving in climb, and specific fuel consumption goes up in the cruise, but there is a significant saving in taxiing—about 3.5% out and 0.5% in."

There are other ways to use parallel hybridization, says Lents. Putting motor/generators on both spools of a turbofan would allow electrical power to be extracted or inserted rapidly to improve control of the engine and reduce the margins that have to be designed in to allow for stall and other off-design conditions. By operating closer to its limits, the engine can be smaller and more efficient.

There are several key assumptions to be aware of in most hybridization studies. The biggest involves the power densities of electric motors and power electronics as well as energy density of batteries. NASA's near-term goals are at least 13 kW/kg for a 1-megawatt motor and 19 kW/kg for a converter. These figures seem achievable.

Progress in motors has been fast. Siemens' eAircraft unit, now part of Rolls-Royce, flew a 260-kW motor at 5.2 kW/kg in 2016. It is now bench-testing the 2-megawatt motor for the E-Fan X at 10 kW/kg. Under a five-year program with NASA, Ohio State University is developing a megawatt-class drive system with densities better than 14 kW/kg for the electric motor and 25 kW/kg for the power electronics.

Batteries are less certain. The 500-Wh/kg cell-level target of the Battery500 consortium "is not unrealistic, but difficult," says Yet-Ming Chiang, a professor at the Massachusetts Institute of Technology (MIT). Lithium-sulfur and lithium-metal cells at 300-400 Wh/kg are in test, but with no guarantee of when they could result in aerospace-grade batteries with adequate pack-level energy densities and cycle lives.

And will electrifying aircraft reduce aviation's emissions? Regional airliners may be within reach for hybrid-electric propulsion, but they account for only a small percentage of fuel used. Urban air mobility and short-range regional flights could be all-electric, but could add significantly to the total passenger-miles flown by taking people out of cars and buses, says Brian German, a professor at Georgia Tech.

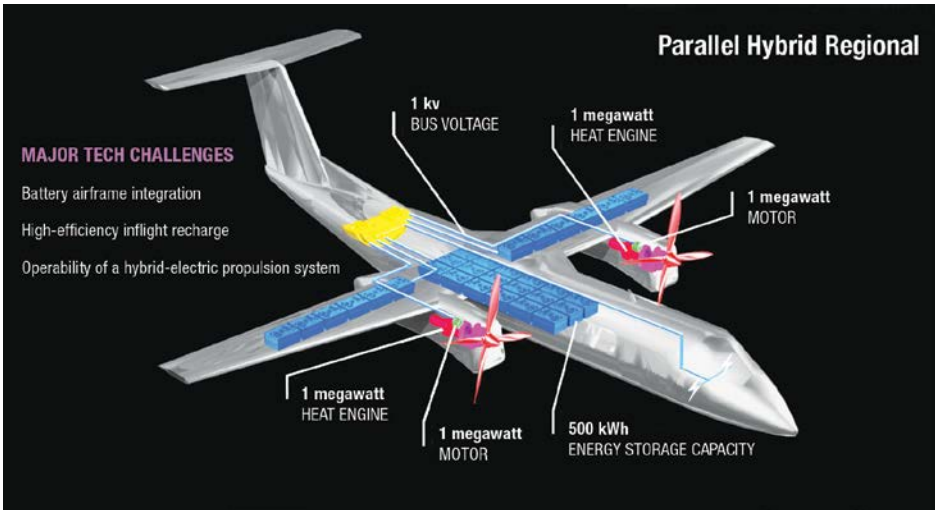
Electric drives are efficient, but the fossil-fueled electrical grid used to charge batteries is not. About two-thirds of the energy is lost during generation and distribution. Most analyses focus on emission reductions from the vehicle or assume airports will use renewable power, which is cleaner and more efficient but could require significant investment.

And customers must be willing to operate aircraft with significantly less range than today's airliners. Whether they accept the complexity of having a separate fleet of shorter-range, slower-speed electrified aircraft likely will depend on how much of their flying will benefit from the emission reductions. EasyJet, for example, says going all-electric on the short but busy London-Paris route has strong appeal.

But these caveats aside, there appears to be some promise in the hybridization of commercial aircraft. The technology builds on progress made by the automotive industry and looks to be within reach by the 2030s. Existing aircraft designs could be adapted—even retrofitted—with hybrid-electric powertrains, avoiding the challenge of certifying unconventional configurations with distributed propulsion.

And electric propulsion should not be considered in isolation. Aircraft are already becoming more electric—the Boeing 787 has 1.5 megawatt of electrical generation onboard. "More electric aircraft are a reason to work on motor/generators up around 1 megawatt" says Alan Epstein, a professor emeritus at MIT and former head of technology and environmental strategy at Pratt & Whitney. The batteries required for mild hybridization "might get paid for by other things," he says.

The fuel-burn reduction from mild hybridization may only be a few percent but should not be discounted. The benefit would be above and beyond those anticipated from low-drag aerodynamics and lightweight structures, as well as expected continued improvements in gas-turbine performance. Each in itself could account for only a few percentage points of improvement. What will matter for the sustainability of aviation is how they add up.



UNITED TECHNOLOGIES CORP.

UTC envisions the parallel hybrid-electric conversion of a 30-50-seat aircraft.

Small Satellites, Big Picture

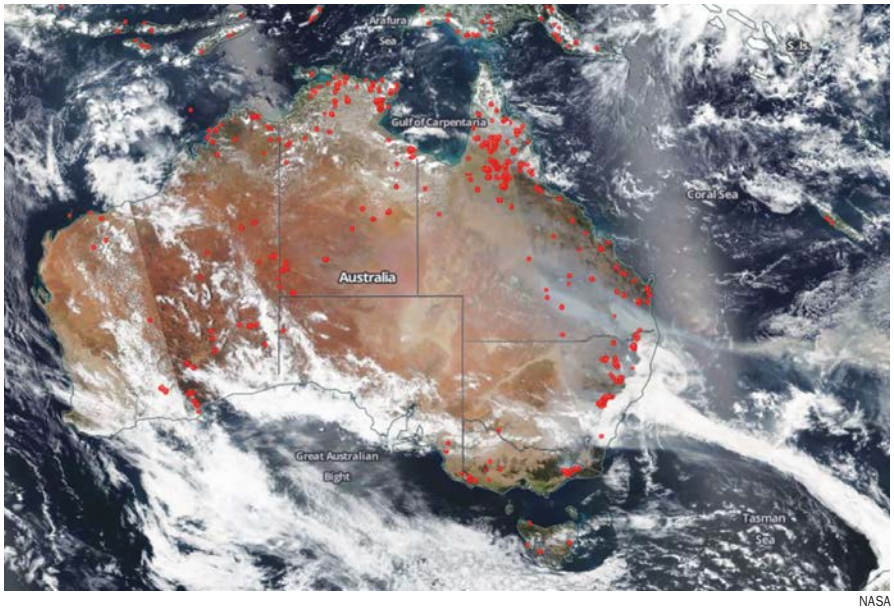
> NASA PILOT PROGRAM SHOWS PROMISE

> ROUND 2 COMMERCIAL SOLICITATION UNDERWAY

Irene Klotz San Francisco

With more than 60 companies worldwide planning to deploy Earth-observation and other remote-sensing satellite networks, NASA is stepping up efforts to evaluate how to use commercial data for ongoing observations of the changing planet.

In January 2019, NASA kicked off a 10-month program to assess the scientific value of data collected by small-satellite constellations owned by Maxar Technologies' DigitalGlobe and privately owned Planet and Spire Global. The results, presented in December, are promising, though licensing agreements are presenting a challenge, says Kevin Murphy, program executive for NASA's Earth Science Data System.



NASA

Fires burning in New South Wales and Queensland, Australia, were captured Dec. 22 by the Visible Infrared Imaging Radiometer Suite Instrument aboard the NASA/National Oceanic and Atmospheric Administration Suomi National Polar-orbiting Partnership satellite.

"The data is of sufficient quality for NASA to pursue continued access to the information," Murphy said at the 2019 American Geophysical Union conference in San Francisco last month.

"The issues we have were mostly internal, in terms of access to the data," he added. "Standard scientific collaborations were inhibited by the licensing agreements, which makes them very difficult to use. . . . There's a whole lot of work that has to go into ensuring that people who access the information are vetted and don't misuse [it]."

Data from Maxar, Planet and Spire were used in 39 pilot projects under the Commercial Smallsat Data Acquisition Program, with the goal of assessing commercial sources to support NASA's Earth science research and applications. The agency is interested in essential climate variables focused on the atmosphere, cryosphere, land and oceans as identified by the Global Climate Observing System program, a collaboration of the United Nations, World Meteorological Organization and International Science Council.

NASA wants to know if commercially acquired data can provide an inexpensive option to augment Earth observations currently acquired by NASA and other U.S. agencies, as well as international partners. Specifically, the goals of the pilot program were to create a process to continually add new commercial data vendors, assess if the data has the potential to advance NASA's Earth science research and applications, and establish the ability to continually use purchased data and disseminate it for broader use.

"Sustained use is important because we have a very large research community and we want to be able to support them. We need to have licenses that support that," Murphy said.

The pilot study assessed the commercial data's science value as well as licensing rights, cost, the vendors' ability to provide frequent data and their plans for constellation maintenance and evolution. Maxar and Planet's multispectral imagery also were evaluated on their radiometric calibration and geolocation accuracy.

"The data was found to be useful for specific types of analysis," Murphy said. "We need frequent coverage to monitor environmental changes and be able to do that in repeat visits."

Tasking the constellation for data was "a little bit difficult," he added, "but where those products exist, especially in the Arctic and Antarctic regions, it's really useful."

NASA plans to continue to use Maxar and Planet data, in partnership with the U.S. National Geospatial-Intelligence Agency. Spire data analysis is ongoing.

Planet's data is useful, but "there were limitations on what it can be used for," Murphy said. "We found it incredibly helpful in many areas, such as point-in-time analysis and verification, but monitoring long-term trends is difficult," he observes, because of inconsistent calibration, uneven radiometric performance and inconsistent geolocation.

"Planet certainly did a lot in terms of user services," Murphy added. "They helped us out the entire time and were very responsive."

NASA is in the process of soliciting vendors for a follow-on Earth smallsat data program as it transitions to a sustained series of commercial data buys expected every 12-18 months.

It could be a popular offering: More than 60 companies worldwide are planning optical, synthetic aperture radar, infrared, hyperspectral and emissions tracking spacecraft for Earth observations. In addition to Maxar, Planet and Spire, 24 companies already have launched at least one satellite.

A website for the Commercial SmallSat Data Acquisition program is at earthdata.NASA.gov.

U.S. AIR FORCE

U.S Air Force F-15 fighters were among the combat aircraft damaged by Hurricane Michael in 2018.

U.S. Military Given Authority To Defend Against Climate Change

> CONGRESS ADDRESSES CLIMATE CHANGE IN DEFENSE LEGISLATION

> CLIMATE CHANGE NEGATIVELY AFFECTS MILITARY TRAINING

Lee Hudson Washington

The U.S. Congress is providing the military with direct responses to the threat of climate change. The passage of defense policy legislation provides the military with new tools to address the effects of the warming globe on strategic security interests, installations and readiness.

That climate change is a threat to national security has been acknowledged by the military for nearly 30 years. In 1990, the U.S. Naval War College issued a report on "Global Climate Change Implications for the United States." But in recent years, the issue has become politically charged, with the Republican-controlled House of Representatives voting in 2016 on an amendment to block Pentagon action on climate change.

Now legislative support for addressing the security effects of a warming planet is growing. The 2018 National Defense Authorization Act (NDAA) characterized climate change as a direct threat to national security. Two years later, lawmakers are uniting around potential solutions. Last month, President Donald Trump signed into law the 2020 NDAA, which includes 10 provisions related to climate security.

The bill made it through the Democrat-controlled House and the Senate, past Armed Services Committee Chairman Jim Inhofe (R-Okla.), who wrote a book in 2012 calling global warming *The Greatest Hoax*.

The 2020 NDAA mandates creation of a Climate Security Advisory Council within the intelligence community to ensure analysis is informed by the best possible science. Intelligence experts must incorporate the foresight scientists have in projecting stress on various regions to predict potential crises. Establishing a Climate and Security Council is a positive step, John Conger, director of the Center for Climate and Security, tells Aviation Week.

"If you know there is going to be a water shortage in some portion of the world, that would inform, for example, the assessment of whether that region is going to go unstable," Conger says.

Another provision in the bill related to climate-security strategic interests for the U.S. revolves around the Arctic.

Section 1752 of the 2020 NDAA directs the Pentagon to consider sites for a strategic port in the Arctic and submit a report to Congress no later than June 2020. The document should include a cost estimate for construction and sustained operations at the site. For years, experts have rallied for the U.S. to have a more permanent presence in the Arctic as melting ice caps begin to open sea lanes to vessels from Russia and other nations.

As the Arctic continues to warm, extreme weather has hit hard at existing bases in the continental U.S. In 2018, Hurricane Michael decimated Tyndall AFB in Florida. Tyndall was home to the Air Force's fleet of Lockheed Martin F-22 Raptors.

The Air Force is still coping with the aftermath. While Tyndall is undergoing repairs, F-22s assigned to the 43rd and 95th Fighter Sqdns. have moved to other installations. The jets assigned to the 43rd relocated to Eglin AFB in Florida, while the 95th's aircraft are being spread out across F-22 units at Joint Base Elmendorf-Richardson in Alaska, Joint Base Pearl Harbor-Hickam in Hawaii, and Joint Base Langley-Eustis in Virginia.

The military is not just concerned about its coastal bases. A few months after Hurricane Michael floodwaters reached 7ft. (2.1 m), damaging Offutt AFB in Nebraska and causing personnel to move aircraft and munitions to higher ground. The flooding damaged one-third of the Midwestern base, home to the headquarters of the nation's nuclear arsenal, U.S. Strategic Command (Stratcom) and the 55th Wing. The 55th Wing is Air Combat Command's largest wing, with an annual budget of more than $477 million, 45 aircraft, 31 squadrons and 7,000 employees. In total, the damage at Tyndall and Offutt will cost the American taxpayer an estimated $5 billion to rebuild.

Air Force Chief of Staff Gen. David Goldfein and former Air Force Secretary Heather Wilson had to beg Congress for $5 billion in emergency funding to begin rebuilding the installations damaged by natural disasters.

Section 328 of the 2020 NDAA creates a dedicated budget line item for adaptation to and mitigation of extreme weather on military networks, installations, facilities and other assets. These include loss or obstructed access to training ranges. The bill defines extreme weather as recurrent flooding, drought, desertification, wildfires and thawing permafrost.

In 2019, the Air Force submitted to Congress a "Top 10" list of installations at risk of extreme damage from chaging weather. Six of the bases are in Florida—Eglin, Hurlburt Field, Patrick AFB, Homestead Air Reserve Base,

MacDill AFB and Tyndall. The base taking the top spot is Vandenberg AFB in California, home to the Space Force's Space Operations Command. The remaining installations at risk are Dover AFB in Delaware and Langley-Eustis in Virginia.

"As developed, the above list reflects installations susceptible to the consequences of severe weather events: coastal and inland flooding, wildfires, and/or drought; not necessarily 50-100-year climatic changes," the submission states. "This list does not look at any specific critical mission implications (i.e., even if the base is subject to flooding because a portion is within a 100-year flood plain, a mission-critical facility may not be impacted because of its location on the base or it is on high ground; e.g. the Stratcom Headquarters Building on Offutt AFB)."

The Army assessed six climate vulnerabilities on its military bases in the U.S. The service is most concerned about desertification, or land degradation caused by dry conditions, affecting its installations especially at Yuma Proving Ground and Fort Huachuca in Arizona, Fort Irwin and Camp Roberts in California, Fort Bliss in Texas, White Sands Missile Range in New Mexico, Hawthorne Army Depot in Nevada, Tooele Army Depot in Utah and Pueblo Chemical Depot in Colorado.

"The analysis is based on climate science only and is not influenced by strategic or mission considerations," the Army report says.

The majority of the measures to defend the military against climate change to date are reactionary, but Section 2801a of the 2020 NDAA is more preventative, directing the Pentagon to incorporate military installation resilience into master plans; it authorizes funding for climate resilience projects.

Flooding in Nebraska in March 2019 overwhelmed Offutt AFB, home to U.S. Strategic Command, forcing the evacuation of nine aircraft.

U.S. ARMY

These installation master plans will specifically assess vulnerabilities to the bases and surrounding communities, identify missions affected by those susceptibilities and propose projects to address those weaknesses.

"Until you start incorporating these risks into your master planning process, you aren't going to fully appreciate what you have to do at a particular location," Conger says. "You can't just throw money at a problem not knowing what you're supposed to do."

The Navy paid attention to climate change early on because the service has the most coastal bases and infrastructures in its inventory. Separate from climate change, a few years ago Congress directed the Navy to study the infrastructure requirements of its shipyards. That assessment found that the dry docks at Portsmouth Naval Shipyard in Virginia were not high enough to deal with sea level rise, Conger says. The 2020 NDAA authorizes $49 million for a project at Portsmouth Naval Shipyard to increase the height of the floodwalls around its dry docks. The shipyard's primary mission is the overhaul, repair and modernization of Los Angeles-class fast-attack nuclear-powered submarines.

Climate change is also affecting the U.S. military's readiness levels because of an increasing number of Black Flag days, when the temperature rises to 90F or higher, and training is suspended. This affects units being able to complete a training syllabus on time, Conger says.

"It's not like we've never done workarounds in training, but these are things where the training experts in all of the services will have to look at trends and figure out how to adjust what they have to do," he says. "It is not something they're immune from; it's something they're going to have to accommodate and deal with."

U.S. Military Installations Vulnerable to Climate-Related Emergencies

		Recurrent Flooding		Drought		Desertification		Wildfires		Thawing Permafrost	
Service	Number	Current	Potential	Current	Potential	Current	Potential	Current	Potential	Current	Potential
Air Force	36	20	25	20	22	4	4	32	32	-	-
Army	21	15	17	5	5	2	2	4	4	1	1
Navy	18	16	16	18	18	-	-	-	7	-	-
DLA	2	2	2	-	2	-	-	-	-	-	-
DFAS	1	-	-	-	1	-	-	-	-	-	-
WHS	1	-	-	-	-	-	-	-	-	-	-
Totals	**79**	**53**	**60**	**43**	**48**	**6**	**6**	**36**	**43**	**1**	**1**

DLA = Defense Logistics Agency DFAS = Defense Finance and Accounting Service WHS = Washington Headquarters Services *Source: Defense Department*

Blackout Period

JENS FLOTTAU/AW&ST

> EMBRAER'S BOEING DEAL HINGES ON EUROPEAN COMMISSION APPROVAL

> 737 MAX CRISIS ADDS TO UNCERTAINTY ABOUT TIE-UP

Embraer's 195-E2 is the most popular version of the E2 family.

Jens Flottau Frankfurt

In a way, Boeing's production facility in Renton, Washington, and Embraer's Sao Jose dos Campos site in Brazil now look very similar. A few people will be on special projects, but both locations, usually buzzing with activity, will be otherwise quiet.

As Boeing is forced to shut down final assembly of the 737 MAX while it awaits regulatory approval to return the aircraft to service, Embraer is also temporarily halting production of its commercial aircraft. Of course, the reasons are very different.

Embraer will send 14,000 people on forced vacations for three weeks to facilitate a very complex migration of information technology systems. During the three-week period scheduled to end on Jan. 21, the company is closing down the legacy operating systems of the existing company and implementing its so-called digital transformation plan. Essentially nothing will work during this blackout period.

In place of the old system, Embraer will restart with two new, separate systems: one for the future Brazilian defense and business aviation company, and the other for the future Boeing Brasil-Commercial joint venture. The latter will be a wholly owned but organizationally separate subsidiary of Embraer until the deal has received all the necessary regulatory approvals, a process already dragging on for much longer than the two parties had hoped.

The information technology transition is "an enormously complicated transaction," says Embraer Commercial Aircraft President and CEO John Slattery. But it is necessary to prepare Embraer's commercial aircraft business for what it hopes will be a more promising future than it would have had on its own. "We will be able to sell more aircraft by having access to Boeing's customer base, which is five times bigger than Embraer's," Slattery says.

There has been much debate in the industry about Embraer's view that sales of its new E2 family will benefit from the Boeing deal. Some have argued it would have been better off on its own as a specialist focused on its market. Following the leadership transition at Boeing from Dennis Muilenburg to David Calhoun, there is renewed uncertainty as to the aerospace giant's priorities. Can Embraer be a focus, or does Boeing need its money and management attention elsewhere? Would not an independent manufacturer focused on the regional market be better off, keeping in mind how Airbus is positioning its A220, the former Bombardier C Series?

The skeptics may conclude that if there is a growth opportunity in the deal for Embraer, it will be in future programs such as the proposed new midmarket airplane (NMA) or a successor to the 737 MAX, rather than with Embraer's own legacy portfolio. It is a view Slattery, unsurprisingly, does not share. "Our focus is building aircraft up to 150 seats," he says. "It was never our core priority to be part of NMA."

If that is the case, it is all the more important for the E2 to become the success Embraer hopes it will be. So far, sales have been disappointing, with 44 orders for the 190-E2, 127 for the 195-E2 and none for the 175-E2 at the end of November. Deliveries also were made at a modest pace in 2019, though they are to accelerate in 2020 in spite of the January line closure. Embraer plans to give an initial guidance on 2020 deliveries early in the year, provided the Boeing deal has not closed by then. In the now unlikely event that it has, the new company will take over communicating that.

E2 deliveries so far total 16 aircraft. Air Astana has received five 190-E2s, Wideroe has three and Helvetic Airways two. Binter has taken two 195-E2s, while Azul now has four in its fleet. Azul, with 51 aircraft on firm order, is also the largest customer of the E2 family, followed by lessors AerCap (50) and Aercastle (25).

The timeline of the proposed Boeing deal is now almost entirely up to the European Commission. The EC has launched an in-depth investigation into the transaction, asserting there could be anti-competitive ramifications at the lower end of the narrowbody market if

Boeing and Embraer Commercial are allowed to join forces.

That would be the case in particular, the EC asserts, as the U.S. market becomes more difficult for Airbus to access as a result of new tariffs and, as a consequence, the European market could become closed to Boeing in an extreme case as the European Union imposes countertariffs on Boeing aircraft. The EC has stopped the clock in its investigation as it awaits further documentation. It could be several more months before the joint venture becomes a reality—if it does.

By contrast, Slattery hopes Brazilian competition watchdog CADE will approve the transaction "with no conditions" in January, as "there is no overlap with Boeing." Assuming CADE does clear the deal, Embraer and Boeing will have nine of the 10 antitrust approvals it needs, none of which have come with any limitations.

Embraer's future joint-venture partner is still struggling to first end the MAX grounding and then recover from its consequences, short- and long-term. Many believe the MAX problems will have a lasting impact on Boeing's future product strategy, as the manufacturer may have to develop a MAX replacement sooner, possibly in place of the current NMA proposal. In spite of Slattery's official claim that Embraer is not betting on NMA work, that program is providing a massive growth opportunity, and the Brazilian company's stellar track record in engineering and design has been a major attraction for Boeing, more than the E2, a program marginal in size for the aerospace giant.

In the short term, joint MAX/E2 sales were seen as a chance for Embraer to escape having to compete with the Airbus A220 on its own. The delayed return of the MAX "has no effect on E2 sales because we are not competing," says Slattery, nonetheless pointing at campaigns where customers are looking for a choice between the MAX and a competing aircraft such as the Airbus A320neo. However, the grounding and the wait for the EC's joint-venture approval are holding back sales campaigns in which the MAX and the E2 could be offered together against the A320neo family and the A220.

The takeover of the former C Series from Bombardier ultimately triggered the Boeing/Embraer deal when it was announced in July 2018. More than a year later, the picture has changed substantially, seemingly supporting those who believe Embraer could have continued on its own, only partially competing with the A220. As it turns out, the A220 is moving more upmarket and therefore away from Embraer's scope.

At the end of November, Airbus had 431 firm orders for the A220-300, which is not only larger and heavier than the Embraer 195-E2 but also much more range-capable. The smaller A220-100, which more directly competes with the 190-E2 and the 195-E2, has garnered only 99 sales. As airlines such as Air France press Airbus to develop an even larger variant dubbed the A220-500, the family is moving much more into MAX and legacy A320 and A319neo territory and away from the E2 market.

In terms of sales to operators seeking regional and shorter-range mainline missions, the A220 development (which now also includes true long-haul versions) is good news for Embraer. But does it also indicate management hastily pushed for a takeover that was ultimately unnecessary? "Boeing should abandon the Embraer acquisition," says one senior industry source. "It always seemed like a knee-jerk reaction to Airbus."

Before it surrenders control of its commercial aircraft business to Boeing, Embraer orchestrated a special moment on Dec. 12. Management decided that it would attempt to roll out and fly the 175-E2 for the first time on the same day, an unusual exercise. Embraer did that once before, almost exactly 50 years ago, when the first prototype of the Bandeirante took off the same day it was first publicly presented. Slattery says the plan enabled "employees to own that moment" and find "an elegant bookend for the story of [Embraer] commercial aviation."

The aircraft took off at 11:07 a.m. for a flight lasting 2 hr. 18 min. in the airspace around Sao Jose dos Campos. In the second quarter of 2020, two more prototypes will join the flight-test campaign, an exercise that is to last up to 24 months. While Slattery points out that the aircraft is substantially different from the other two models of the E2 family, with its dedicated wings and landing gear, thus requiring an extended flight-test program, two years is an unusually long period even for a completely new aircraft; 1,200 flight-test hours are to be accommodated.

The reality is that Embraer cannot be in a rush to bring the aircraft to market. The 175-E2 so far has no orders, and there are more than a few industry skeptics who expect the smallest version of the E2 family will be the first to be killed by Boeing once Chicago is in charge.

Sales of the type have been hampered because it is not compliant with scope clauses in pilot deals at United Airlines, American Airlines and Delta Air Lines, effectively closing off the biggest market for regional jets for now. Slattery does not expect scope restrictions to be lifted at the three carriers soon, "so the focus of my sales team is outside of the U.S.," he says. In the meantime, the 175-E1 has been selling exceptionally well over the past few years as North American regional airlines have been renewing and upgauging their fleets.

For the 175-E2 there is "meaningful interest from flag carriers," Slattery says, and therefore he would be "disappointed" if Embraer has not secured at least one firm order by the end of the first quarter.

EMBRAER

The E175-E2 flew for the first time in December. So far, there are no firm orders.

Phoenix Rising

ALAN RADECKI/NORTHROP GRUMMAN

The NATO Alliance Ground Surveillance platforms are based on the Block 40 Global Hawk. The first is pictured on its delivery flight to Sicily.

- AGS WILL USE FIVE RQ-4D DERIVATIVES OF THE GLOBAL HAWK
- THE NATO SYSTEM WILL BE BASED IN SIGONELLA, SICILY
- FULL OPERATIONAL CAPABILITY IS EXPECTED IN THREE YEARS

Tony Osborne Naval Air Station Sigonella, Sicily

Almost 25 years after the initiative was first proposed to members, NATO is finally seeing its Alliance Ground Surveillance (AGS) system become a reality.

With delivery of the first two of five Northrop Grumman RQ-4D Phoenix high-altitude, long-endurance platforms to Sigonella, Sicily, where the NATO AGS Force (NAGSF) is based, the long-running program is finally making the transition from acquisition to operations.

But the platform's introduction has been far from straightforward, plagued by additional spending associated with the challenge of flying a complex unmanned aircraft system in the civilian airspace of alliance nations. Procurement documents also mention disputes over sensor performance requirements.

The AGS had originally been envisaged with a manned platform using an Airbus A321. But during the 2000s, NATO caught the UAV bug and, like Germany with its Euro Hawk signals-intelligence program, both opted for the Global Hawk platform, with NATO selecting its Block 40 model as a baseline. While the challenge of certifying the airworthiness of the Euro Hawk proved insurmountable for German authorities, for the AGS the challenge had been handed to Italy in its role as host nation to militarily certify the system.

"I thought this would never happen. I expected to have to tell everyone we had to shut the program because we couldn't do it," Brig. Gen. Volker Samanns, general manager for the NATO AGS Management Agency (Nagsma) told journalists here in December.

"There were moments in the past where I thought, 'This is never going to happen; the obstacles are too high, political, programmatic, legal and technical challenges,'" he added.

"The main lesson out of the Euro Hawk was that the regulatory framework in place at the time was not made to cope with military type certification of such a complex system," says Paul Linnell, program manager at Nagsma.

Italy took a different approach. After assessing all the documentation made available, "they came up with a different set of questions," says Linnell.

The team was able to approach the U.S. Air Force, which was also operating the Block 40, to provide additional data on the Global Hawk software, systems and airframe, producing some 2 million pages of evidence.

Rome's Directorate of Air Armaments and Airworthiness then proceeded to work on a certification based on the U.S. Air Force's Military Handbook 516B. Citing 638 of 900 criteria contained in the manual, it awarded a limited type certificate in October, paving the way for delivery flights from Northrop Grumman's factory in Palmdale, California, to Sigonella, the first of which took place on Nov. 20-21, the second on Dec. 19.

The aircraft was not compliant with all 638 criteria, "but that does not mean they are not safe," says Linnell. Where the aircraft did not meet the criteria, a risk-based assessment was made.

"This is a platform that was never designed to be certified. . . . Northrop Grumman had to generate a significant amount of data. A lot of this didn't exist," Linnell adds.

One result is that because the aircraft does not have lightning protection, AGS crews have to steer well clear of thunderstorms. And with a new Microsoft Windows-based interface to fly the aircraft, the pilots have easy access to a backup laptop with which they can take control of the aircraft should the primary ground control station computer crash or require a restart.

Although the term "limited" will never be lifted, Nagsma officials argue the platform is the safest Global Hawk variant to fly. "That gives the assurance that it is safe to fly and safe to operate," said Samanns.

Details of the type certification have been handed to alliance nations to support their own assessments for overflights. Countries could deny permission for the aircraft or pose additional limitations, although such issues are not envisaged.

"We anticipate NATO members will allow overflight based on the limitations established by Italy in the certification process," says Linnell.

Although it wears NATO markings, the Phoenix will carry an Italian military registration.

Current AGS plans call for the RQ-4Ds to operate solely in the Euro-Atlantic region, which means all flights can be performed from Sigonella with no need for additional forward operating bases, as with the NATO E-3 force.

Nonetheless, NAGSF has an established set of diversion airfields across mainland Europe and is piggybacking on the experience gathered by the U.S. Air Force, which regularly flies Global Hawk missions into Eastern Europe, the Baltic and over Ukraine.

The U.S. Navy is expected to fly its Triton system from Sigonella in the coming years in the maritime reconnaissance role. The base also plays host to Air Force MQ-9 Reapers.

Once airborne, the Phoenix aircraft will spiral up to their operating altitude to 50,000-60,000 ft. and then

transit to their operating areas well above Europe's commercial air traffic.

Although the $1.5 billion cost of the AGS program has been paid by 15 of the 29 NATO members, the operational phase will be funded by all 29.

The NAGSF force currently consists of around 300 personnel representing almost every NATO country. They are often from different services in each nation, as the mission requires expertise from different domains, including land and sea. Once at full strength, NAGSF will have 600 personnel. NAGSF is currently operating out of temporary facilities, including hangars provided by the Italian Air Force.

The next step is construction of permanent infrastructure at two sites on Sigonella's airfield. One is a headquarters and operations facility with offices and suites for training. The other site on the airfield flight line entails construction of three hangars and a maintenance facility with two bays for the RQ-4D aircraft. Work is underway and due for completion in 2021.

Despite the temporary facilities, Sigonella-based teams performed both the ferry flights and have also flown test sorties out of Palmdale.

With the arrival of the second aircraft, Nagsma hopes to complete two verification flights in January before handing the aircraft and the AGS Core system over to NAGSF to begin training and workup toward initial operational capability (IOC).

"There are target goals [for IOC], but they are not set in stone," says U.S. Air Force Brig. Gen. Phillip Stewart, NAGSF commander. "Our short-term goal is to make IOC in six months, and our long-term goal is to be [at] FOC [full operational capability] in three years."

One of the criteria for IOC is to be able to perform at least one mission a week, but by the time NAGSF achieves FOC, the unit wants to be able to deliver two task-lines, performing observations in two geographical areas for a sustained period should it be required.

To perform its mission, the AGS RQ-4Ds are fitted with a belly-mounted Multi-Platform Radar Technology Insertion Program (MP-RTIP) sensor capable of performing all-weather ground-moving-target indicator and synthetic aperture radar (SAR) imaging modes out to 200 km (125 mi.), allowing it to observe a long way into unfriendly territory.

The radar is mounted on a rotating pylon so that the sensor can view to the left or right of the aircraft. Until now, such a capability was available only to a handful of NATO air services, including the U.S. Air Force with its Northrop Grumman E-8 Joint Surveillance Target Attack Radar System and the UK with its Raytheon Sentinel aircraft. Through software manipulation, the analysts can establish patterns of life and use change-detection algorithms in SAR imagery.

"This is a quantum leap forward in the reconnaissance capabilities of the 29 nations. That's no hyperbole," says Stewart. "What we are providing here is near real-time, high-definition imagery that was previously not available to any of the nations. Now it is available to all 29."

Unlike in the U.S. Air Force, the AGS Global Hawks will have a crew of around 12 with a mission director, usually an intelligence officer, at the helm. Also among the 12 are the pilot, sensor operator, intelligence analysts and a processing, exploitation and dissemination team that distributes the gathered information to commanders across the 29 alliance member states.

Although the aircraft are not envisaged to forward-deploy, European industry has developed a Mobile General Ground Station and a Transportable General Ground Station so that data can be delivered into the hands of commanders on the front line should it be required. The facilities are self-sustaining, with their own power and communications system including high-bandwidth K_u-band satellite uplink/downlink.

NAGSF also has established its own training center for pilots and intelligence personnel, with pilots requiring 15 simulator sessions to make the transition to type. Many pilots already have experience flying UAVs and larger types, but NAGSF also has fighter and helicopter pilots in its ranks.

"We are basically creating a small air force," said Samanns.

Looking ahead, there currently is no funding line for upgrades, but the NAGSF force is expecting additional radar capability for maritime reconnaissance. "We have a platform here tailor-made to suit NATO needs, and we have everything we need for operations," says Stewart.

The AGS Phoenix fleet is using temporary facilities until new hangars and operations buildings are ready in 2021.

CHRISTIAN TIMMIG/NATO ALLIED AIR COMMAND

NATO Takes First Steps for Future Surveillance System

> FIRST CONTRACTS WERE AWARDED IN DECEMBER

> AFSC PROGRAM IS IN EARLY-CONCEPT PHASE, WITH EARLY INDUSTRY PARTICIPATION

Tony Osborne London

NATO has taken the first steps toward replacing its fleet of Boeing E-3 Sentry airborne early-warning platforms. With the Germany-based fleet envisaged to exit service in 2035, a $1 billion contract agreed with Boeing in November for what the alliance calls the Final Lifetime Extension Program is expected to keep the platform relevant until then.

Beyond 2035, the E-3's role will be one of several to be handed to Alliance Future Surveillance and Control (AFSC), likely be a dedicated distributed, multidomain system of systems.

"The E-3 retirement was a driver in terms of timeline and the anticipated capability gap," says Cagatay Soyer, AFSC program manager for the NATO Support and Procurement Agency (NSPA). "Capability gaps are not just caused by a system going out of service but also by a changing environment, and 2035 definitely calls for this kind of analysis to take place."

NATO E-3A COMPONENT

Soyer says it is hard to know what the AFSC will look like but notes alliance members are not focused on individual platforms but on capabilities. "This is not about simply replacing an old system with a new system," he notes, but industry offering "different combinations of systems and solutions."

"We will not buy the entire suite of sensors," Camille Grand, NATO's assistant secretary general for defense investment, told Aviation Week in December. "Our plan is to procure the core of the C3 [command, control and communications] system that will enable us to plug in all these things. . . . That's where we make sure we enable all these systems, all these sensors in an architecture that enables the alliance to work jointly."

Grand acknowledged similarities with acquisition for the Advanced Battle Management System (ABMS) in development by the U.S. Air Force. In the near term, that program is focused on replacing the battle management role for ground strikes now played by the E-8C Joint Stars fleet. In the longer term, the Air Force plans to replace the E-3C Airborne Warning and Control System fleet using the same distributed communications architecture developed under ABMS.

"We know we need something at this horizon, which is slightly earlier than the Air Force replacement for the E-3 and slightly before the replacement of E-3 capabilities for both the French and the Brits," Grand said. "So in a way NATO is—and I put this gently—slightly ahead of the curve. And what we have to do here is think through allied air operations in this."

Industry has been involved at an early stage compared to other NATO programs, notes Soyer. The NSPA wants industry to take an early look at the technologies needed for such a system, with a particular focus on automation: how much in which areas and what functions. Information sharing will also be a significant technology consideration, as will deployablilty, sensor technologies and cyberdefense. "NATO has made some significant strides into interoperability and information sharing. . . . AFSC will harness this," says Soyer.

In early December, the NSPA awarded the first concept-phase contracts under a NATO Security Investment Program based on what Soyer describes as a "very broad requirement." Tenders were issued to Airbus, the Boeing-led Abiliti consortium, General Atomics, an L3Harris Technologies-led consortium, Lockheed Martin and MDA of Canada. Abiliti includes Indra, Inmarsat, Leonardo and Thales, while the L3Harris team includes UK companies Musketeer Solutions, Videns, 3SDL and IBM UK. It also includes German firms Synergeticon and Hensoldt as well as Deloitte in Belgium.

Contract amounts have not been disclosed, but looking ahead, AFSC could be lucrative. The E-3 alone has generated some $13 billion of contracts since the the 1970s. The Alliance Ground Surveillance (AGS), based on the Northrop RQ-4D Global Hawk, has generated another $1.5 billion (see page 50).

The NATO Final Life Extension Program will extend the E-3A Sentry fleet until 2035, by which time NATO hopes the AFSC will be in a position to take up its mission and more.

The concept stage will run until 2025, with the six high-level concepts reporting back this year to be assessed by the nations to select the most promising and potentially narrow them down for more detailed studies to address system specifications, performance and cost estimates.

"We are asking industry to develop this for us and to justify their analysis. . . . On the NATO side, we will independently look at this and the realism of the proposed concept," says Soyer. "Toward the end of next year, we will have promising concepts which should be more tangible."

The concept phase work also will include what Soyer describes as a "capability gap analysis" to understand how the alliance could fill gaps in AFSC, either through NATO common-funded capabilities or contributions from either individual or groups of nations. This could include the UK's new fleet of Boeing E-7 Wedgetail airborne early warning aircraft, which the UK is purchasing to replace its own E-3 fleet in the 2020s. The gap analysis "will identify what is going offline and what is being introduced [by NATO countries]," says Soyer. "That will give us the way forward."

The later phases of the concept work will also prepare and establish programs and likely will see memorandums of understanding with alliance members and groups of nations to provide capabilities. A development and procurement phase will get underway after 2025.

—With Steve Trimble in Washington

Demos Prove Reaper's Maritime Merit in Greece

> GA-ASI PUSHES SEAGUARDIAN OVERWATER VERSION OF SKYGUARDIAN

> BESIDES A MALE SYSTEM, GREECE WANTS TO DEVELOP LOCAL UAV CAPABILITIES LIKE THOSE OF TURKEY

Tony Osborne Larissa Air Base, Greece

TED CARLSON/GENERAL ATOMICS

General Atomics demonstrated the maritime capabilities of the MQ-9 with flights over nine days, and proved the sense-and-avoid capabilities of onboard sensors against Hellenic F-16s.

Greece could be the next European country to invest in General Atomics' (GA-ASI) MQ-9 Reaper family of medium-altitude long-endurance (MALE) air systems.

Recognizing the rapid advances made by neighboring Turkey in developing unmanned aircraft systems, as well as the challenges associated with keeping an eye on the nation's territorial waters and network of islands, the government in Athens soon may take the first steps toward a MALE platform acquisition.

"We are in negotiations with the U.S. government for three UAVs with strategic surveillance capabilities," Defense Minister Nikolaos Panagiotopoulos told the Greek Parliament on Dec. 13.

Panagiotopoulos said he wanted a system that could operate from the "Black Sea to Libya," partly reflecting concerns about Turkey's attempts to modify the international maritime boundaries between it and Libya and also Ankara's exploratory drilling in the waters off Cyprus.

Closer to home, more persistent observation of the Greek islands could help police the trafficking that has seen thousands of refugees and migrants land on the country's beaches.

Hellenic minds already may be made up. In December, GA-ASI conducted a series of flight demonstrations for its proposed SeaGuardian, a derivative of the company's internally developed MQ-9B SkyGuardian that would be fitted with a Raytheon-developed SeaVue surface search radar to perform the maritime surveillance mission.

Demonstrating the concept to potential European customers, the company flew its experimental civilian-registered Block 1 Reaper fitted not only with the search radar, but also with the company's sense-and-avoid, due-regard radar over the Aegean Sea and along the Greek coastline. It even flew to within a few miles of the Istanbul flight information region, whose western border snakes between the Turkish coastline and numerous Greek islands. Similar demonstration flights were previously performed in Japan.

On the back of Panagiotopoulos' statements, Mark Kaniut, GA-ASI's director for current customers, told journalists "there is [Greek] interest in a system," defining a "system" as three air vehicles and two ground control stations.

Flights were performed from Larissa Air Base, a facility already familiar with the MQ-9 as two U.S. Air Force examples have been flying missions from the airfield since May 2018.

From the air, the aircraft produced a picture of regional shipping using a combination of the automatic identification system used by commercial vessels combined with radar information, and also proved the potential of the due-regard radar system as Hellenic Air Force F-16s intercepted the UAV from behind and head-on, with the detect-and-avoid system providing prompts to the pilots.

While the MQ-9 capabilities were displayed to the Hellenic Armed Forces, they also were demonstrated to Belgium, France, Italy, the Netherlands, Spain and the UK.

Spain began taking delivery of its Reapers in mid-December.

GA-ASI has sensed a new opportunity, already having sold the MQ-9 to many of Europe's major air services for the intelligence surveillance-and-reconnaissance (ISR) mission. The enhanced capabilities and the certified nature of the MQ-9B—being developed as the Protector for the UK—paves the way for homeland overland and, notably, maritime surveillance missions in nonsegregated airspace. Securing civil certification for the platform could smooth the path for civil agencies to use the platform for other missions such as forest fire surveillance, search and rescue, fisheries and environmental control. Several of these missions were demonstrated during the flight trials in Greece.

Company officials say they are developing new operating models including so-called co-co (contractor-owned/contractor-operated) and (government-owned/contractor-operated) to support future customers. The co-co solution already has been used by the U.S. Air Force's MQ-9 operation in Poland.

GA-ASI also has sensed growing frustrations, notably from France, about the multinational EuroDrone development program involving Airbus, Dassault Aviation and Leonardo for France, Germany, Italy and Spain. French officials are unhappy with the apparent cost of the program, which according to media reports exceeds €7 billion ($7.8 billion), and its 11-ton maximum takeoff weight, a compromise driven by German certification requirements.

Greece has limited experience in operating UAVs, with the air force budget largely focused on modernizing its F-16 fleet. The service currently flies a fleet of locally produced Pegasus tactical UAVs made by Hellenic Aerospace Industry, which have a takeoff weight of 130 kg (87 lb.) and a limited endurance of around 3.5 hr. Panagiotopoulos said he wanted Greece to be able to develop more capable systems on its own.

"We have the talent, we have the research product, prototype, funding opportunities, [and] defense industry. With a specific schedule and a road map we will soon have the Hellenic UAV," he said.

AVIATION WEEK'S 63RD ANNUAL

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Since 1957, Aviation Week has annually bestowed its Laureate Awards upon people, programs and products that have had an outsize impact on the aviation, aerospace and defense industries. This year's winners, showcased here, will be recognized March 12 at a black-tie gala at the National Building Museum in Washington. That evening, our editors will also announce which of these winners will receive a "Grand Laureate" for particular achievement in 2019—one each in defense, space, commercial aviation and business aviation. They will also present Aviation Week's Lifetime Achievement awards.

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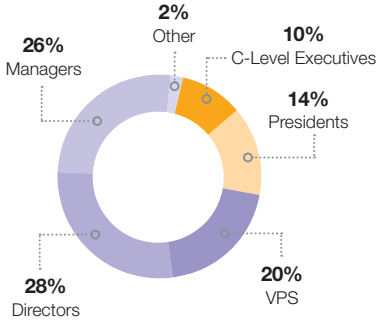


AVIATION WEEK NETWORK

Commercial Aviation

PLATFORMS Airbus A321LR

The first long-range version of the A321neo, Airbus' A321LR, is developing a new market niche—narrowbodies flying in secondary long-haul markets. Building on the LR, the upcoming A321XLR variant has the potential to open even more destinations for long-haul travel.

AIRBUS

ALBERTO E. RODRIGUEZ/GETTY IMAGES

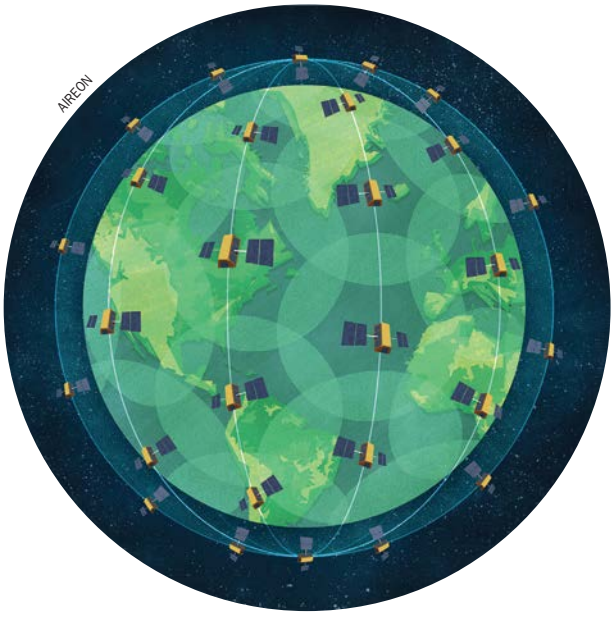
LEADERSHIP David Neeleman

Entrepreneur David Neeleman has set up multiple airlines including Morris Air, JetBlue Airways and Azul Linhas Aereas. Now he is preparing to get Moxy, his latest venture, off the ground with a new business model built around the Airbus A220.

AIRLINE STRATEGY Adel Ali, CEO, Air Arabia

In Air Arabia, CEO Adel Ali has built a sustainably profitable low-cost carrier pioneering the business model in the Middle East. The carrier continues to add bases, grow its fleet and has entered long-haul narrowbody flying.

AIR ARABIA



AIREON

AIR TRAFFIC MANAGEMENT Aireon

Aireon is the first satellite-based air traffic surveillance system and provides continuous tracking of aircraft over oceans and remote regions, using automatic dependent surveillance-broadcast receivers on Iridium Next low-Earth-orbit satellites.

PROPULSION Rolls-Royce

Rolls-Royce's surprise acquisition of Siemens' eAircraft unit has catapulted the engine manufacturer into a leading position in the electrification of aircraft propulsion. The acquisition cemented Rolls' key position on Airbus' E-Fan X hybrid-electric regional aircraft demonstrator.

AIRBUS

BOEING

SUSTAINABILITY

Boeing ecoDemonstrator

Over six test campaigns beginning in 2012, Boeing's ecoDemonstrator flight research program has served as a tool to accelerate the development and testing of multiple new technologies that could improve the efficiency and environmental performance of its airliners.

DONECLE

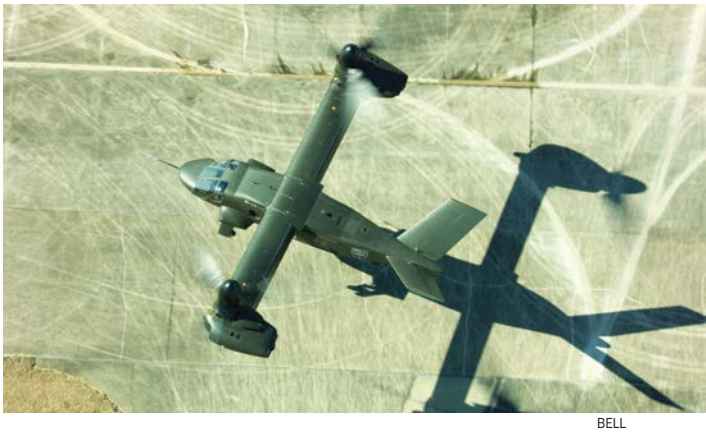
MRO Donecle

French company Donecle has become a leader in offering aircraft visual inspections by automated drone. Inspection times are reduced by 90%. The drone can inspect a narrowbody within 1 hr. while Donecle's software assists technicians in detecting defects.

Defense

PLATFORMS Bell V-280 Valor

From its low-speed agility to its maximum speed of more than 280 kt., Bell's V-280 Valor advanced tiltrotor has met or exceeded its ambitious objectives in flight-testing since December 2017 under the U.S. Army's Joint Multi-Role technology demonstration.



BELL

EMBRAER

BEST NEW PRODUCT Embraer C-390

Embraer delivered the first C-390 to the Brazilian Air Force in 2019. The tanker/transport is the largest and most sophisticated aircraft yet developed by Embraer and the most ambitious defense development program in South American history.

MANUFACTURING Northrop Grumman F-35 Center Fuselage Production

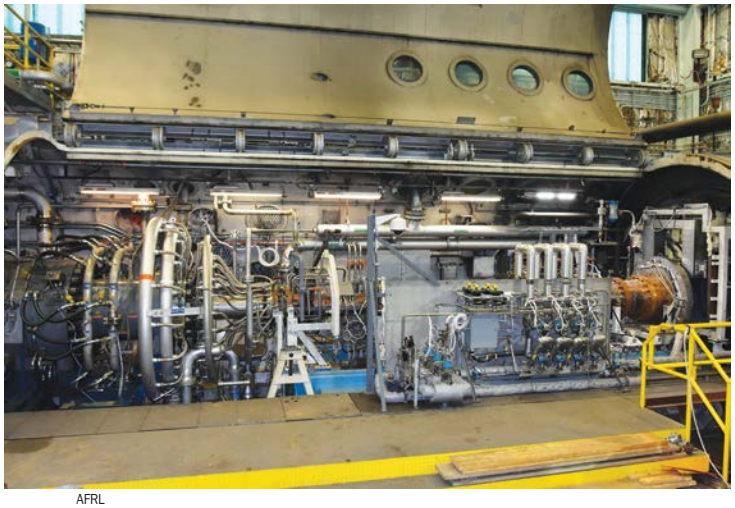
In 10 months, Northrop Grumman increased production of F-35 center fuselages from six a month to 15—parts deliveries increasing from 81,000 a year to 274,000—using a disciplined structure of program reviews and metrics that were regularly updated to keep pace with the schedule.

NORTHROP GRUMMAN

UK DEFENSE MINISTRY

MRO BAE Systems Typhoon Total Availability Enterprise

Combining Eurofighter support packages into one program focused on management of the Royal Air Force fleet, rather than individual aircraft, has lowered support costs for the Typhoon fighter by around 38%, allowing savings to be applied to fleet modernization.



AFRL

PROPULSION

AFRL Medium-Scale Critical Components Scramjet Program

Ground tests by the U.S. Air Force Research Laboratory and Air Force Test Center in 2019 set a record for the highest thrust produced by a U.S. air-breathing hypersonic engine when a Northrop Grumman supersonic-combustion ramjet engine produced more than 13,000 lb. of thrust.

TECHNOLOGY & INNOVATION

Kratos XQ-58 Valkyrie

Developed by Kratos for the U.S. Air Force Research Laboratory, the XQ-58 Valkyrie blurs the traditional boundaries between a disposable cruise missile and a reusable unmanned aircraft and could usher in a new approach to air warfare that relies heavily on manned-unmanned collaboration.

AFRL

MISSILE DEFENSE AGENCY

WEAPONS

Missile Defense Agency/Boeing Ground-based Midcourse Defense FTG-11

On March 25, 2019, the U.S. Missile Defense Agency led a government/industry, multi-contractor team in launching two ground-based interceptors from Vandenberg AFB, California, to shoot down not one but two threat-representative ICBM targets launched from Kwajalein in the Pacific in the most challenging test yet of the Ground-based Midcourse Defense system.

Space

SPACEFLIGHT INDUSTRIES

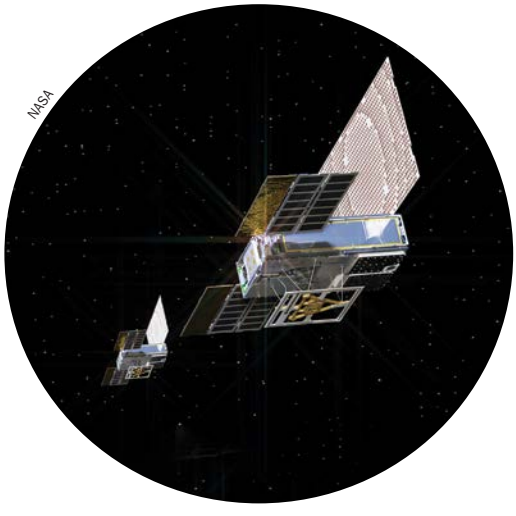
LAUNCH SERVICES Spaceflight Industries

Originally a satellite operator itself, Spaceflight Industries has blossomed by creating a new way to deliver small satellites to space—by allowing government and commercial customers to share the ride. Following the launch of 64 satellites on a Falcon 9 in late 2018, Spaceflight expects to close out 2019 having launched spacecraft on 10 rockets.

SPACE SCIENCE Chang'e 4 Moon Landing

With the Jan. 3, 2019, touchdown of the Chang'e 4 robotic lunar lander on the floor of the 115-mi.-wide Von Karman Crater, China became the first country to soft-land on the Moon's far side. Since deploying from the lander, its Yutu-2 rover has driven more than 300 m (980 ft.) across the South Pole-Aitken Basin.

THE PLANETARY SOCIETY



NASA

PLATFORMS Mars Cube One Mission

In the first demonstration of cubesats in deep space, the two-spacecraft Mars Cube One mission relayed near-real-time telemetry of the entry, descent and landing of NASA's Insight spacecraft, providing a backup communications link to Earth and demonstrating a new architecture to enhance space exploration.

OPERATIONS Hawkeye 360

U.S. startup Hawkeye 360 in February 2019 launched the first commercial service for geolocating radio-frequency signals from space when it commissioned its first three Pathfinder satellites. The satellites fly in a unique formation that can pinpoint a wide range of radio-frequency signals.

HAWKEYE 360

PROPULSION Reaction Engines

Reaction Engines has demonstrated the technical viability of its pre-cooler concept at temperatures representative of hypersonic speeds. The test marks a critical milestone toward development of its Sabre air-breathing rocket engine, which could power space-access and atmospheric vehicles and transform the performance of high-speed turbojets.

REACTION ENGINES

ONEWEB SATELLITES

SUPPLIER INNOVATION

OneWeb Satellites

In a unique transatlantic joint venture between aerospace giant Airbus and mega-constellation operator OneWeb, Florida-based OneWeb Satellites is bringing aircraft mass production to satellite manufacturing. The factory will produce more than 640 satellites at a rate of two a day—an unheard-of output for the space industry.

TECHNOLOGY & INNOVATION

RemoveDEBRIS Mission

In a groundbreaking series of on-orbit tests, the European Commission-funded RemoveDEBRIS mission demonstrated a series of active debris-removal technologies designed to clean up low Earth orbit. Deployed from the International Space Station, the RemoveDEBRIS satellite tested vision-based navigation, net capture, harpoon capture and drag-sail deorbiting.

UNIVERSITY OF SURREY

Business Aviation

GULFSTREAM

PLATFORMS Gulfstream G500/G600

The first of a new generation of large-cabin, long-range Gulfstreams, the G500 and G600 feature the Symmetry flight deck including fly-by-wire controls, active sidesticks, 10 touchscreen controllers and links to most aircraft systems through GE Aviation's Data Concentration Network. Their ultra-quiet three-section cabins maintain a 4,850-ft. altitude at 51,000 ft.

GARMIN

SAFETY Garmin Autoland

The push of a red button by a pilot or untrained passenger activates Garmin's Autoland, a virtual co-pilot that takes control of the aircraft. The system automatically evaluates winds, weather and fuel reserves, then selects a suitable divert airport, alerts air traffic controllers of its intent, flies to the field, descends, extends landing gear and flaps, then lands and stops.

PROPULSION Pratt & Whitney PT6E Series

The first general aviation turboprop to feature a dual-channel, integrated electronic propeller and engine control system, Pratt & Whitney's next-generation PT6E also delivers 10% more power than its predecessor and features an unprecedented time between overhauls of 5,000 hr.

REGA

OPERATIONS Rega Swiss Air-Rescue

To operate during periods of reduced visibility in mountainous terrain, Rega helped develop a low-altitude, helicopter-specific instrument route and approach system using satellite navigation, along with its own weather station network. Its aircraft are fitted with multiple optical systems to help pilots spot obstacles and conduct searches.

MRO Robotic Skies

In anticipation of the widespread growth of commercial unmanned aircraft, Robotic Skies has created an expanding global network of repair stations to maintain and service the burgeoning fleet. The company develops maintenance programs for operators, trains technicians and has teamed with Boeing to manage the supply chain.

BOEING

WING AVIATION

TECHNOLOGY & INNOVATION Wing Aviation

A subsidiary of Google parent company Alphabet, Wing in April 2019 became the first commercial drone delivery service to be awarded a Part 135 air carrier certificate by the FAA. Its Hummingbird drone, capable of vertical takeoff and landing as well as wingborne flight, conducted the first scheduled delivery by drone to a U.S. home in October.

Lifetime Achievement

Robert Leduc

Bob Leduc came out of retirement to return to Pratt & Whitney as president and used his leadership skills to shake up the corporate team and guide the PW1000G geared turbofan engine program through a challenging service introduction and production ramp-up, setting it on a path to success.

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President/Publisher: Gregory D. Hamilton;
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Managing Director, Global Media: Iain Blackhall (UK);
+44 (0)20 7975 1670; iain.blackhall@aviationweek.co.uk

U.S. Sales Offices

Managing Director, Americas: Beth Wagner;
(202) 517-1061; beth.wagner@aviationweek.com

Director, Commercial Sales: Tom Davis;
(469) 854-6717; tom.davis@aviationweek.com

International Regional Sales Offices

Publisher, Defense, Space & Security:
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Marketing Services

Director, Digital Customer Solutions: Jason Washburn;
(216) 931-9161; jason.washburn@informa.com

Sales Team Listings: @AviationWeek.com/sales-contacts

Business/Production

Senior Manager, Ad Production: Jim Heffron;
(630) 524-4552; jim.heffron@informa.com

Production Coordinator: Kara Walby;
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Advertising/Marketing Services

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Aerospace Calendar

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

Jan. 23-April 2—RTCA Plenary Sessions. Various locations. See rtca.org/content/upcoming-committee-meetings

Jan. 27-30—HAI Heli-Expo 2020. Anaheim Convention Center. Anaheim, California. See rotor.org/home/heli-expo

Jan. 29-30—FAA Commercial Space Transportation Conference. Ronald Reagan Building. Washington. See cstconference2020.com

Feb. 3-6—SmallSat Symposium 2020. Computer History Museum. Mountain View, California. See 2020.smallsatshow.com

Feb. 4-5—NASA's Sustainable Aerospace Supply Chain and High-Volume Manufacturing Workshop. NASA Ames Conference Center. Mountain View, California. See nari.arc.nasa.gov/aerosupplychain

Feb. 4-5—Asia Defence Expo & Conference Series (ADECS). Marina Bay Sands Expo and Convention Center. Singapore. See asia-decs.com/welcome

Feb. 5-8—DefExpo 2020. Vrindavan Yojna. Lucknow, India. See defexpo.gov.in

Feb. 11-16—Singapore Airshow. Changi Exhibition Center. Singapore. See singaporeairshow.com

Feb. 18-19—Aviation Festival Asia. Suntec Singapore Convention & Exhibition Center. Singapore. See terrapinn.com/exhibition/aviation-festival-asia/index.stm

Aviation Week Network Events

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Feb. 4-5—Aero-Engines Americas. Miami.

Feb. 4-6—Routes Americas 2020. Indianapolis.

Feb. 5-6—CAPA Qatar Aviation Aeropolitical & Regulatory Summit. Doha, Qatar.

Feb. 24-26—MRO Middle East Summit & Expo. Dubai.

March 2-3—CAPA Middle East & Africa Aviation Summit. Dead Sea, Israel.

March 8-10—Routes Asia 2020. Chiang Mai, Thailand.

March 9-11—Commercial Aviation Industry Suppliers Conference. Beverly Hills, California.

March 9-11—Aerospace Raw Materials & Manufacturers Supply Chain Conference. Beverly Hills, California.

March 11-12—MRO Australasia. Brisbane, Australia.

ADVERTISERS IN THIS ISSUE

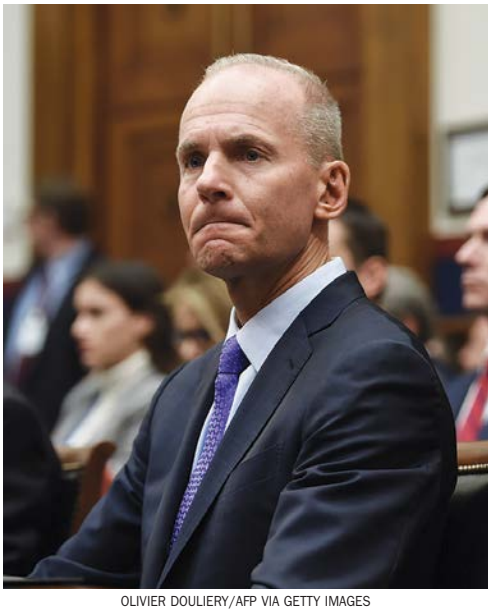
FROM THE EDITOR

After Muilenburg

What would have happened if Boeing's CEO had rushed to Ethiopia last March to stand beside his Ethiopian Airlines counterpart after the crash of a 737 MAX that claimed 157 lives? If at that early moment he had delivered in person a message of contrition and deep sorrow for the victims and their families? If his company decisively had asked operators to stop flying the MAX out of an abundance of caution until investigators learned more about what caused the second crash of the aircraft in less than five months?

If Dennis Muilenburg had done all that, might he still have his job—and might one of corporate America's greatest crises have been avoided?

Our industry desperately needs a strong Boeing, and just a year ago it appeared to have one. Muilenburg was Aviation Week's Person of the Year for 2018, and with good reason: A push into the lucrative aftermarket business was accelerating and major Pentagon contract wins were rejuvenating its defense business. Profits were soaring, and the company's stock value had more than tripled in three years as Boeing returned mountains of cash to shareholders.



OLIVIER DOULIERY/AFP VIA GETTY IMAGES

Yes, investigators were probing the crash of a Lion Air MAX in Indonesia that had taken 189 lives, but operational issues, not fundamental flaws in the airliner's design, were seen as the most critical links in the accident chain. The FAA had determined the aircraft was safe to fly while Boeing devised a software fix for its Maneuvering Characteristics Augmentation System (MCAS).

Then it all changed. Boeing's public image was battered as it came to light that most airline pilots did not even know of the existence of the MCAS, which triggered both crashes. Boeing's timelines on the MAX's return to service proved overly optimistic again and again, vexing customers. Hundreds of undelivered 737s filled up the parking lots near Boeing Field. Relations with the FAA grew testy. And a firestorm of media coverage—some fair, some overly sensational—painted a picture of a company being run by sharp-elbowed and tone-deaf lawyers. The contrition came, but it was late and sometimes appeared calculated.

Muilenburg was fired on Dec. 23 and will be succeeded on Jan. 13 by longtime board member David Calhoun. But his departure hardly will cure what ails Boeing. The company still has to get the MAX back into service. When that will happen is anyone's guess. It also needs to figure out a next-generation airplane design to compete with Airbus, which has had phenomenal sales success with the Neo, particularly the A321 version.

There are two broader issues at play: culture and governance. Numerous industry veterans believe Boeing's culture has been infected with arrogance and an emphasis on profits and shareholders over engineering excellence and innovation. The company's website boasts that Boeing has returned nearly $50 billion to shareholders in dividends and share repurchases over the past five years. Would it not have been better to reinvest some of that in cutting-edge products? Muilenburg, who spent his entire career at Boeing, did not create that culture. He is a product of it. Remember that his mentor, former CEO Jim McNerney, promised "no more moonshots" after the bills for the 787's delays started mounting.

It is hard to foresee meaningful reform if Boeing's governance is not fixed. Muilenburg may be gone, but the board of directors that presided over this mess is still in place and sorely needs an overhaul. Can we really expect anything different if the same group keeps calling the shots in the boardroom? Former Continental Airlines CEO Lawrence Kellner, the board's new chairman, has work to do.

Calhoun, the new CEO, is capable and respected. He spent 26 years at GE and ran its aircraft engines business. He has served on Boeing's board since 2009 and was a finalist for the CEO position before McNerney got the job. However, that was 15 years ago, and Calhoun has not worked a day job in aerospace since he left GE to run Neilsen in 2006. At 62, will he stay for the long haul? Or will he stabilize the company and groom a younger successor who can take over in 1-2 years and guide Boeing toward making its next momentous decision: when to launch a next-generation narrowbody airliner?

The aviation industry needs a robust, responsible Boeing. It needs a vibrant, reliable competitor to Airbus, and safe and sustainable new aircraft. It is time for some more moonshots.

—Joe Anselmo, Editor-in-Chief

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Laureates

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Category Winners Announced!

COMMERCIAL AVIATION

Platforms – Airbus A321LR
Leadership – David Neeleman, Airline Entrepreneur
Airline Strategy – Adel Ali, CEO, Air Arabia
Propulsion – Rolls-Royce
Sustainability – Boeing ecoDemonstrator
Air Traffic Management – Aireon
MRO – Donecle

DEFENSE

Platforms – Bell V-280 Valor
Best New Product – Embraer KC-390
Manufacturing – Northrop Grumman F-35 Center Fuselage Production
MRO – BAE Systems Typhoon Total Availability Enterprise
Propulsion – AFRL Medium Scale Critical Components Scramjet Program
Technology & Innovation – Kratos XQ-58 Valkyrie
Weapons – Missile Defense Agency Ground-based Midcourse Defense FTG-11

SPACE

Launch Services – Spaceflight Industries
Space Science – Chang'e 4 Moon Landing
Platforms – Mars Cube One Mission
Operations – HawkEye 360
Propulsion – Reaction Engines
Supplier Innovation – OneWeb Satellites
Technology & Innovation – RemoveDEBRIS Mission

BUSINESS AVIATION

Platform – Gulfstream G500/G600
Safety – Garmin Autoland
Propulsion – Pratt & Whitney Canada PT6E
Operations – Rega Swiss Air-Rescue
MRO – Robotic Skies
Technology & Innovation – Wing Aviation

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Robert Leduc – President, Pratt & Whitney

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