STARTS AFTER **PAGE 38**

InsideMRO™
$14.95 JULY 13-26, 2020
AVIATION WEEK & SPACE TECHNOLOGY

EUROPE'S DEFENSE Comes Together

RICH MEDIA EXCLUSIVE

OEM Product Support
The New Leaders

Flight Paths Forward
Industry Waits On Airline Recovery
How MRO Could Climb Out

CEO Interviews
RICH MEDIA EXCLUSIVE
Lufthansa Technik
Raytheon Technologies

AVIATION WEEK NETWORK

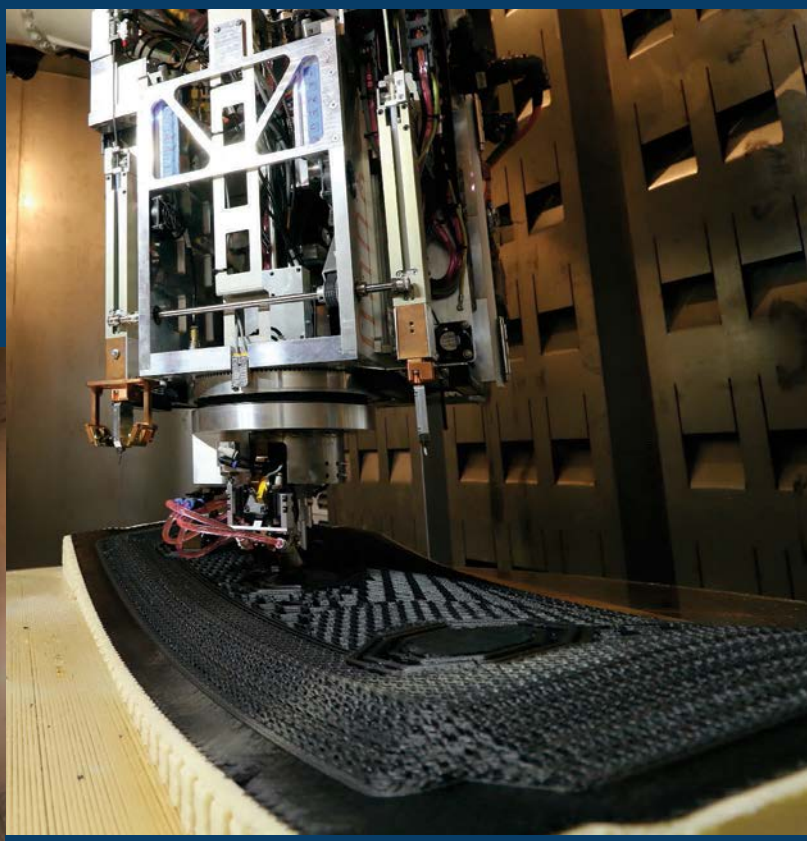
ELECTROIMPACT

World-Class Automation Solutions

American-owned family business since 1986

New

Continuous Fiber **True 3D** Printing



Tool-less integrated composite structures

Electroimpact has developed an industrial true 6-axis continuous fiber reinforced 3D printer, enabling the tool-less rapid fabrication of aerospace-grade integrated composite structures. High-performance thermoplastics combined with a high percentage of continuous fiber reinforcement are used to produce parts with exceptional material properties previously unheard of in the world of additive manufacturing.

electroimpact.com/3d

SALES@ELECTROIMPACT.COM (425) 293-4203

ROBOTICS, AUTOMATED COMPOSITES, RIVETING, DRILLING, FASTENING, TOOLING, METROLOGY, OFFLINE PROGRAMMING, SPACE, ADDITIVE MANUFACTURING

— ELECTROIMPACT — (425) 348-8090 — WWW.ELECTROIMPACT.COM —

AVIATIONWEEK
& SPACE TECHNOLOGY

July 13-26, 2020 · Volume 182 · Number 14

JESSE H. NEAL AWARDS
Est. 1955
2020 Winner
66 WINNER

INTERVIEWS

FEATURES

COMMERCIAL AVIATION

DEPARTMENTS

62

The Hubble Space Telescope caught this view of Mars from 54 million mi. away in 1999.

CONNECTED AEROSPACE

PROPULSION

DEFENSE

SPACE

ASK THE EDITORS

VIEWPOINT

ON THE COVER

Since the economic crisis of 2008, European nations have been banding together under new cooperative agreements to pool research and development that could lead to a generation of new weaponry. London Bureau Chief Tony Osborne's report begins on page 44. Aviation Week cover concept based on an image by khvost/Getty Images.

Aviation Week publishes a digital edition every week. Read it at **AviationWeek.com/AWST**

DIGITAL EXTRAS *Access exclusive online features from articles accompanied by this icon.*

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.com
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

Director, Editorial and Online Production Michael O. Lavitt

Associate Managing Editor Andrea Hollowell

Art Director Lisa Caputo

Artists Thomas De Pierro, Rosa Pineda, Colin Throm

Copy Editors Jack Freifelder, Arturo Mora, Natalia Pelayo, Andy Savoie

Production Editors Audra Avizienis, Theresa Petruso

Contributing Photographer Joseph Pries

Director, Digital Content Strategy Rupa Haria

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

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

Paris
Helen Massy-Beresford helen.massy-beresford@aviationweek.co.uk

Washington
Jen DiMascio jen.dimascio@aviationweek.com

Wichita
Molly McMillin molly.mcmillin@aviationweek.com

President, Aviation Week Network
Gregory Hamilton

Managing Director, Intelligence & Data Services
Anne McMahon

AVIATION WEEK NETWORK
By Informa Markets

FEEDBACK

STEFAN KALM/SAAB

RULES OF ENGAGEMENT

Tony Osborne's excellent two-part series on awesome air-to-air missile capability available today *(June 1-14, p. 34 and June 15-28, p. 28)* left me reminiscing about the AIM-7E3 and AIM-9J missiles we carried on our F-4Es. Crude by today's standards, there was one limitation we had that wasn't mentioned in this article: rules of engagement (ROE). They can differ by theater and can have a dramatic effect on air-to-air missile employment and effectiveness. Noncooperative target recognition (NCTR) systems were in their infancy during the Vietnam War and were driven by the ROE requirement to visually identify your target or confirm hostile by "other" means. Hopefully, NCTR capabilities have advanced as the missile capabilities have moved forward. If not, much of the new missile capability could be unusable due to ROE restrictions.

John Locke, Albuquerque, New Mexico

SEPARATION SPECIALISTS

As a third-generation recycler and avid fan of Aviation Week, I thoroughly enjoyed the article on recycling *(May 4-17, p. 32)*. Our trade organization, the Institute of Scrap Recycling Industries, has for years pushed the idea of design for recycling. It would behoove future designers of aircraft to consider the environment. Thierry Dubois mentions in the article the difficulty of separating the high-temp alloys that are inside most engines. With today's technologies, most modern scrap metal facilities are able to do a very accurate job in separating and packaging the items for recycling.

Robert B. Kimmel, Detroit

THE MERIT OF CLARITY

I am glad to see the clarifying grammatical usage in "Short Story" *(May 18-31, p. 49)* of "maximum lift coefficient," "At high . . . C_L," and "achievable lift coefficient," where the subject—coefficient/C_L—is included in those three statements.

This clarity of usage, resulting in understanding, is in contrast to the following examples of what would be an alternate grammatical usage as applied to those three statements, examples of an all too common usage earning its place as an aeronautical standard: "maximum lift," "At high . . . lift" and "achievable lift," where the subject—coefficient/C_L—is absent. Thereby clarity is absent. The statements, and others similar, are thus misleading by their ending term "lift," a reigning grammatical usage driving misunderstanding.

The clarifying grammatical usage in "Short Story"—the clarity that the lift coefficient/C_L is the subject, not lift—could be a pivotable point for aeronautics to step away from its noted standard, a standard of long consequential history. Aviation Week continues to raise the level of accuracy of aeronautical language to reach and to match the accuracy that's demanded, nay required, of the science of aeronautics.

Terry Golden, Minneapolis

LEAVE IT TO ROBOTS

Regarding "New Era" *(June 15-28, p. 22)*, covering the success of the Space X Falcon 9 manned launch to the International Space Station, although the technology continues to advance the ability to get to the Moon and Mars, little is being addressed about long-term manned spaceflight and its impact on the human travelers.

First, the trip to Mars and back is much longer than a trip to the Moon, and radiation exposure will be significant both during the trips and on the surface of Mars. Second, the lack of gravity during the long voyage and on the surface of Mars will have a significant impact on astronauts' physical health and mobility. Third, Mars' atmosphere is so thin, it would be difficult to land, it offers no micro-meteorite protection, and any enclosed structure on the planet's surface must be completely sealed—plus, breathable air will have to be generated artificially. Any leak will be deadly. And clouds of atmospheric dust will make cleaning space suits and outside equipment difficult. Also, I understand that Mars' soil is full of poisons, making it impossible to use it to grow a local food source.

All in all, due to the many dangers of long-term human space travel and any colonization on Mars and given the amazing successes of robots like the Curiosity spacecraft, the planet would be far better served by continuing to send robots to explore (and save billions of dollars in the process). So far, nothing has been discovered during many unmanned robot explorations to sacrifice human visitors or colonists.

Peter Parsons, Mission Viejo, California

INTERNAL IMPERATIVE

As a former Marine Corps CH-46 pilot and a Vietnam War veteran, I find it incredible that the U.S. Army would seriously consider buying Bell's 360 Invictus with no internal six-troop cabin as described in "SOAR Points" *(June 1-14, p. 28)*.

Aside from troops being exposed to adverse weather and enemy fire and the possibility that pieces of personal equipment and weapons could detach and strike the tail rotor and other airframe parts, they would literally be hanging out with no protection in the event the helicopter went down. Given the choice, I'd bet even the most hardened SOCOM troopers would prefer to fly into combat in an old hand-me-down Vietnam-era Huey than that thing.

Arnold Reiner, Pensacola, Florida

CORRECTION

"New Research and Technologies Fuel Single-Pilot Operations Debate" *(June 29-July 12, p. 36)* should have stated that retired Air France captain and flight-safety consultant Bertrand de Courville is a member of the Toulouse-based Air and Space Academy and the International Society of Air Safety Investigators.

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

WHO'S WHERE

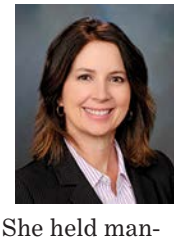
Roger Raley has been appointed president of *Alpine Advanced Materials*. He had been TTI Inc. vice president of military and aerospace business (known for its thermoplastic nanocomposite HX5), and before that was with Arrow Electronics.

U.S. Air Force Maj. Gen. (ret.) **Clint Crosier** has been hired by *Amazon Web Services* to lead its new business segment for communications companies, which must process and make actionable the massive quantity of data that now transits through space. Crosier is former U.S. Space Force director of planning.

SES, the multi-orbit satellite-constellation operator, has promoted **Thai Rubin** to chief legal officer from executive vice president of legal services; he succeeds John Purvis, who will work part-time. SES CEO **Steve Collar** also becomes SES Video CEO, succeeding Ferdinand Kayser, who will retire at year-end. Kayser remains chairman of both the SES Astra and GovSat boards.

Former *FLYHT* Aerospace CEO **Bill Tempany** will serve as interim CEO and continue as a company director while FLYHT recruits a replacement for Thomas R. Schmutz, whose CEO contract has been terminated. FLYHT also has named **Barry Eccleston** executive chairman; Eccleston retired from Airbus as president and CEO in 2017.

Western Aircraft, a Greenwich Aero Group maintenance/modification company, has hired **Tonya Wood** as interiors manager. She will oversee aircraft refurbishment according to customer specifications. She held management positions with Gulfstream Aerospace, J. Banks Design Group and Release Marine.



The *Center for Strategic and Budgetary Assessments* has added three new staff members: **Josh Chang**, as a research assistant focusing on strategy and international military doctrines; **Regan Copple**, as a research assistant for East Asian security, future warfare and Great Power competition; and **James Mersol**, as publications manager.

CDB Aviation has hired **Paul Boyle** as head of commercial leasing for Europe, the Middle East and Africa. Boyle has worked for Aer Lingus, Airbus Financial Services, SMBC, AerCap and Avolon. CDB is a wholly owned Irish subsidiary and the only leasing arm of the China Development Bank.

Twin Commander Aircraft, a maintenance provider for twin-engine airplanes, has hired **Andrew Wilson** as technical service manager. Wilson had been with Dynamic Aviation as maintenance controller and flight operations support. Before that, he operated his own inspection and maintenance operation, handling contract management and FAA compliance for the U.S. Air Force.

Electra.aero has hired **Marty Bradley** as a senior technical fellow. An American Institute of Aeronautics and Astronautics (AIAA) fellow in electrified aircraft and sustainable aviation, Bradley teaches at the University of Southern California and teaches the AIAA course "Design of Electrified Propulsion Aircraft." He recently retired from Boeing.

Mitre's Center for Technology and National Security has a newly established advisory board. Its members include: U.S. Army Gen. (ret.) **John Campbell**; former U.S. Air Force undersecretary **Lisa Disbrow**; U.S. Navy Adm. (ret.) **Bill Gortney**; Vice Adm. (ret.) **Bob Murrett**; **Bob Work**, former deputy secretary of defense.

Melbourne-based *Titomic* has named **Andreas Schwer** board chairman for the additive manufacturer. He was the inaugural CEO of Saudi Arabian Military Industries, where he recently stepped down. He also held executive roles at Rheinmetall Defense and Airbus.

Parsons Corp., a provider of defense, intelligence and infrastructure technology, has named U.S. Air Force Gen. (ret.) **Darren W. McDew** and **David C. Wajsgras** to its board. McDew was commander of U.S. Transportation Command, and Wajsgras was Raytheon senior vice president and chief financial officer.

Cobham Advanced Electronic Solutions, a data transfer provider for extreme environments, has been acquired by *Advent*. Its new board of directors includes CEO **Shawn Black**, **Robert F. Weiss**, **Mark Sirangelo**, U.S. Air Force Gen. (ret.) **Kevin Chilton**, **Bob Hitt**, **Mark Santamaria**, **Shonnel Malani**, **Michael Marshall** and **Wayne Berman**.

Skyrora has named **Tim Peake** to its advisory board. He is a former European Space Agency astronaut, International Space Station crew member and British Army Air Corps officer. Skyrora is developing the Skyrora XL orbital launch rocket.

The *National Air Transportation Association* has announced its 2020-21 board of directors. Chairman **Curt Castagna** was reelected, as were **Larry Wade** and **Clive Lowe**. Newly appointed for three-year terms are **David Best**, **Joe Gibney**, **Josh Hochberg** and **John King**.

Toronto-based *Aero Asset* has named **Philip Louis Amadeus** London sales director of the helicopter brokerage. He will cover Canada, the U.S. and Mexico. Amadeus is a former Boeing 737 pilot as well as a helicopter pilot.

Professional Aviation Associates of Greenwich AeroGroup has hired **Rob Burch** as a regional sales manager for the Northeast and Southwest regions. Burch was director of sales for Avgroup Inc. and a Global Parts.aero sales associate.

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

WE'RE MAKING
MORE POSSIBLE

MORE INTELLIGENT
MORE CONNECTED
MORE ELECTRIC

At Collins Aerospace, we're shaping a future that's more intelligent, more connected and more electric than ever.

Our breakthroughs in intelligent systems and automation are enabling increased collaboration, situational awareness and mission success in the modern battlespace. Our touchpoints and partners across the commercial aviation ecosystem are unlocking insights to improve efficiencies and travel experiences. And our leaps forward in electric propulsion will reduce aviation's carbon footprint, decrease noise pollution and lower costs.

All to make the skies and spaces we touch smarter, safer and more amazing than ever.

collinsaerospace.com/more

Collins Aerospace

AEROSPACE REDEFINED

FIRST TAKE

For the latest, go to
AVIATIONWEEK.COM

AIRBUS

GENERAL AVIATION

Airbus has secured long-awaited certification for its H160 medium twin helicopter from the European Union Aviation Safety Agency, but first delivery must wait for approval from the FAA.

The National Business Aviation Association has canceled its October 2020 NBAA Business Aviation Convention and Exhibition in Orlando, Florida, after COVID-19 cases in the U.S. took an upward turn.

Manufacturers are advancing 12 drone models toward FAA type certification, according to the head of the agency's Unmanned Aircraft Systems Integration Office.

COMMERCIAL AVIATION

Airbus workers in Toulouse staged a brief strike on July 8 over plans to cut 11% of the workforce—or 15,000 positions, 5,000 of them in France—in response to the coronavirus crisis and global economic downturn.

JetBlue Airways and its pilots have struck an agreement that will remove the possibility of involuntary furloughs through May 1, 2021. It is the first deal of its kind at any U.S. airline during the COVID-19 crisis.

Aeromexico has become the latest Latin American airline to seek Chapter 11 bankruptcy protection as the region's carriers struggle to remain solvent without government support.

Portugal has increased its stake in TAP Air Portugal from 50% to 72.5%, agreeing to buy a stake previously held by airline entrepreneur David Neeleman for €55 million ($62 million).

Scandinavian Airlines has secured a 14.25 billion Swedish krona ($1.5 billion) recapitalization, led by the Danish and Swedish governments along with shareholder the Knut and Alice Wallenberg Foundation.

Environmental groups have expressed disappointment at the ICAO's decision to adjust the baseline for the Corsia carbon offsetting scheme to reflect the COVID-19-related drop in 2020 international flights (page 25).

The FAA has extended relief for pilots and other certificated industry professionals who have certain qualifications, medical certificates and other training due for renewal through September 2020.

A U.S. Transportation Department Inspector General report on Boeing 737 MAX certification underscores the inadequacy of communication between Boeing and the FAA (page 18).

Boeing declines to confirm reports it is preparing to end the five-decade production run of the 747, but Aviation Week understands suppliers have been briefed on plans to complete deliveries in 2023.

Certification of Russia's Irkut MC-21 narrowbody is now expected in mid-2021, according to business daily *Vedomosti,* citing Minister of Industry and Trade Denis Manturov.

Comac has delivered the first ARJ21-700s to China's three state-owned carriers: Air China, China Eastern Airlines and China Southern Airlines.

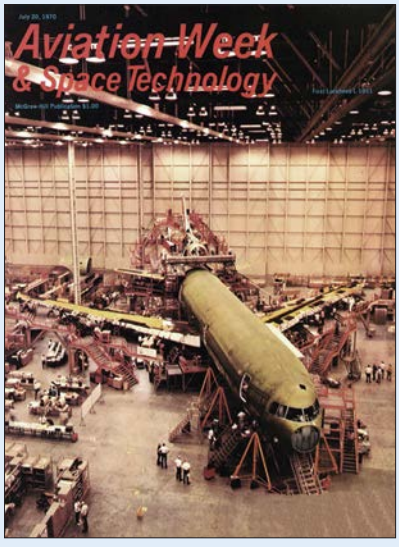
DEFENSE

The U.S. Army has confirmed plans to award a sole-source contract to Lockheed Martin to develop the longer-range Precision Strike Missile to replace the Advanced Tactical Missile System.

Serbia displayed three China Aerospace Science and Technology Corp. CH-92A armed unmanned aircraft on July 4, the first Balkan nation to acquire such a capability.

50 YEARS AGO IN AVIATION WEEK

A technical marvel but a financial albatross, Lockheed's first L-1011 "TriStar" widebody passenger jet was pictured on our July 20, 1970, cover nearing completion on the company's assembly line in Palmdale, California. Conceived to transport 250 passengers on transcontinental routes, the L-1011 was packed with advanced avionics and systems including direct lift control and an early form of fly-by-wire primary flight control system. It was also the first large commercial airliner capable of completing an automatic flight from takeoff to landing, as well as the first widebody to be certificated for Category 3B autoland operations. The three-engine, three-crew jet set a new standard in passenger comfort, with extra-wide aisles and storage bins, glare-resistant windows, a below-deck galley and an engine configuration that reduced cabin noise. But difficulties developing the L-1011's RB211 engine sent Rolls-Royce tumbling into bankruptcy in early 1971, forcing the British government to nationalize the company and the U.S. to put up loan guarantees to enable the project to be completed. The first L-1011 was finally delivered to Eastern Airlines in April



1972, just as a spike in oil prices triggered a recession and weakened demand for new aircraft. Lockheed ultimately produced 250 L-1011s and sustained $2.5 billion in losses on the program before shutting the line down and exiting the passenger aircraft business in 1983.

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

LEONARDO

U.S. Navy instructor pilots have begun training on the TH-73A at Leonardo's facility in Philadelphia. The new training helicopter is scheduled to become operational in 2021.

Australia is allocating $4-6 billion from 2021 to beyond 2040 for research and development in high-speed strike and missile defense, building on decades of hypersonic research (page 40).

Moldovan authorities closed down a factory clandestinely producing helicopters similar to Kamov's Ka-26 for illegal export to Commonwealth of Independent States countries.

The first of eight Airbus A330 MRTTs for the Multinational Multirole Tanker Transport Unit arrived at its home base in Eindhoven, the Netherlands, on June 30.

UNITED LAUNCH ALLIANCE

SPACE

Blue Origin has delivered the first of two methane-burning BE-4 development engines to United Launch Alliance (ULA) for attachment to the Vulcan rocket for configuration checks and testing.

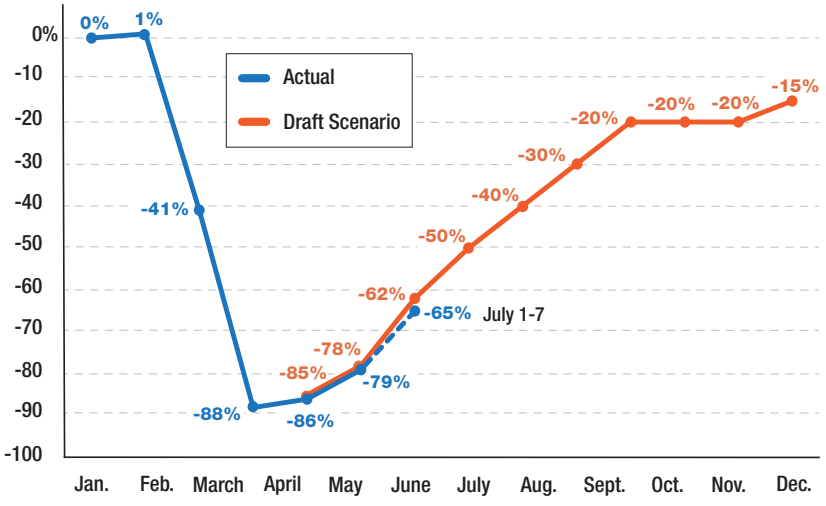
The UK government is to invest $500 million in OneWeb after a successful $1 billion joint bid with Indian cellular provider Bharti Global for the bankrupt satellite communications company (page 70).

Rocket Lab's 13th Electron rocket was lost after liftoff from New Zealand on July 4 when the small launch vehicle experienced an issue 4 min. into a planned 6-min., 21-sec. second-stage burn.

The Israeli military on July 6 launched the Ofek 16 electro-optical reconnaissance satellite into low Earth orbit from central Israel on an Israel Aerospace Industries Shavit 2 rocket.

A problem with a liquid oxygen sensor on the ULA Atlas V launch vehicle has further delayed the launch of NASA's Mars 2020 rover to July 30 (page 68).

Europe's Traffic Recovery Tracking Predictions for 2020



Source: Eurocontrol

Air traffic in Europe is tracking to the draft recovery scenario laid out by Eurocontrol on April 24, and for the first seven days of July was down 65% from a year earlier, with a significant increase in flights by many airlines since July 1, says Eurocontrol.

VIEW FROM WASHINGTON

House Nixes NASA Budget Hike

U.S. legislators' first draft of a fiscal 2021 budget for NASA, if approved, would cast doubt on a 2024 crewed landing on the Moon.

The Trump administration asked for $3.37 billion in 2021 for development of human lunar landers. In a draft funding bill, the House Appropriations Commerce, Justice, Science and Related Agencies Subcommittee included just $628.2 million—less than 19% of the request.

"The $628.2 million in funding for the human landing system is an important first step in this year's appropriations process," says NASA Administrator Jim Bridenstine. He will now look to the Senate to provide the resources to land humans on the Moon in 2024.

The draft House bill fully funds NASA's plans to conduct an uncrewed and a crewed flight test of the Space Launch System (SLS) and Orion capsule before the first Moon landing. The proposed budget allocates $1.4 billion for Orion and $2.6 billion for the SLS.

The draft bill includes $4 billion for space operations, including the International Space Station, $7 billion for NASA's science program and $1.1 billion for space technology programs.

UP FRONT

BYRON CALLAN

Debt Matters

But so does the **interest on federal debt**

THE COVID-19 PANDEMIC HAS stoked consternation that U.S. defense spending is going to be significantly pressured in the 2020s. Congress likely will stick to the $740.5 billion defense discretionary top line agreed to in last year's budget deal for fiscal 2021. But the combination of trillions more in federal debt from higher spending and lower tax receipts this year and next and the probability that there will be future federal spending to better prepare for pandemics raises the probability of defense spending pressure.

"Flat" was already the new "up," but "flat" now may be a budget that does not keep pace with annual inflation. There might be fears that defense spending will decline in the 2020s after a couple of good years of largesse from Congress and the White House.

Despite trillions in additional deficits and federal borrowing in 2020-21, there is one bright spot that indicates less dire defense spending pressures than now perceived—the interest on the federal debt.

OLIVIER DOULIERY/AFP/GETTY IMAGES

U.S. federal debt is composed of debt held by the public and intragovernmental debt, which is owned by different federal trust funds, the largest of which is Social Security. As of May, total debt held by the public was $19.8 trillion, and intragovernmental debt was another $6 trillion. Often, these two sums are lumped together, but they should be treated separately. The interest paid on debt held by the public is dispersed by the Treasury in the form of outlays to the owners of that debt. The interest paid on intragovernmental debt is, in essence, interest the federal government pays itself.

The Office of Management and Budget (OMB), in its annual projections of outlays, breaks out these two components of interest outlays to show net interest outlay. This is mandatory spending, and so it has been paid along with the other mandatory and discretionary funding the U.S. federal government provides.

One of the silver linings of the pandemic has been the Federal Reserve's aggressive lowering of interest rates. This makes federal debt more affordable, much in the way that a lower interest rate on a home mortgage can make a place to live more affordable.

The OMB projections released in February showed net interest outlays of $378 billion for fiscal 2021 rising to $665 billion by 2030. One could take issue with the deficit projections behind these outlay projects, as they may have rested on GDP growth expectations that were too optimistic and nondefense spending cuts that were not going to be realized. However, dividing interest outlays on debt held by the public by debt projections implies an interest rate of 3% or more over the forecast period.

The pandemic has trashed those rate projections. Federal debt held by the public is offered in different maturities. Treasury bills, which mature in a year or less as of May, were 23% of the total debt held by the public. Treasury notes that mature in 1-10 years were 51%, and bonds that mature in 10-30 years were 12%. (There is another 10% of other Treasury instruments.)

Rates now are much lower, although clearly that would matter only for new debt that is issued by the Treasury. The rate on a 90-day Treasury bill is currently 0.13%. On a five-year note, it is 0.33%, and on the 10-year note, 0.69%. The 30-year note rate is 1.4%.

This implies that interest outlay projections should be declining, although new projections may have to wait until the White House releases its 2022 fiscal budget request and out-year projections, presumably in February-March 2021. Net interest outlays could be at least $100 billion less in 2022-23 than the February 2020 projections on higher debt but lower rates.

In the scheme of total federal outlays, which the OMB projected to be $4.8 trillion for 2021, $100 billion is not a lot, but it indicates there is a bit more headroom for defense spending and other nondefense discretionary spending than a focus on federal debt alone might suggest. Federal infrastructure spending could be one area of more traction in the 2020s, and the issue of social justice may also spur more demand for federal resources.

One outcome of the pandemic, however, will be to make defense expectations more sensitive to interest rate expectations. It is not too difficult to project scenarios with rising debt and interest rates that increase to more "normal" levels. The pandemic also underscores that the unthinkable should be given a bit more room on long-term projections. It is quite conceivable that a major military conflict, a massive natural disaster or another economic contraction could further add to federal debt in the 2020s.

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


MTU
Aero Engines
Thinking ahead –
the future of aviation now.
The aviation industry has set itself ambitious targets, including a dramatic reduction in emissions by the year 2050. In order to achieve this, we need aero engine solutions that surpass the technology of today. 11,000 MTU experts are already working day-to-day with passion and enthusiasm, bringing visionary ideas to life.
The future of aviation starts now.
www.mtu.de

GOING CONCERNS
MICHAEL BRUNO

THE BAD NEWS OUT OF WICHITA on June 22 was not too surprising for most in the industry. In a regulatory filing, Spirit AeroSystems revealed that Boeing has told it to cut total 737 shipset production to 72 this year—below the 125-shipset target set just a few weeks earlier and far off the 216 envisioned back in February. The reasons cited were COVID-19's impact on the commercial aerospace sector and the growing inventory of undelivered 737 MAX narrowbodies.

Commercial aerospace suppliers remain on edge for more production-rate reductions from Airbus and Boeing. No industrywide updates have surfaced since April, but what little market insight that has emerged in recent weeks makes it clear that monthly narrowbody new-build rates will be in the 30s at best by the end of 2021.

For Airbus, that is a letdown from a production rate in the 60s before the novel coronavirus outbreak; for Boeing, it is a humbling rebuilding effort from zero earlier this year due to the MAX crisis. The Chicago-based OEM appears to be looking for the floor for its supply base in subtle ways—that is, the lowest sustainable production rate for its chosen suppliers so that the supply chain maintains the ability to ramp up someday.

But first, everyone has to step down. "It may take an even more cautious tack to increasing supplier rates until it has better visibility as to how many MAXs customers will accept for delivery through year-end 2021," say Cowen analysts Cai von Rumohr, Dan Flick and Scott McCrery.

For Boeing and its suppliers, the problem is twofold. MAX customers have sidelined around 383 of the type while they await its recertification. And Boeing has built up an inventory of about 450 undelivered MAXs. That figure could hit 470 in the third quarter, according to Jefferies analysts Sheila Kahyaoglu and Greg Konrad. At the same time, Spirit has about 120 fuselages it has yet to send to Boeing for finishing.

The Jefferies team sees the MAX production rate reaching five per month by year-end and 31 per month by the end of 2021, in line with Boeing's existing estimates. But the analysts expect a peak MAX delivery rate for Boeing, including aircraft from inventory, that is just 40 per month by sometime in 2022—a rate that will continue for only 6.5 years thereafter.

Finding the Floor

Boeing and suppliers look for the **lowest sustainable rate**

SPIRIT AEROSYSTEMS

Why such a low delivery rate for so short a time? Boeing cites a 737 backlog of 4,232 aircraft across more than 80 customers, but it is increasingly at risk for two reasons. First, there are so-called ASC 606 revenue-recognition accounting changes that have forced all OEMs to revise how they recognize sales. At Boeing, that means scratching off 506 orders to shrink the backlog to just 3,726 as of May. But then there are cancellations: 313 have already been announced, and Jefferies thinks another 600 could be at risk due to stressed-out lessors and Middle Eastern and Latin American operators. Altogether, that could mean an effective 737 backlog of just about 3,100 aircraft.

Kahyaoglu and Konrad project Boeing will deliver 45 737 MAXs this year, 360 in 2021 and 480 in 2022. That compares with new-production totals of 45, 198 and 372 for 2020, 2021 and 2022, respectively. Spirit expects that 72 shipsets produced for Boeing will be "delivered" this year, then 150 in 2021 and 346 in 2022. In turn, 737 inventory at Spirit will climb through the end of the year and not get burned off until the end of 2023, just "slightly ahead" of Boeing's burnoff of MAX inventory by mid-2024.

Optimistically, direct subtier suppliers to Spirit and/or Boeing are looking at build rates topping out around 100 this year and into next year. But that will be affected by whatever inventory subtier suppliers already have produced and shipped to those end customers, as well as other factors such as the strength of the direct relationship with Spirit or Boeing, according to several consultants.

There are further considerations, including maintaining economic viability of supply. For instance, Tier 2 provider Triumph Group recently struck a deal with Boeing Commercial Airplanes across multiple programs that included a build rate of 15-20 shipsets a month for the 737. "One of the nice things about [the] MAX—and we've been in lockstep with Boeing—is that they've allowed us to produce at much higher rates than they're building in their factories," says Triumph CEO and President Dan Crowley.

Suppliers still may not know what their build rates will be, but ranges are forming. Who knows when the industrial base may get a universal forecast from OEMs, but individual companies probably can discern ranges depending on where they sit and whom they serve.

Loitering Munitions – Meeting the Challenge of Time-Sensitive Targets

In modern battlefields, spotting the enemy in time and acting on real-time information has become a critical capability. The precise location of the enemy in modern combat is not always known, even if the general area of their activities is.

Persistent surveillance of a broad area, timely detection, and quick engagement of the enemy, immediately upon a target emerges are imperative to dominate the modern battlespace. Such missions are the specialty of Israel Aerospace Industries (IAI) loitering munitions.

These weapons are designed to operate in complex arenas and to detect moving targets on foot or in a vehicle immediately. Having a loitering munition in the sky with the right sensors is the most efficient way to deal with such adversaries.

IAI's family of loitering munitions is the ideal match for the time-critical, elusive, and evasive fleeting enemy targets of the modern battlefield. These loitering munitions resemble an alert hunter on the prowl, patiently watches, and waits for its target to reveal itself, then pounces just at the right time.

Loitering munitions can stay in the relevant area of combat operations for an extended time, and use sensitive electro-optic or anti-radiation sensors to cover and acquire an entire area in which enemy activity is known to be happening.

Ground forces can operate loitering munitions from a distance, further back behind the frontline, or operate them on the frontline, using portable tablet-based controls.

A Legacy of Loitering Munitions

In the 1980s, IAI pioneered the loitering munitions field with its development of the Harpy platform, as a method to overcome intelligence gaps on enemy activity.

Later, the larger Harop platform was born. In recent years, IAI has continued to act as a trailblazer in the area, introducing several loitering platforms that serve the tactical level.

Among others These include the electrically-powered Mini Harpy, equipped with dual-homing capabilities - utilizing anti-radiation and electro-optical seekers.

Weighing 40 kilograms, the Mini Harpy is vehicle-lunched, like the Harop. With a broadened capability spectrum, Mini Harpy can utilize all sensors simultaneously. By employing the radiation-sensors, day, and night electro-optics sensors at the same

time, Mini Harpy enables the user to cover broader areas, and look for targets more effectively, rather than searching for them through a straw. With the anti-radiation sensor cueing the camera on-board. The Mini Harpy carries a warhead with eight kilograms of explosives. It can strike targets within one-meter accuracy. Its operating range is 100 kilometers, enabling ground units to extend operations deeper into a hostile area or employ offensive weapons from far back if needed.

IAI's Rotem quadcopter munition is the second tactical loitering solution offered by IAI, designed for employment by the ground forces and the individual soldier at the small unit level. With a range of 10 kilometers, it is relevant for units up to the battalion level.

Lightweight, compact, and affordable, Rotem enables individual soldiers to put eyes in the sky over the next hill, beyond the line of sight, and strike the enemy as soon as targets appear.

The Rotem provides tactical field units with a new advantage against adversaries. If it does not receive an attack authorization, the Rotem can fly back and retrieved safely, have its battery replaced, and immediately deploy on a new mission. It carries electro-optical day and night sensors.

IAI's loitering munitions don't just hover in the sky. Like alert hunters, they ensure that ground forces are monitoring the right area, waiting to detect and pounce on targets as soon as they appear. By empowering the tactical and operational level, Loitering munitions enable ground forces and special operations elements to arrive at the battlefield with game-changing advantage, by overcoming intelligence gaps and dealing effectively with the elusive 'disappearing' enemy.'

https://www.iai.co.il/defense/land/

LEADING EDGE
GRAHAM WARWICK

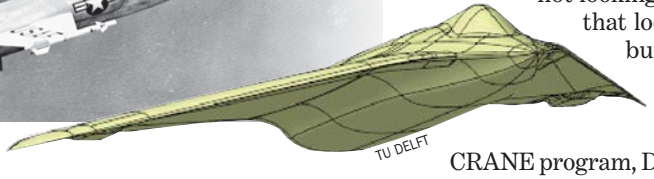
ALL X, NO PLANE IS HOW PROGRAM manager Alexander Walan characterizes DARPA's recent efforts to build and fly experimental aircraft. After a spate of projects being terminated before reaching flight, he hopes to reverse that trend with his program to fly a subsonic X-plane designed around active flow control.

Walan manages the new Control of Revolutionary Aircraft with Novel Effectors (CRANE) program, which aims to fly by mid-2024 a large-scale X-plane

Flow in Control

DARPA wants to see how active flow control could **reshape aircraft**

LOCKHEED MARTIN



TU DELFT

with a configuration enabled by active flow control (AFC). Three contracts for a yearlong conceptual design phase are to be awarded in early July.

AFC involves adding energy into the boundary-layer airflow to maintain, recover or improve vehicle performance. Fluidic or plasma actuators can replace conventional mechanical flight controls and reduce observability, enhance efficiency, increase maneuverability or achieve other benefits.

Previous applications of AFC include boundary layer control using wing blowing to reduce the landing speed of carrier-based aircraft such as the North American RA-5C Vigilante. But such previous uses have involved adding AFC to already-frozen designs to fix problems. For example, flap blowing was added to the Lockheed F-104 during development to make it easier to land.

There also have been flight tests of AFC to reduce wing download on tiltrotors in hover, minimize wake turbulence from targeting pods, stabilize weapon release from a bay at Mach 2, and increase rudder effectiveness to enable a smaller tail. More recently, there have been flights in the U.S. and UK of subscale models using fluidic AFC for flight control of tailless aircraft.

The goal of CRANE is to "bring AFC out of the lab and into large-scale flight," Walan says. "We thought the technology had evolved to the point where a full-scale flight demonstration was feasible. We had a suite of mature technology, proven CFD [computational fluid dynamics] code, wind-tunnel and subscale demonstration . . . so we thought there was enough underlying engineering and science behind it . . . [to] have a flying vehicle within a five-year window."

And actually flying this X-plane is important to DARPA. Despite its rich history of experimental aircraft from the 1970s to the 1990s, Walan says, "it's been since 2007 [the A160 Hummingbird] that DARPA has flown anything it could rightly call an X-plane."

Walan's list excludes several hypersonic demonstrators, the X-47B unmanned combat aircraft and X-60 air-launched and -recovered drone but reflects the termination of DARPA's Ares, LightningStrike and Tern programs without taking planned X-planes to flight. "We felt DARPA had atrophied a bit," he says. "So that's what we are trying to do with CRANE: Get back into the pure X-plane experimental realm."

The focus of CRANE is to demonstrate a clean-sheet aircraft that incorporates AFC as the primary design consideration. DARPA is looking for novel configurations for a manned or unmanned X-plane weighing between 1,000 lb. and 10,000 lb. and capable of maneuvering and flying at high subsonic speed. "We are not looking to do a prototype or something that looks like an operational airplane, but we are looking for high-risk, high-payoff ideas," says Walan.

Rather than specify what DARPA was seeking from the CRANE program, DARPA said: "We want novel planforms and geometries, and then you, industry, can show us what that airplane can do that is different." In the extended, one-year Phase 0 of CRANE, each contractor will design multiple different concepts to explore the trade space for AFC-enabled vehicles.

Another goal of CRANE is to "inject disruption into the design process," Walan says. By giving contractors a year to go from contract award to conceptual design, rather than the usual 3-6 months, they can "really work the tools and process almost as much as the configurations early on" to come up with more novel aircraft.

"We asked folks to start with multiple configurations with different benefits," he says. "Three months into Phase 0, we'll probably downselect from three or four ideas per contractor to one or two. This time next year, we'll start downselecting from multiple contractors and multiple ideas, to one or more that will go forward to a preliminary design review."

In terms of performance metrics for CRANE, "we're looking at improvements in efficiency, maneuverability, takeoff-and-landing performance or weight," Walan says. "The X-plane may be heavier than a relevant airplane. We may have dual control surfaces at first. But what we want to do is push the envelope and quantify the potential benefit for a transition airplane down the road."

Enabling the Extraordinary
To Fly To Power To Live

EXTREME

Advanced thermal management for extreme military environments

Around the globe, military and aerospace systems designers have turned to Meggitt to help them meet thermal and power management challenges with compact, lightweight, and efficient vapor cycle systems, liquid cooling systems and components including fans, pumps and compressors.

Meggitt has developed cooling solutions for the most challenging flight conditions, missions, and extreme environments. From low supersonic flight, to high hot wet hover, to desert and arctic operations, our thermal management solutions are proven and ready to meet the challenge of the more electronic platform and battlefield.

Tel: +1 949 465 7700
E-mail: gerry.janicki@meggitt.com

MEGGITT

www.meggittdefense.com

THE LAUNCHPAD
IRENE KLOTZ

THE LAST TIME A NASA ASTRONAUT strapped inside a spaceship for a suborbital flight was on July 21, 1961, when Virgil "Gus" Grissom was dispatched for a second test of the Mercury-Redstone system.

Challenged to get astronauts to the Moon in nine years, suborbital flight was quickly abandoned as NASA turned to more powerful rockets and durable spaceships that could better withstand atmospheric reentry at higher orbital speed.

Fast-forward 59 years, and suborbital spaceflight services are in late-stage development by two U.S. companies, Virgin Galactic and Blue Origin, with others eyeing a potential market for sending tourists, researchers, entertainers and others on short trips beyond the atmosphere.

The passenger list may soon include NASA astronauts and other agency employees. On June 23, NASA released a request for information about upcoming suborbital spaceflight systems. The data will be used to assess the systems' safety, capabilities and pricing, with the intent of issuing a solicitation for suborbital crew transportation services.

"We really want to know what the industry has to offer," says Scott Colloredo, newly named manager of NASA's Commercial Crew Program Suborbital Crew (SubC) office. "We're looking for industry to help drive this, for them to come in and tell us what's available, how they would like us to go about this acquisition. We're asking for technical data, different aspects of their approach, how their vehicle operates—things like that.

"Our intent is to do what we're calling a 'system qualification,' where we'll ensure that our astronauts and employees are safe to fly on the vehicles," he adds.

Suborbital flights will expose passengers to a few minutes of microgravity and the opportunity to view the curvature of Earth against the blackness of space. NASA envisions using the services for training, experiments, and to test and qualify flight hardware.

"We want to see what the industry has to offer that we can take advantage of," says Colloredo. "We haven't had this capability before, but we think it's close enough now to become a buyer."

SubC

NASA eyes **suborbital human spaceflight services**

NASA

Mercury astronaut Virgil "Gus" Grissom, who launched on July 21, 1961, became the second—and last—U.S. astronaut to fly in suborbital space.

Virgin Galactic is building a fleet of six-passenger, two-pilot winged vehicles known as SpaceShipTwo that are carried to an altitude of about 50,000 ft. by the WhiteKnightTwo mothership and released. A single hybrid rocket engine ignites to power the spaceship to an altitude of more than 50 mi. It then reenters the atmosphere and glides to a piloted landing on a runway.

The first ship expected to enter commercial service, VSS Unity, has made two test flights into suborbital space. The operation is based in New Mexico, and the company is selling tickets to ride for $250,000.

Blue Origin, owned by Amazon founder and CEO Jeff Bezos, is developing the autonomously flown, six-passenger New Shepard system, which takes off and lands vertically. Uncrewed flight tests began in 2015.

Blue Origin so far has made 11 flights into suborbital space using two different capsules, reaching a maximum altitude of 66 mi. The company, which flies from a privately owned complex in West Texas, has not yet flown any people nor has it announced pricing.

Having NASA as a customer could go a long way toward assuaging concerns about the new vehicles' safety.

"NASA requires review and approval of hazardous activities involving NASA personnel in commercial human spaceflight missions outside of NASA's operational control," the agency noted in its solicitation. "For Suborbital Crew opportunities, NASA will analyze risks and take steps to assess the safety and operational readiness of suborbital vehicles for use by NASA astronauts and other NASA personnel."

Specifically, the agency is requesting details on how providers determine flight readiness for missions, accident survivability and mitigation, recommended passenger safety standards, system reliability and other information. NASA also wants to know how the companies identify and control hazards; analyze failure modes, effects and criticality of systems; address fracture control and failure tolerance; and establish and maintain reliability of critical systems.

It will be up to the companies to suggest how NASA should make its safety assessments. Proposals are due on Aug 7.

WE GO ANYWHERE.

LEE MINIATURE PILOTING
SOLENOID VALVES.

The Lee Company has been helping aerospace engineers solve mission critical problems for decades. And now, our ability to help optimize your designs has expanded. That's because the world's most reliable solenoid valves now offer options with customizable interfaces and electronics. Choose what's right for your application, wherever it might be, and we'll provide a solution that's compact, lightweight, affordable, 100% tested, and absolutely reliable.

Learn more at **TheLeeCo.com/aero**

Innovation in Miniature

LEE®

The Lee Company

2 Pettipaug Rd, Westbrook CT 06498-0424
860-399-6281 | Fax: 860-399-2270 | 1-800-LEE PLUG | www.TheLeeCo.com
WESTBROOK • LONDON • PARIS • FRANKFURT • MILAN • STOCKHOLM

SIGNS OF A SHIFT

> AIRLINES ARE REVIEWING PROPOSED MAX TRAINING

> CHANGES EMPHASIZE DETAILS OF PROCEDURES

> FAA FLIGHT-TESTED SOFTWARE OVER THREE DAYS

Sean Broderick Washington and **Guy Norris** Los Angeles

Boeing's comprehensive changes to the 737 MAX flight control computer (FCC) software are being matched by a significant shift in pilot training, with added emphasis on explaining systems and failure scenarios while clarifying key non-normal procedure checklists.

Drafts of training material proposed for the MAX and presented to U.S. operators suggest that Boeing has moved away from concerns about providing pilots with too much information. Pilots who have reviewed the material report that the updates expand on existing procedures and add detail, including a review of the MAX's Maneuvering Characteristics Augmentation System (MCAS) flight-control law implicated in two fatal accidents that have grounded the MAX fleet for 16 months.

Details on the MCAS and other flight control computer software changes were expected as part of the new training package. But Boeing's 190 pages of new material also includes narratives about many other 737-family systems and processes.

"They went from fear of inundating pilots to indulging us," a North American MAX pilot who reviewed the material says. "It's clear by the delivery that there's been a change in philosophy in how they provide information to pilots, and that's what we've been asking for."

Boeing is proposing changes to seven non-normal checklists (NNC). Two of them, speed trim fail and horizontal stabilizer out of trim, required updates to align with changes to the MCAS and FCC software. The new software takes input from both MAX FCCs, adding redundancy. Previously, erroneous inputs from a single, active FCC could trigger spurious alerts.

This is what happened in both MAX accidents, Lion Air Flight 610 in October 2018 and Ethiopian Airlines Flight 302 in March 2019. Erroneous angle-of-attack (AOA) data from one of two AOA sensors told the FCC that the aircraft's nose was too high. The MCAS, designed to provide automatic nose-down horizontal stabilizer trim in certain high-AOA scenarios, activated, pushing the aircraft's nose down. The confused pilots did not respond as Boeing expected they would, and both aircraft entered fatal dives. The accidents killed all 346 onboard both flights, left the 385-aircraft MAX fleet grounded and triggered reviews of both Boeing's and the FAA's roles in designing and approving the latest 737 family variant.

One of the key findings from the reviews and accident investigations was that Boeing assumed pilots understood more than they actually did. The MCAS, designed to operate in the background, was not covered in MAX training manuals or emergency procedures.

Boeing determined that pilots would quickly recognize an MCAS malfunction as uncommanded stabilizer movement and react by executing the runaway stabilizer trim checklist. In the accidents, neither crew did, and the Ethiopian crew had even had the advantage of a special bulletin issued after the Lion Air accident that called attention to the procedure.

One of the many pilot-related takeaways from the accidents was that Boeing defined uncommanded stabilizer trim too broadly. When the manual trim wheel in the cockpit spins continuously, diagnosing a runaway stabilizer is quick and easy. But short bursts of movement such as what the original MCAS logic exhibited and that are part of normal speed trim system operation, are less noticeable. "The trim on a 737 runs all the time, especially just after takeoff," one MAX pilot says.

The draft training material explains such nuances in more detail. Updates to five NNCs—runaway stabilizer, stabilizer trim inoperative, airspeed unreliable, altitude disagree and AOA disagree—consist of verbiage changes and explanatory notes prompted by realization that pilots need more, and clearer, instruction.

One example is the runaway stabilizer NNC. The current 737NG and MAX checklist defines the condition as when "uncommanded stabilizer trim movement occurs continuously." The proposed new language adds, "or in a manner not appropriate for flight conditions," which would more closely match the intermittent, nose-down commands that the original MCAS software was programmed to provide when it sensed the AOA was too high. (The revamped MCAS software does not fire multiple times from a single data input, and AOA values are now compared so one faulty sensor cannot trigger the MCAS.)

Asia-Pacific fleet strategies **p. 26**

Boeing also added details on manual-trim wheel operation, part of the NNC if pilots determine that the stabilizer motor needs to be cut off to stop uncommanded movements. Tests done after the accidents showed pilots did not understand that aerodynamic forces on the stabilizer can make the trim wheel difficult to turn. The new checklist and training material underscores this and says unloading the stabilizer by reducing air speed may be necessary.

The material stops short of reintroducing a technique dubbed the roller-coaster that Boeing used to include in its manuals, where pilots repeatedly let the nose drop to reduce force on the stabilizer, crank the trim wheel, and then pull up to stop the descent until the stabilizer is at the desired position. One source says Boeing is reluctant to reintroduce the technique, pointing instead to trials that showed two pilots could exert enough force to move the trim wheel without dropping the aircraft's nose.

In many cases, information added to the checklists came from flight crew training manuals Boeing develops for instructors but that many line pilots never see. The changes reflect Boeing's acknowledgment that manufacturers, and not regulators or airlines, play the most critical role in ensuring pilots have the necessary tools to operate the products they sell.

"That pilot-control interface is real, and it should be studied every day," Boeing CEO Dave Calhoun tells Aviation Week. "And it should be studied based on the complete variation of skills that are available in the aviation market. We can never short that again. Every time we drop a spec for a flight control system in an airplane, we've got to understand that man-machine interface. And we have to understand it well, with science, and it has to be contemporary."

With the software finalized and proposed training in place, Boeing and the FAA have begun putting the changes through their final paces before regulatory approval. Recent certification flight tests trialed the MCAS and all of the new NNCs, as well as possible FCC anomalies.

On June 29, the 737-7 development aircraft 1E001 departed Boeing Field, Seattle, for the first of three days of FAA certification flights. Beginning with a direct climb to 19,000 ft. and a starting airspeed of around 400 kt., the crew then descended to 15,000 ft. for a series of maneuvers to test the MCAS at medium altitudes.

Over the first hour, these maneuvers included a set of high AOA test points suggesting stalls or approaches to stalls. The aircraft then descended below 5,000 ft. for the second phase of low-altitude MCAS tests. These included three missed approaches with descents down to around 1,000 ft. The 737-7 touched down at Moses Lake after just over 2 hr.

Further tests were conducted on the return flight to Boeing Field, including 11 rapid climbs and descents between 10,000 and 15,000 ft. Airspeed for the initial set of aggressive maneuvers was at or above 300 kt., while the latter series was conducted at 300 kt. or below.

The second day of tests took place on June 30 over eastern Washington at higher altitudes up to 37,000 ft. and speeds exceeding 500 kt. Tests then transitioned to low and mid-level altitudes following a rapid descent from 35,000 ft. to 10,000 ft. Work is believed to have focused on missed approaches and MCAS activations at around 15,000 ft. at and around Moses Lake. The aircraft landed after a flight lasting 3 hr. 56 min. It then returned directly to Boeing Field.

The final certification flight tests occurred on July 1 and featured some of the trial's most dramatic maneuvers, including high-angle banking turns and steep climbs and dives. Returning once again to airspace over south central Washington, the bulk of the testing was conducted during rapid descents and climbs between 17,000 ft. and 2,000 ft. during a 2-hr. flight.

While the FAA does not have a schedule, the current timeline could see all MAX changes and training approved in September. Still to be determined is whether the agency will require a public comment period for the airworthiness directive mandating the software upgrades and other return-to-service prerequisites. If the FAA opts for the traditional public-comment period, final return-to-service approval could be pushed out another month or more.

JOE WALKER

Boeing is revamping key training elements as part of getting the 737 MAX fleet airborne again.

Familiar Risks Evident in Pakistan A320 Accident Sequence

Unstable approaches continue to be a significant factor in approach-and-landing accidents.

- PK8303 PILOTS KNEW THEY WERE TOO HIGH AND FAST ON FINAL APPROACH
- WARNINGS FROM CONTROLLERS AND FLIGHT DECK DID NOT INFLUENCE CREW ACTIONS

Sean Broderick Washington and **Jens Flottau** Frankfurt

While the preliminary report on the fatal May 22 accident involving a Pakistan International Airlines (PIA) Airbus A320 leaves many questions unanswered, its contents make clear that two familiar risk areas—unstable approaches and flight deck human factors—featured prominently in the accident sequence.

The June 24 Pakistan Aircraft Accident Investigation Board (AAIB) report confirmed that the pilots of PIA Flight 8303 (PK8303) chose to continue their approach to Karachi Jinnah International Airport despite coming in too high and too fast during the initial final-approach phase. Critically, they were also acutely aware of their situation.

Air traffic control (ATC) "advised repeatedly . . . about excessive height," the report says. "The landing approach was not discontinued."

Instead, the pilots adjusted the aircraft's configuration so that it would descend more quickly and align with the recommended approach path, or glideslope. They retracted the landing gear and speed brakes and changed the flight mode to "open descent," disconnecting the autopilot.

PK8303 acquired the glideslope, but preliminary analysis of the flight data recorder (FDR) and cockpit voice recorder (CVR) confirmed that the aircraft's energy state triggered several flight deck messages, including overspeed, an enhanced ground proximity warning system (EGPWS) alert signifying imminent impact with terrain or an obstacle, and a landing-gear-up alert. The pilots "disregarded" all of them and touched down with the gear retracted, scraping the engine nacelles along the runway, the report says.

The crewmembers then decided to go around but could not maintain altitude as they vectored back around to the runway for a second approach, and the aircraft went down in a residential neighborhood 1.3 km (0.8 mi) from the runway threshold.

The crew reported engine problems during the go-around, and investigators believe the A320's CFM56-5Bs were "most likely" not producing thrust at impact. Debris found on the runway included nacelle and engine parts.

All but two of the 99 people onboard died, as well as one person on the ground.

The AAIB report includes no details on the flight crew's experience or training history, nor does it discuss the CVR's contents, which may shed light on what the pilots were thinking as they flew the initial approach and whether they did not notice the flight deck alerts and warnings or simply ignored them. Details in the report suggest there were no problems with the landing gear, and Pakistani Aviation Minister Ghulam Sarwar Khan told reporters on May 28 that the crew did not report any problems during the initial approach.

Investigators will more closely examine many factors during their probe, the report says. Among their actions will be "critical analysis of monitoring of performance of the pilots by PIA for stabilized approaches," including the airline's use of flight-data-monitoring (FDM) tools and crew resource management (CRM).

The airline is no stranger to FDM and CRM; not only are both programs part of its curriculum, but PIA also offers FDM and CRM courses to other operators.

Taking a broader view, the accident underscores ongoing shortcomings in compliance with standard operating procedures that cover go-arounds. Research shows that approach-and-landing (ALA) is the most common phase for accidents, accounting for 65% of the total. While accident sequences almost always include many individual factors, "empirical data" show that nonadherence to go-around policies "is the most common contributor" to ALA events, a 2017 Flight Safety Foundation (FSF) study says. Research by the International Air

Transport Association (IATA) of 375 air transport accidents in 2012-16 found that 61% occurred during the ALA phase, and failure to go around played a role in 10% of the total.

Research by the FSF and others shows that only 3-4% of unstable approaches result in go-arounds.

"Interestingly, and sadly, the collective industry performance of complying with go-around policies is extremely poor," the FSF says. "It is evident that the state of noncompliance has been steady for many years and will remain steady unless changes are made."

Industry is not ignoring the issue. IATA publishes regularly updated guidance on minimizing the risk of unstable approaches, including policies and best practices that operators can implement. The FSF produced a tool kit on reducing ALA-phase accidents, with modules that focus on stabilized approaches.

Following the 2011 fatal accident of a First Air Boeing 737-200—another high-and-fast approach—Canada's Transportation Safety Board (TSB) recommended that Transport Canada (TC) require operators to "monitor and reduce" unstable approaches. TSB included the issue on its 2014 watch list of top safety risks. TC did issue mandates, but voluntary efforts such as data monitoring and closer scrutiny by the regulator resulted in fewer unstable approaches, leading TSB to remove the item from its watch list in 2018.

While the overall accident rate is falling, go-around adherence continues to be an issue. An IATA analysis of 53 air transport accidents in 2019 shows that "continued landing after unstable approach" was a factor in seven of them, or 13%.

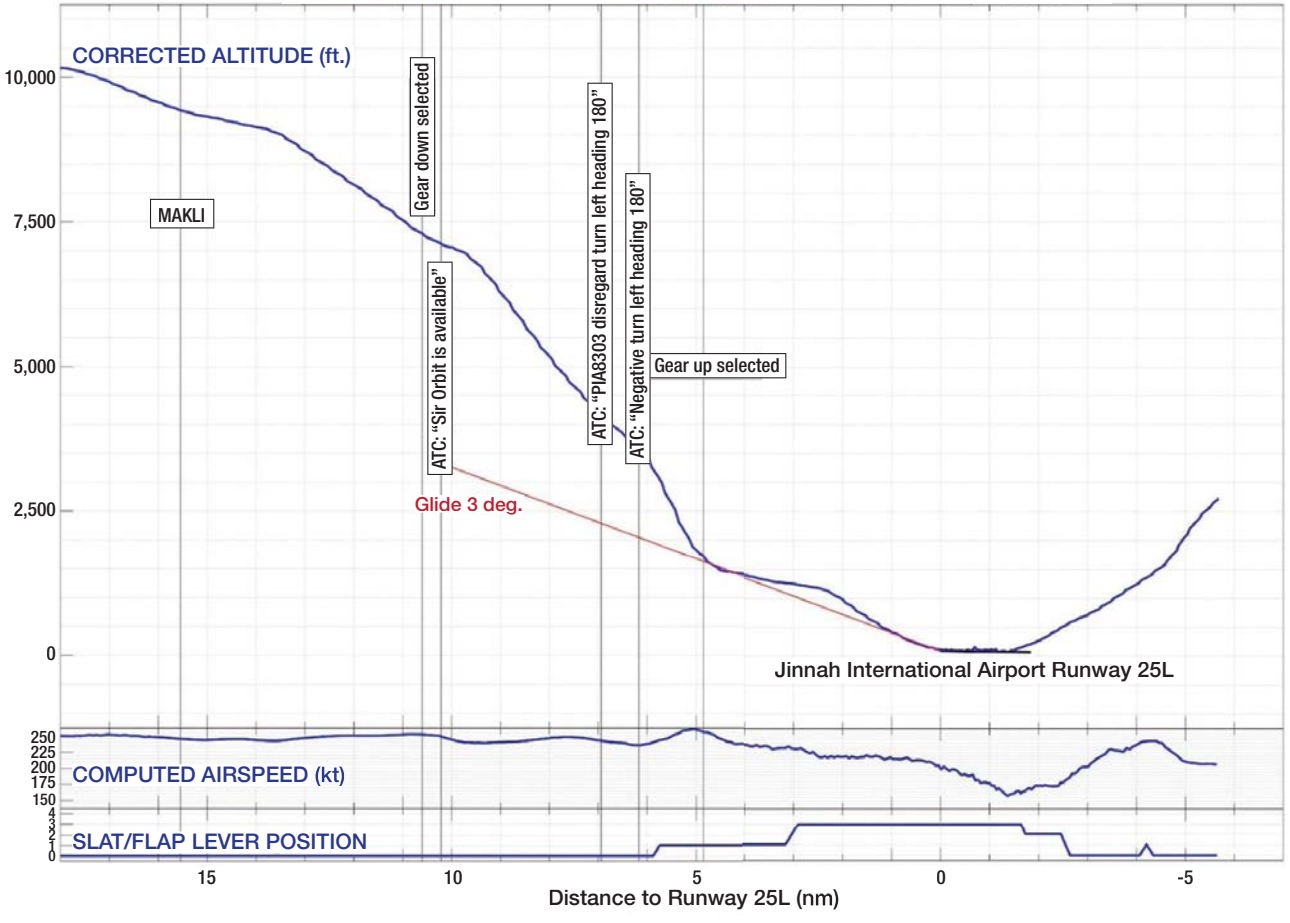
PK8303 will be on a similar list for 2020. The aircraft was on a scheduled domestic flight to Karachi from Lahore, leaving at 1:05 p.m. local time with eight crewmembers and 91 passengers onboard. While nearing Karachi, the aircraft was cleared for a direct vector to the Makli waypoint, 15 nm from the field. Karachi approach controllers cleared the aircraft to descend to 3,000 ft. overhead of Makli (see chart), but at Makli it was still at 9,780 ft. and an indicated airspeed of 245 kt.

The report does not specify which pilot was flying the aircraft.

Realizing their excessive altitude, the crewmembers selected the "OPEN DES" mode on the flight con-

DEPOSIT PHOTOS

Pakistan International Airlines Flight 8303 Final Approach Sequence



Note: Data sourced from flight data recorder and analyzed by BEA.

Sources: Pakistan Aircraft Accident Investigation Board and BEA

trol unit. Both autopilots were disengaged, and the speed brakes extended. ATC then requested the crew to "confirm track mile comfortable for descent" and recommended taking an orbit to lose altitude and for the aircraft to intercept the glideslope safely. The crew chose not to execute an orbit and instead continued the fast descent. At 10.5 nm from the runway threshold and an altitude of 7,221 ft., the landing gear was lowered. The recommended approach path would have seen the aircraft at about 3,000 ft. at this point, the report shows.

ATC twice advised the crew to discontinue the approach and alerted it about the unstable approach one other time. At an altitude of 1,740 ft., 6 nm from the runway, and having now intercepted the glideslope and localizer, the pilots raised the landing gear again and retracted the speed brakes. The crew selected the Flaps 1 position at a speed of 243 kt., triggering overspeed and EGPWS warnings.

In a deviation from normal procedures, Karachi Approach ATC did not hand over the aircraft to "Aerodrome Control" but instead sought landing clearance for it by telephone. Aerodrome Control granted the clearance without noticing that the gear was up.

According to the AAIB report, the A320 was descending through 500 ft. at Slats/Flaps 3, a speed of 220 kt. and a descent rate of 2,000 ft./min. with the gear still retracted.

The aircraft touched the runway on its engines, and the crew applied reverse thrust and "initiated a braking action," the report says. Both engines were damaged, and Aerodrome Control conveyed its observations about the gear-up landing to Karachi Approach, but neither alerted the crew.

The crew initiated a go-around, although the FDR indicates a brief action to move the gear lever to the down position that was immediately reversed. The crew told ATC it intended to go around for another approach to the same Runway 25L, but shortly after becoming airborne again, the crew reported that its engines had failed. The ram-air turbine was deployed to provide emergency power, but the aircraft could not maintain altitude.

The A320 was registered as AP-BLD and built in 2004. It was powered by CFM56-5B4/P engines. It had accumulated 47,124 flight hours and 25,866 cycles. China Eastern Airlines operated the aircraft from 2004 until 2014, when it was delivered to PIA.

During the accident probe, AAIB learned that 262 of Pakistan's 860 commercial pilots may be unfit to fly because their licenses are not valid. The pilots apparently paid other people to take their final written exams, AAIB told Pakistani government officials. PIA has grounded 141 of its 450 pilots as a result.

"Dubious pilots' licenses do not pertain to PIA alone. Let it be on record, these licenses were issued by the competent authority and are valid as per their records," the airline says. "It's the process and discrepancies through which they were obtained."

The AAIB's pilot-licensing findings are not discussed in the preliminary report.

Airlines Plan To Focus on Innovation After the COVID-19 Crisis

> AIRLINE IT MARKET TO GROW MORE SLOWLY THAN PREDICTED

> DATA USE AND ARTIFICIAL INTELLIGENCE ARE AMONG AREAS OF TECHNOLOGY FOCUS FOR AIRLINES

Helen Massy-Beresford Paris

As airlines in many countries begin to recover from the peak of the COVID-19 pandemic, the short-term focus is on getting flights back up and running while also convincing passengers that flying is safe.

But looking further ahead, carriers are increasingly convinced of the need to stay on top of innovative technologies such as blockchain, which can be used to improve loyalty programs, and artificial intelligence (AI), which can drive customer revenues through tools such as chatbots.

SAVO PRELEVIC/AFP/GETTY IMAGES

Post-pandemic technology investments will help airlines recover.

Advances in big data analytics and internet of things technology open up opportunities for greater personalization, optimized pricing and increased ancillary revenues, says Abhilash Varkey Abraham, aerospace and defense research analyst at Frost & Sullivan and author of an analysis of the global airline information technology (IT) market through 2025.

On the operational side, new technologies can help airlines cut turnaround times by smoothing out boarding, slot management and ground operations; predicting cancellations and disruption; reducing rates of missing luggage; and minimizing unscheduled maintenance.

"By predicting and optimizing these processes, airlines will be able to reduce costs, increase utilization rates of aircraft and improve passenger experience," Abraham says. "Predictive big data analytics and AI/machine-learning-enabled solutions capable of collecting large quantities of data and analyzing them in real time will help airlines predict key parameters with a high level of accuracy."

SITA's 2019 Air Transport IT Insights survey—released last November before the pandemic hit—revealed AI as the most common technology airlines were investing in: 44% of airlines had a major program underway, up from 32% in the previous survey, and a further 45% were running a pilot. The survey also found that 72% of airlines were investing in blockchain.

For now, the coronavirus outbreak is throwing technology and other investment plans off course. The Frost & Sullivan report predicts that the airline IT market will generate revenue of $20.74 billion by 2025, compared with $21.20 billion in 2019 and a prepandemic forecast that the market would reach $25.1 billion by 2025.

"The disappearance of revenues has halted investment and progress in technology development in airlines globally," Abraham says. "And the priority right now is cash preservation, cost reduction, optimal usage of assets and regaining passenger confidence to fly."

But technological advances can help airlines meet their main short-term challenge—the dramatic drop in demand for travel—as well as improve their longer-term prospects.

"Airlines will need to stimulate demand and target market segments that will enable them to start regaining at least a minor percentage of their regular incomes," Abraham says.

For this to occur, it will be important for carriers to focus on improving contactless technologies to convince passengers they are safe throughout their journey.

"Another key area of investment should be revenue management and operations," Abraham says. "In times of depressed demand, pricing systems coupled with forecasting and analytical techniques will need to be fine-tuned to identify the right price point to potential passengers."

If airlines are putting off digital and IT projects in favor of preserving cash for now, they know that staying on top of emerging technologies and innovative use of data will help their recovery and long-term health.

It is not just about helping airlines manage disruptive situations, however. "'Hyperpersonalization' is the new buzzword, and efforts have been taken to create a detailed profile of each individual customer rather than a pattern-based grouping of similar profiles," Abraham says. "Technologies such as machine learning enable efficient segmentation of passengers into multiple categories based on a wide variety of parameters, and airlines are researching to provide these customers insights in real time."

For now, in common with many other industry experts, Abraham sees brighter recovery prospects for low-cost carriers (LCC) compared with their legacy counterparts, thanks to their low cost bases and emphasis on domestic routes.

He also believes LCCs, often with dedicated innovation departments such as Ryanair's Labs division, show greater potential for modernization and will remain more agile in their technology investments as the recovery takes hold.

Abraham cites Mexico's Volaris as an example of an LCC that has managed to invest in digital solutions amid the pandemic. The carrier posted an increase of 16.2% in ancillary revenues in the first quarter of the year, with total operating revenues up 8.8%, before the full impact of the pandemic had started to occur in Mexico.

"During the current environment, we have also been accelerating digital transformation initiatives," Holger Blankenstein, Volaris' executive vice president of airline commercial and operations, said during the ultra-low-cost carrier's first quarter webcast in April.

He noted that Volaris had upgraded to the latest version of the Navitaire New Skies reservations platform and developed an automated platform for flight cancellations initiated by the airline. It offers passengers the options of a voucher, flight change or refund, without any human interaction.

Data innovations can also help airlines take incremental steps toward improving environmental credentials.

DAN KITWOOD/GETTY IMAGES

Airlines are focusing on improving contactless technologies to reassure travelers and thereby stimulate demand.

That is an important consideration as airline sustainability comes under ever greater scrutiny, with many countries attaching environmental conditions to state aid awarded to help airlines weather the pandemic crisis.

Paris-based software company Safety Line said on June 29 that it had secured a patent for its Opti-Direct tool, which is already in use by Air France and Transavia. This interface draws on data learning to show previously used shortcuts and data on time and fuel savings, thereby allowing pilots to request more efficient routes from air traffic control.

Airlines Stricken by COVID-19 Cheer Change to Carbon-Offsetting System

- ICAO COUNCIL AGREES TO ADJUST CORSIA BASELINE TO REFLECT COVID-19 EFFECTS
- AIRLINES HAD CONTENDED THAT THE DRAMATIC DROP IN 2020 EMISSIONS SKEWED THE SCHEME

Helen Massy-Beresford Paris

ONE IN A SERIES

Reactions to the International Civil Aviation Organization (ICAO) Council's decision to adjust the baseline for the Carbon Offsetting and Reduction Scheme for International Aviation (Corsia) to reflect the COVID-19-related drop in 2020 demand perfectly encapsulate the air transport emissions dilemma: on the one hand, airline survival, and with it jobs, economic growth and connectivity; on the other, the pressing need to cut CO_2 emissions.

The ICAO Council listened to the air transport industry's pleas for the scheme to be changed to reflect the post-COVID-19 reality when it decided June 30 to set 2019 emissions as the offset target for the program's initial three-year phase. Under the initial Corsia resolution, the voluntary pilot phase, set to run from 2021 through 2023, was to have been based on average CO_2 emissions from 2019 and 2020 combined.

The program requires the offset of any emissions above the baseline so that participating airlines are carbon-neutral beyond the baseline year.

But the coronavirus pandemic brought the global air transport industry to a virtual standstill. In March, the International Air Transport Association (IATA) began lobbying ICAO to modify the program to reflect the changed situation.

Almost four months later, the first extremely tentative signs of recovery are visible in the industry, with passenger demand in May measured in revenue passenger kilometers 91.3% lower than in May 2019, a slight uptick from the 94% annual decline recorded in April 2020, IATA said July 1.

Even if some slight improvements are underway, aviation industry emissions in 2020 will be dramatically lower than predicted precoronavirus. Airlines, unsurprisingly, have welcomed ICAO's move.

"[The] decision is important because, at a time of extreme volatility, it provides immediate certainty and a clear path forward for the successful implementation of Corsia," said IATA.

"This will help ensure the sustainable development of international aviation and avoid an inappropriate economic burden on our sector, which continues to reel from the COVID-19 crisis," says Thomas Reynaert, managing director of Airlines for Europe (A4E). The group's members include Air France-KLM; International Airlines Group, the parent company of Aer Lingus, British Airways, Iberia, Level and Vueling; Lufthansa Group; Finnair; and low-cost carriers EasyJet and Ryanair.

Reynaert says A4E's members had reported traffic down 89% compared with June 2019.

"Using 2019 emissions will . . . maintain a level of ambition comparable to that which underpinned Corsia's adoption: Net emissions will be stabilized at a level close to the precrisis forecast of around 600 million tons of CO_2," IATA says.

Aviation's impact on the environment, already under increased scrutiny in recent years, has come into even sharper focus as the travel restrictions put in place to manage the pandemic led to largely empty skies. Some governments have taken the opportunity to link financial help for stricken airlines to renewed environmental efforts.

The French and Dutch governments have both agreed to multibillion-euro bailouts for Air France-KLM's airlines but have attached emissions reduction, sustainability and competitiveness conditions to the aid.

France's economy ministry said Air France must cut the volume of its CO_2 emissions from domestic flights by 50% by the end of 2024 as it unveiled a €7 billion ($7.9 billion) bailout package in April, part of a broader objective of cutting CO_2 emissions per passenger kilometer by 50% by 2030 compared with 2005 levels.

"Where there are rail alternatives to an internal flight of under 2.5 hr., these internal flights should be cut drastically and in fact limited to transfers to a hub," Economy Minister Bruno Le Maire said at the time, describing it as a "new and drastic condition" that should lead to a reevaluation of transport options within France.

Although the move to link financial help to emissions action has broadly been welcomed, some environmental

Airlines say the decision on Corsia gives them much-needed certainty.

JOEPRIESAVIATION.NET

LOGO: ARTHOBBIT/UNDEFINED UNDEFINED/WASTESOUL/MARYLOO-GETTY IMAGES

campaigners say the conditions do not go far enough.

The Brussels-based lobby group Transport and Environment says reducing emissions from domestic French flights by 50% by 2024 would cut French aviation emissions by only 0.8%, and that the condition should be expanded to routes where rail journeys under 5 hr. exist, which it said would make the reduction 4.5%.

The organization is part of a group of nongovernmental organizations making up the International Coalition for Sustainable Aviation (ICSA), which also criticized the ICAO decision, saying: "The ICAO Council's decision to further deflate the ambition of Corsia is a betrayal to future generations and a slap in the face to the multilateral work to build the program."

It added: "Airlines, in pushing for this change, have undermined their own case for international action. Given ICAO's unwillingness to lead, ICSA urges governments to adopt national measures to support the climate ambition that is needed."

The U.S.-based Environmental Defense Fund (EDF) also criticized ICAO's move.

"With offset obligations likely suspended for the pilot phase, today's decision leaves the field wide open for governments—at local, state and national levels to require airlines to integrate climate action into their economic recovery," wrote Annie Petsonk, EDF international counsel, on June 30. "That could, in turn, leave the industry with the very patchwork of regulations it fears."

The EDF also called into question the legitimacy of the 36-member ICAO Council "unilaterally" deciding to change the baseline without fully consulting the more than 190 ICAO member states.

"[The move] set a troubling precedent for the legitimacy of future decision-making by the [United Nations'] aviation body," Petsonk wrote. "As airlines scramble to recover from the COVID-19 crisis, they can't afford to ignore the looming global crisis of climate change. Real leadership means setting the aviation sector on a path toward net zero climate impacts as swiftly as possible. The sooner the costs of carbon control are included in the costs of doing business, the sooner new technologies will be developed."

COVID-19 Spurs Drastic Changes in Asia-Pacific Fleet Strategies

- ALMOST ALL ASIA-PACIFIC AIRLINES ARE LOOKING TO DEFER 2020 DELIVERIES
- MANY WIDEBODIES WILL BE GROUNDED FOR SOME TIME OR RETIRED EARLY

Adrian Schofield Auckland

In a span of just 5-6 months, COVID-19 has rendered airline fleet plans completely irrelevant to market realities. Asia-Pacific airlines are now scrambling to defer this year's aircraft deliveries and reassessing long-term orders as they look to realign their strategies with the industry's bleak outlook.

With so much of their fleets likely to remain parked for an extended period—particularly international aircraft—airlines in the region have little appetite to add new aircraft if they can avoid it. There will also be significant changes in the composition of existing fleets as larger aircraft are retired early or grounded for the foreseeable future.

Some moves by Asia-Pacific carriers to scale back growth were already occurring and have been accelerated and amplified by the latest crisis. However, despite the prevailing trends, some airlines are still planning to receive orders—or in rare cases are even contemplating adding new types.

Two of the region's major players in the international connecting market, Singapore Airlines (SIA) and Cathay Pacific, are holding negotiations with manufacturers about delivery deferrals.

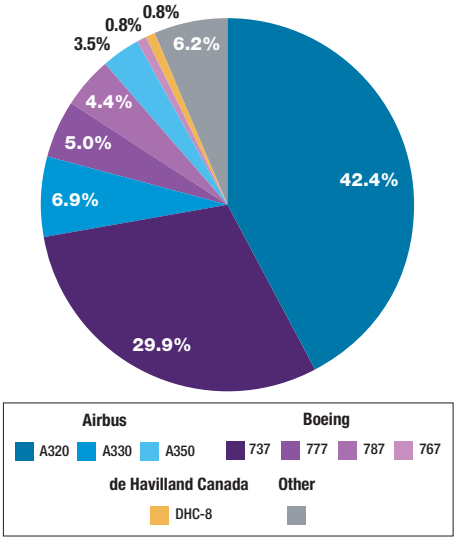
The SIA Group has about 150 aircraft on order from Boeing and Airbus. While it has not divulged details about what types will be delayed, the carrier has stressed that its fleet renewal program will remain an important part of its strategy. Major owner Temasek Holdings also reiterated its support of fleet modernization.

Because newer aircraft will be returned to service first, some of SIA's older aircraft such as its Boeing 777-200s will be retired early. The carrier also intends to return its remaining Airbus A330s to lessors.

Cathay Pacific Group has 17 aircraft due to be delivered this year, comprising Airbus A350s and A320/321neos. The carrier is working with Airbus to delay as many of these as possible into 2021 or beyond, says Ronald Lam, Cathay's chief customer and commercial officer.

The airline has a total of 70 deliveries due through 2024. This includes 21 Boeing 777-9s scheduled to start arriving in 2021, and one of Cathay's options would be to delay these and extend leases on some of its current 777s.

Asia-Pacific In-Service Fleet*
By percentage of total seats



*As of July 6, 2020. Not including inactive aircraft.

Source: CAPA – Centre for Aviation

In Japan, All Nippon Airways (ANA) confirmed it is considering deferring aircraft deliveries as it looks for ways to reduce capital expenditure. However, the airline says its "long-term strategy to expand overseas remains unchanged," and that would require more aircraft. The carrier may provide an update on its fleet plans when its next financial results are released at the end of July. One change that has been announced is the deferral of the airline's third Airbus A380. ANA is currently scheduled to begin receiving 777-9s next year and also has other types remaining on order.

Meanwhile, Japan Airlines has already received three 787s and two A350s this year. The carrier says it has no plans yet to seek deferrals, but the delivery timetable may be altered anyway due to manufacturer production delays. JAL's widebody orders consist of A350s.

Korean Air has deferred all of its deliveries planned for this year, the carrier tells Aviation Week. It was previously expecting to receive 10 deliveries, comprising four 787-9s and six 737 MAXs. More than half of the carrier's fleet remains grounded, including all A380s and 747-8 passenger aircraft.

Vietnam Airlines was due to take delivery of seven aircraft this year: five A320neos and two 787-10s. However, the airline is in discussions with the manufacturers to defer some of them until next year.

Some Asia-Pacific carriers were already in negotiations regarding the deferral or possible cancellation of their 737 MAX orders before COVID-19 emerged. The worsening industry outlook will increase their resolve not to receive these aircraft or at least delay them for a significant time.

Garuda Indonesia accepted one of the 50 737 MAX 8s it had on order before deferring the remainder in 2017. The airline will cancel these MAX orders, CEO Irfan Setiaputra confirmed during a televised Bloomberg interview in March. He did not reveal whether the carrier is discussing taking other Boeing aircraft instead.

Malaysia Airlines stated in January that it will not take delivery in 2020 of any of its 737 MAX orders. It was due to receive its first six this year. The airline has 25 MAX-family aircraft on order, including the 737-8 and -10 models.

AirAsia has deferred all of its Airbus narrowbody deliveries scheduled this year due to the COVID-19 demand downturn. Its widebody affiliate, AirAsia X, has shelved its A330neo deliveries.

Indian low-cost carrier (LCC) IndiGo says it will continue to take delivery of A320neos. It will switch its focus from growth to fleet renewal, using the new deliveries to phase out older aircraft more quickly.

One of the major longer-term issues for Asia-Pacific LCCs is their massive order backlogs. For example, four LCCs—IndiGo, Lion Air, VietJet and AirAsia—account for a combined 1,700 narrowbody orders. If demand does not fully return for 2-3 years, these orders could become a serious headache for the LCCs and the manufacturers alike.

In Australasia, Air New Zealand has pushed back the delivery of some of its A321neos. The airline's 777-200ERs could be phased out earlier than scheduled; they have been put into long-term storage and are unlikely to be needed before their planned exit after 2022.

The Qantas Group will defer its 787-9 and A321neo deliveries that are due this year. The carrier's six remaining 747-400ERs will not return to service, meaning they will effectively be retired six months early.

Qantas estimates about 100 of its aircraft will remain grounded for at least a year. Its 12 A380s will be stored for at least three years, although the airline stresses it will eventually return them to service.

In the longer term, the carrier still intends to pursue its plans to order aircraft to operate ultra-long-haul flights from Australia's east coast to London or New York, says CEO Alan Joyce. Qantas has selected A350-1000s for these flights, although it has put the firm order process on hold.

Virgin Australia is another airline with 737 MAX orders on its books. However, last year it delayed the first delivery of these aircraft to July 2021. The longer-term fate of these orders is uncertain, as the carrier is under voluntary administration and will soon be sold to a new owner. The airline has also accelerated the exit of the remaining nine A320s that were operated by its Tigerair subsidiary.

Virgin CEO Paul Scurrah previously said the carrier would consider ordering new widebodies to replace its 777s and A330s, but such a move will now depend on the new owner's appetite for long-haul routes.

One of the few airlines looking to add new types is Australian turboprop operator Regional Express Holdings. The carrier has confirmed plans to launch jet services on domestic trunk routes by March 2021, which will require 5-10 narrowbody aircraft.

Cathay Pacific and many other Asian airlines are negotiating to delay aircraft due this year.

A. DOUMENJOU/AIRBUS

How The Aviation Industry Can Deal With the 'Data Link Dilemma'

> VHF ACARS IS CHALLENGED BY INCREASED DATA

> HIGHER-CAPACITY ADVANCED VHF IS PROPOSED

Bill Carey Washington

Collins Aerospace is recommending steps the aviation industry can take to safeguard data link messaging between pilots and their airlines and air traffic controllers until a new aviation communications network is established.

"We as stakeholders are in many ways obligated to be stewards of that and protect it and evolve it until the next generations of technology are ready to take over," he adds.

During a recent webcast, entitled "The Data Link Dilemma," Pendergast recapped the history of the ACARS communications protocol, which was introduced by ARINC—now part of Collins Aerospace—in 1978 using its VHF radio network as the means of transmission.

Intended for data messaging between pilots and airline operations centers, the system was expanded in the early 1990s to include Future Air Navigation System controller-pilot data link communications (CPDLC) with air navigation service providers (ANSP), routed by satellite over oceans.

ACARS messages can now be sent over IP-based broadband and legacy satellite communications (satcom), VHF, high-frequency data link, cellular and WiFi networks. Collins and Geneva-based SITA are the major aviation data link service providers.

In the late 1990s, Eurocontrol required reduced channel spacing between adjacent frequencies of 8.33 kHz from 25 kHz, increasing the number of channels available to relieve growing congestion in the VHF band used for aviation voice and data communications.

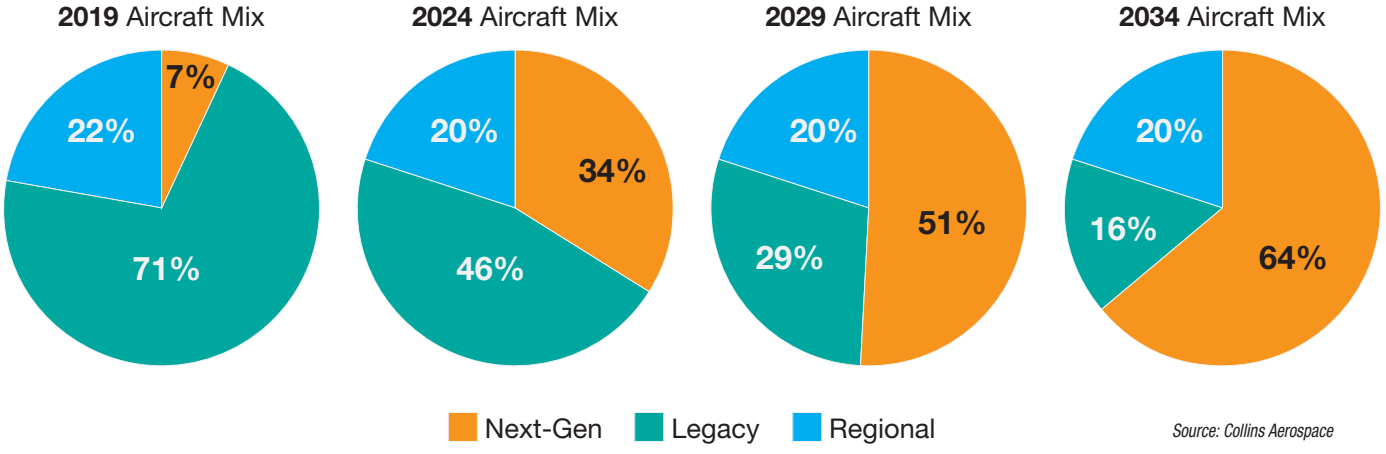
Congestion issues with VHF ACARS led to the development of the higher-bandwidth VHF Digital Link Mode 2 (VDL2) data link in the early 2000s. VDL2 is the means of transmission the FAA and European ANSPs have specified for CPDLC over ground.

As the rate of air travel has grown in recent years, airlines and ANSPs continue to rely on VHF-based ACARS, Collins says. But congestion looms as a problem, exacerbated by the entry into service of newer aircraft types such as the Boeing 737 MAX and Airbus A320neo that generate four times the amount of engine and systems data as legacy airliners.

"That's been a significant revelation as newer versions of aircraft have come out," Pendergast says. "Especially from narrowbody aircraft—the A320neo and the 737 MAX—VHF ACARS is being used to send the information. Why? Because there really is not another link on the airplane that has been set up to send all this data. So VHF data is growing, and the reason "it is growing is engine and aircraft data."

Collins estimates that just 7% of the current world fleet is what it calls next-generation aircraft, with 71% consisting of legacy aircraft and 22% regional aircraft. The fleet mix becomes more balanced in 2029 with

Global Growth in New-Generation Aircraft



Source: Collins Aerospace

Citing a growing volume of data being transmitted via Aircraft Communications Addressing and Reporting System (ACARS) messages over terrestrial VHF radio networks, Collins proposes two steps to relieving potential future congestion as new-generation aircraft produce ever more data.

Ultimately, the industry's goal is to establish an internet protocol suite (IPS) for aviation, an IP-based communications architecture that would be agnostic about the type of media used to send messages.

"We began a journey over 40 years ago with data link, and this journey has evolved over time. Our VHF network especially has grown in capabilities and become more valuable to not only airlines but air traffic control authorities," says Dan Pendergast, Collins Aerospace head of flight deck data link connectivity services.

51% next-generation aircraft; in 2034, Collins projects that 64% of the fleet will be data-intensive next-generation aircraft.

The Collins technology road map for data link calls for step improvements leading to the IPS. The company has already implemented ACARS-over-IP (AoIP), which enables aircraft to send and receive ACARS messages by either IP-based satcom, including new-generation, operational and safety-oriented SwiftBroadband-Safety and Iridium Certus flight deck services, or cellular links.

Collins recommends dividing the data an aircraft offloads—sending engine and aircraft data over broadband K_a/K_u-band cabin connectivity systems, for example, and operational and safety-critical data over VDL or satcom safety services. It estimates that up to 75% of ACARS data can be offloaded from VHF to IP-based connectivity.

"One thing about it that we need to work on [is] we need to fine-tune [AoIP] to offload engine and aircraft information. The early implementations we believe are not quite there yet," Pendergast acknowledges. "If the aircraft has a capability to choose between the IP and the narrowband links and the safety services links to send different information, that's an ideal state."

Another step the company proposes is to extend the usable life span of VDL through Advanced VHF. It would implement a new, higher-throughput VDL2 waveform that would be backward-compatible with current aircraft radios and VHF ground networks.

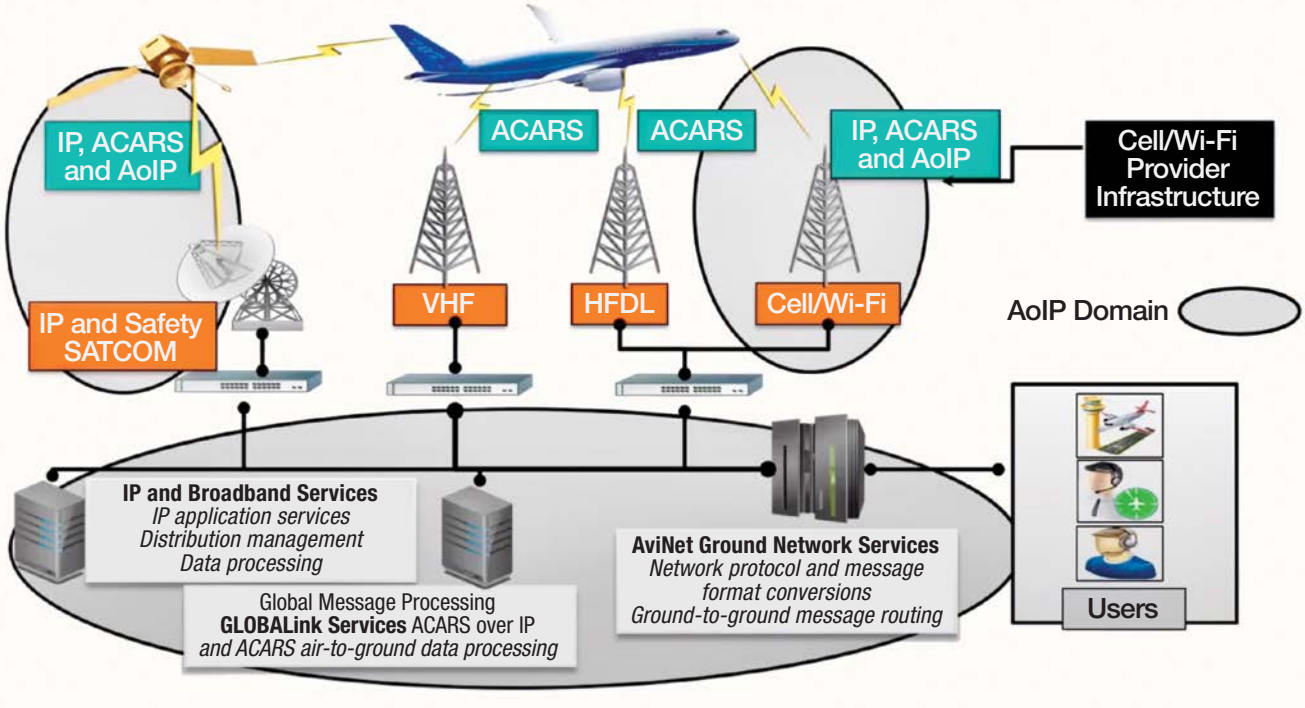
"Twenty years have passed since [the development of] VDL; we believe it's time for a tech refresh of VHF," Pendergast says. "How can we do this? There is a way in a more cost-effective manner to make modest modifications to airborne radios and ground infrastructure in a backward-compatible manner to increase the capacity, the data rate of a VDL frequency."

The VHF system refresh requires buy-in from airlines and ANSPs. Collins wants to advance it as an industry-standard approach focused on safety service performance that makes business sense, Pendergast says.

"What we're talking about are modest modifications, performance changes to the aircraft radios leveraging the same systems that are on the airplane, leveraging the VHF and VDL ground networks that have been deployed," he says.

"We believe we can have [Advanced VHF] deployed in the next 3-5 years, which would give us time to address capacity issues with initiatives like ACARS-over-IP and extend the life of VHF until new technologies are available."

ACARS Over Internet Protocol Overview



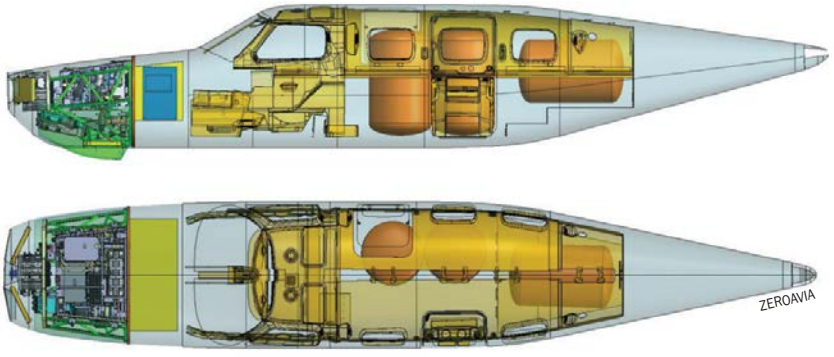
AoIP ACARS over internet protocol **HFDL** High-frequency data link **IP** Internet protocol

Source: Collins Aerospace

ZeroAvia Prepares for Hydrogen Fuel-Cell Propulsion Flight Tests

> PIPER MALIBU WILL TEST 600-KW FUEL-CELL PROPULSION SYSTEM

> 20-SEAT REGIONAL AIRCRAFT TO USE TWO OF THE HYDROGEN POWER TRAINS



Graham Warwick Washington

As attention turns to hydrogen propulsion for climate-neutral aviation, particularly in Europe, startup ZeroAvia is converting an existing 20-seat regional aircraft to zero-emissions fuel-cell power.

As a first step, ZeroAvia plans to fly a six-seat Piper Malibu Mirage converted into a propulsion testbed for its hydrogen fuel-cell power train. With an electric motor replacing its piston engine, the aircraft has completed a series of battery-powered test flights from Cranfield Airport in the UK.

The hydrogen power train has been tested on the ground and will now be installed in the Malibu. "We will start testing in the aircraft pretty soon and fly in the next 6-8 weeks," CEO Val Miftakhov told Aviation Week on July 3.

The 600-kW power train is fully redundant, with dual windings on the electric motor, dual inverters, dual low-temperature proton exchange membrane fuel-cell stacks and redundant cooling. Sufficient gaseous hydrogen for 300-nm range is stored in pressurized tanks in the cabin.

Using automotive fuel-cell technology, the power train is sized to replace Pratt & Whitney PT6-class turboprops powering a range of regional airliners. To be launched soon, the initial 20-seat application will use two of the power trains tested in the Malibu, with hydrogen for 500-nm range.

Hydrogen is stored at 350 bar (5,000 psi) using standard heavy-duty vehicle tank and refueling technology. For 20-seat applications, analysis of weight and drag shows a sweet spot in the 300-500 bar range, Miftakhov says, and the aircraft selected for modification provides flexibility in where the tanks can be mounted, either under the wing or over the fuselage.

Hydrogen volume is a challenge. "Slower aircraft are better initially, as there is not as much aerodynamic penalty and lower energy demand," Miftakhov says. Safety is another concern, but "gaseous hydrogen is safer than jet fuel" as it dissipates rapidly, he says. The system integrates low-pressure lines, safety valves, flow limiters and automatic shutoffs for safety.

The hydrogen-powered Malibu is being tested under Project HyFlyer, supported by a £2.7 million ($3.4 million) grant from the UK government. Partners are renewable hydrogen producer EMEC Hydrogen, fuel-cell developer Intelligent Energy, as well as Cranfield University and Cranfield Aerospace Solutions, which operate Cranfield Airport where the aircraft is based.

HyFlyer is to culminate in a 250-300-nm flight from the Orkney Islands in Scotland. As part of the project, a hydrogen refueling infrastructure has been commissioned at Cranfield. Hydrogen is produced on-site through electrolysis using renewable electricity, then distributed to the aircraft by refueling truck.

In a fuel-cell stack, hydrogen is fed to an anode on one side and air to a cathode on the other. At the anode, a platinum catalyst splits the hydrogen into protons and electrons. Protons migrate through a polymer electrolyte membrane to the cathode. Electrons flow around an external circuit, creating electricity. Protons and electrons then recombine at the cathode, producing water and heat.

In addition to zero carbon emissions, the advantages of hydrogen fuel-cell propulsion include higher energy density than batteries and higher efficiency than gas turbines. "Turbines are only close [in efficiency] to fuel cells at the large end," says Miftakhov. "Compared with smaller turbines like the PT6, fuel cells are twice as efficient."

The Malibu Mirage testbed will be fitted with 350-bar gaseous hydrogen tanks in the cabin.

A disadvantage compared with turbines is lower specific power. "We see a path to 1.5-2 kW/kg within the next five years, compared with small turbines powering 20-seaters at 3 kW/kg," Miftakhov says. Power densities of 4-5 kW/kg, similar to a CFM56 turbofan, are achievable in 10 years, he says, which could expand application to aircraft above 100 seats.

"Today, fuel-cell technology is adequate for a 500-nm 20-seater," says Miftakhov. The biggest challenge is not the fuel-cell stack itself, but "the balance of plant," or supporting components for gas handling, recirculation and thermal management. "This is the heaviest part of the fuel-cell power train. For power density, balance of plant is the critical path."

For the initial 20-seat application, thermal management is a challenge because waste heat is rejected at low temperatures, making it hard to remove, particularly on hot days. "Operating at 80-90C [180-190F] and taking off from Phoenix on a 50C day leaves only 40C delta T [temperature difference]," he says.

ZeroAvia plans to have its hydrogen fuel-cell power train certified in an existing 20-seat aircraft by 2023. While the capital cost is expected to be similar to turbine propulsion, operating cost is projected at be almost halved. "In three years, we will definitely beat the jet-fuel economics of small aircraft," Miftakhov predicts. "In 5-7 years, we will beat jet fuel on larger aircraft."

ONE JOURNEY TOGETHER

Today and always, we are dedicated to keeping you safe, secure and connected.

Gulfstream™

A General Dynamics Company

'Idiot' to 'Genius'

When he was United Technologies Corp. chairman and CEO, **Greg Hayes** took a lot of heat for merging his company with Raytheon to create aerospace powerhouse Raytheon Technologies. But the critics have been silenced as defense has cushioned the company from the battering the commercial downturn has inflicted on its Collins Aerospace and Pratt & Whitney operations. Hayes spoke via videoconference with *AW&ST* Editor-in-Chief **Joe Anselmo** and Senior Business Editor **Michael Bruno**.

RAYTHEON TECHNOLOGIES

AW&ST: **How long will it take the commercial aviation industry to recover from the COVID-19 crisis?** Initially, we thought this was going to be like the severe acute respiratory syndrome (SARS) in 2002-03. We thought it was going to be relatively short-lived, where air traffic would go down for a little while but then gradually recover. I don't think any of us envisioned the morbidity or the scope of this pandemic and its impact on travel. I would say we're looking now at getting back to 2019 in 2023, maybe 2024. It is going to be a slow recovery.

The good news is we've got plenty of liquidity. We'll see our way through this, but it is going to be a tough road. We are hunkering down for a protracted recession on the commercial aero side. Our aftermarket orders are down 50%-plus at both Collins Aerospace and Pratt & Whitney. That's where a lot of the profits come from. The reason we can spend $2.5 billion a year on R&D for the commercial businesses is because we have this spares business that generates strong cash. When that goes away, it's tough. And as a result, we're going to cut R&D this year by $500 million on the commercial side.

Unfortunately, the airlines are not in a position to weather this storm for probably more than another 12 months without government assistance. That's really going to be the key. Do governments in the U.S., Europe, South America and across Asia step up to support what is a critical industry in aerospace?

Is the industry underplaying the severity of the COVID-19 downturn? A vaccine is the key, and it has to be widely available. The World Health Organization is working on that, but we're going to have hotspots with this pandemic for the next year or two. So even if the U.S. and Europe are completely vaccinated, what does that mean for travel to Africa, Asia, to the fast-growing markets?

I'd almost bifurcate the aerospace industry between a narrowbody recovery and widebody recovery. The narrowbody is primarily domestic, whether it's Europe, the U.S. or even China. That will recover more quickly as people become confident—there's either a vaccine or they've found new treatment options. But on the international side, we can't fly today into Europe, and we don't want the Europeans to fly to the U.S. We can't go to South America or China. Those routes are going to take much, much longer to recover.

The fact is there are so many excess aircraft out there right now that we believe you're going to see more parting out of existing fleets before we see a resurgence. And that's why even when passenger traffic starts to come back, there's probably a full 6-12 months before we're going to see a return to normalcy in our aftermarket organization.

Pratt supplies the PW1000G engine option for the Airbus A320neo. How much downside risk is there for deliveries? We're planning for about a 40% reduction in A320 deliveries this year and next year compared with February 2020 production rates. Airbus would love to build more, but it's not clear to us that customers are going to be around to take more than that. The good news is our market share went from about 42% [of A320neo engines] to north of 50% in the last year. Customers are starting to believe in the geared turbofan because of the fuel efficiency.

Do you see the market share between Airbus and Boeing shifting? The order book for the A320 is much stronger today, with all the cancellations that we've seen on the 737 MAX because of delays. We still think the 737 will get back in the air this year, and we continue to work with Boeing on software updates. We firmly believe it's a great aircraft. Keep in mind we have about $2.5 million of content per shipset on the 737. It's going to be a tough couple of years, but we ultimately have faith in the airframe and the certification process.

Where are you focusing your future efforts with Boeing and Airbus? We were optimistically cautious about the [proposed Boeing] new midmarket airplane (NMA), but there is a lot of excess capacity now, and it's not clear another evolutionary design is going to be the answer. So our focus right now is the next-generation single-aisle. And we think that's probably been pushed out a couple of years, to maybe 2033 or 2035.

They're talking about a 30% efficiency gain from the current single-aisle. Two-thirds of that gain has to come from engine design. At the Paris Air Show last year, we talked about a hybrid electric design [Project 804]. We're going to continue on that path. We're trying to figure out how you can have enough power at takeoff while having a much lower fuel consumption at cruise. And that's where hybrid electric comes in. It's going to take us at least a decade to prove that out.

I don't know if hybrid electric is the answer. There are other things that we're working on. But obviously it's got to be something completely different than what we've been building in the past.

Governments around the world are taking on huge debt to alleviate the coronavirus crisis. Are you worried that will put pressure on military spending over the long term? You would have to have your head in the sand to not understand what's going to happen to defense budgets over time. When [Raytheon CEO] Tom Kennedy and I first talked about this merger, it was, "What can we do together that we can't do separately?" And it really was bringing the technologies of the two companies together to solve customer problems in new and innovative ways.

Defense budgets will go down, but I think the real question is where Defense Department spending is going. I remember talking two years ago with [then-Defense Secretary] Gen. [James] Mattis, and he said, "Bring us innovative solutions, not to fight the last war but to fight the next war." And the next war, he said, is going to be fought in cyberspace and outer space. The capabilities of the legacy Raytheon business are second to none in space and are outstanding on the cyber side. You marry that up with the manufacturing and material science that Pratt & Whitney brings, with the communication systems that Rockwell Collins brings, and this is going to be a great play.

The U.S. Air Force wants more software-driven capabilities, delivered in weeks or even days. How does that square with your businesses, which often involve long-term hardware evolutions? It's making sure that we're continuing to evolve our products. The missiles we're delivering today, such as the SM-3 [interceptor] or the SM-6 [anti-air/anti-surface/

ballistic missile defense] are state of the art, and we continue to find new uses for them.

A lot of things will change over time in terms of how the weapons are deployed. Think about the StormBreaker missile that we just demonstrated, which has the tri-mode seeker. It can do things the last generation of missiles could never do in terms of going through smoke, fog, dust and sand. The LRSO [Long-Range Standoff nuclear cruise missile] is another example. And the Tomahawk is an established product that we will evolve as the needs of the battlefield change to meet new requirements. That's really what we want to focus on: How do we continue software-driven solutions but also find ways to redeploy and reinvigorate the product line and bring new capabilities to the warfighter?

Are you making long-term investments in hypersonics? Hypersonics are a destabilizing technology. There's only so much we can talk about, but we know we're behind the Chinese and probably behind the Russians. I think in 3-5 years we'll be on a level playing field. Our focus has been on defensive systems, using space-based assets to track hypersonics. It's nothing that a ground radar could ever do because they move too fast. And then countermeasures that we could use to defend against hypersonics is the bigger market. We're obviously investing. We've got a program, the HAWC [Hypersonic Air-breathing Weapon Concept], which is an air-breathing hypersonic missile that we're working on. I think we'll flight-test that later this year.

Also think about the materials science that Pratt brings. The key to hypersonics is how to keep the electronics from getting fried when you're operating at something like 5,000F. We're investing in cooling materials—that will be one of the big bets that we're going to have to make. Tom Kennedy saw the need to make these investments, and we're going to do that. The other piece is on the space side. There's not a lot that we can say, other than that we think space will be the frontier that will differentiate us—that is, the defense of space assets, as well as using space assets to detect, track and target hypersonic weapons.

When the merger of United Technologies and Raytheon was announced, there was a lot of criticism from investors. Now they're happy about how well-positioned the combined company is to weather the COVID-19 storm. There was a lot of pushback from investors, especially from the hedge fund guys. They saw us taking a lower-margin business, and they didn't like the fact that the technology takes 5-10 years to pay off. I was roundly criticized. All I can say is I was an idiot a year ago and now I'm a genius, through no fault of my own.

We did this for the long term, and it was completely fortuitous that the merger happened when it did. The commercial businesses won't make any money this year, and they are going to struggle for the next couple of years, but now we've got a rock-solid balance sheet and a lot of cash. And that defense business is going to grow 5-8% this year. We've got a good backlog. I'd like to say it was genius, but it really was just doing what's right for the long term. My goal is to leave this company better than I found it.

You have reshaped this company, starting with selling Sikorsky to Lockheed Martin in 2015. Then you acquired Rockwell Collins and moved to break up the UTC conglomerate, and it looked like UTC was going to be a commercial aerospace company. Now comes Raytheon. Are you done, or is there more to come? I'm never done until I'm gone, but we don't need to do anything else big. The driving force [behind the Raytheon merger] was putting two big technology companies together with cyclical balance [between commercial and defense]. Tom Kennedy always felt he was at a disadvantage against the Lockheeds of the world because of the scale of Lockheed versus Raytheon. This gives us the scale to invest and compete head on with the Lockheed Martins and Northrop Grummans, as well as being the largest supplier to both Boeing and Airbus. We have some clout in the marketplace.

We've got 700,000 different things that we deliver to customers: missiles, APUs, engines, communications gear. Some we really love; others don't have the returns that we want or require too much investment for a limited market. We hope to have a portfolio review done by the end of the year. And you'll probably see some divestitures, but not big pieces. We also continue to look for technology bolt-ons as we think about what's next in defense and the space and cyber spectrums.

Longer term, the big question in my mind is what happens to Rolls-Royce, a great technology company that is facing challenging financial circumstances. We loved the partnership Pratt had with Rolls on International Aero Engines. Could we recreate that someday? Perhaps, but not now. Ian Davis, who's the chairman over there, is a good guy. We always say, "Look, we need to find ways to collaborate so we can take on GE Aviation." Despite the fact that GE may be on its heels today, they've got over 30,000 engines out there. Their aftermarket will recover, they will get better, and they will be the formidable competitor for both Rolls and Raytheon Technologies for the foreseeable future.

We're hearing from Wall Street that you're expected to sell off the Forcepoint business. Forcepoint is a commercial cyber business Tom Kennedy created when he brought a couple of companies together about five years ago. It has some great technology, but it clearly doesn't fit in the portfolio. We'll figure that out in the next six months.

How is the integration going? Nothing went according to plan except the merger itself. We sent everybody home the week of March 12 [because of COVID-19], and we were still three weeks away from the merger. So we had to complete the merger and all of the integration remotely. And we had to spin off Carrier and Otis. All of that came to fruition on time and exactly as we had planned while working from home. The resilience and the ingenuity of our folks to figure all this out has probably been the most pleasing.

There was some concern that the cultures at Raytheon and the commercial guys at Pratt and Collins would never come together. That is the last thing I worry about. Everything we laid out has gotten done. We're on track for synergies in cost, technology and revenue. The difference is I have yet to have a staff meeting in person. I've got 17 people who work for me, and we do everything on Zoom. Each one of our three board meetings since the merger has been done on Zoom. If you had told me 3-4 months ago that we would be working from home for a good deal of time, I'd have really panicked. But we figured it out.

JULY 2020

InsideMRO™

FLIGHT PATHS FORWARD

How MRO Could Climb Out of COVID-19

WestJet's Fortuitous Decision

PRODUCT SUPPORT RANKINGS

Why OEMs Are Slipping

AVIATION WEEK NETWORK


Brains behind the brawn
Every day, pilots depend on our full authority digital engine controls (FADEC) for safely transporting passengers. We bring four decades of experience in designing and developing highly reliable, flight critical systems that operate in the harshest environments.
We Innovate For Those Who Move The World™.
baesystems-ps.com
BAE SYSTEMS

ANNETTE FEASAL/ASCENT AVIATION SERVICES

MAINTENANCE CHECK

The Path Forward

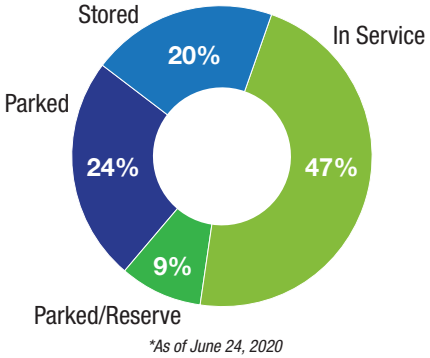
"You have to continue to be able to look around the corner."

Our industry's recovery is like putting together an 18,000-piece puzzle without seeing the picture on the top of the box. You know it's all going to fit together, but the process will be challenging and require patience and focus. But once small sections start forming, it will get easier and easier to assemble.

While the picture has not yet been revealed to us, we are seeing glimpses of what our 276 X 192-cm (9 X 6-ft. 4 in.) puzzle will look like.

For starters, 47% of the global fleet is back in service, compared to 38% last month, and the percentage of parked aircraft has dropped to 24% from 35% last month, according to Aviation Week's Fleet Discovery (see chart). Clearly, more aircraft flying is good for the aftermarket and the industry in general.

Fleet Status Share*



*As of June 24, 2020

Source: Aviation Week Network Fleet Discovery

Airlines like WestJet are taking advantage of parked aircraft downtime to move various projects forward. WestJet technicians have been upgrading Boeing 737 cabins to make the passenger experience consistent with its 787s. The Canadian carrier's technicians also creatively saved millions of dollars by covering flight controls and spoilers with hockey puck board to prevent hail damage. Chief Operating Officer Jeff Martin cautions that while it's easy to be consumed by the COVID-19 crisis, "you have to continue to be able to look around the corner." For instance, he and his team are seeking ways to reduce carbon emissions and save fuel. "You can't let your guard down right now just because you're in the middle of crisis; eventually we will be back in full competition mode, and low cost will win the day," he says. See page MRO 08 for the interview and AviationWeek.com/Inside-MRO for a longer version.

Another trend is that MROs and suppliers need to reinvent their offerings. "Aftermarket suppliers will need to establish more service-led approaches to remain competitive," says Kellstrom executive David Greenwell.

A key puzzle piece is digitalization, which has accelerated due to the COVID crisis. "We developed applications for communication, remote inspections and repair decisions," says Norbert Marx, Gameco's CEO and general manager. Allowing customers to review critical work remotely is crucial in these times and can make processes more efficient as well.

To attempt to show you as many pieces of the puzzle as we can, Aviation Week's editors have created a series of Flight Paths Forward articles, CEO video interviews and webinars—across all industry segments, including MRO, which can be accessed here: AviationWeek.com/AD-Week. I urge you to check it out.

If you think the 18,000-piece puzzle sounds daunting, Guinness World Records says the world's biggest puzzle consisted of 551,232 pieces and measured 14.85 X 23.2 m (roughly 48 X 76 ft.). Our situation is challenging, but it could be worse.

—Lee Ann Shay

Highlights

Qantas Plans Workforce Cuts, Groundings

Qantas Airways has unveiled a three-year strategy to prepare for a slow airline industry recovery, including laying off 6,000 workers, storing or retiring larger widebody airliners and raising A$1.9 billion ($1.3 billion) in new equity to fund its plans.

Job losses will affect Qantas and its Jetstar subsidiary. The company is estimating the 6,000 total cuts will include about 1,450 nonoperational and headquarters workers; 1,500 ground-operations jobs; 1,050 cabin crewmembers; 630 from the engineering division and 220 pilots.

The crew and engineering cuts partly reflect the airline's decision to retire its six remaining Boeing 747-400s about six months earlier than planned. Some jobs also will be lost as low-cost subsidiary Jetstar shifts aircraft maintenance from its Newcastle facility to another in Melbourne.

About 100 of the group's aircraft will remain grounded for at least a year, including most of the international fleet. The airline's 12 Airbus A380s will be stored for at least three years. Qantas intends to return the A380s to service eventually, but for now they are too big to match anticipated international demand, says CEO Alan Joyce.

Hackers Target MRO Provider

In early June, a U.S. subsidiary of ST Engineering—VT San Antonio Aerospace—suffered a serious cybersecurity breach. Ed Onwe, the aircraft MRO provider's general manager, reported that "a sophisticated group of cybercriminals, known as the Maze group, gained unauthorized access to our network and deployed a ransomware attack."

ST Engineering does not believe that IT systems beyond VT San Antonio in the wider group were also breached, but it is taking steps to strengthen its overall cybersecurity architecture nonetheless.

The company did not reveal what data may have been compromised, but Onwe acknowledged the need "to ensure that the data we are entrusted with remains safe and secure."

Taby Launches ATR Support

Sweden's Taby Air Maintenance (TAM) welcomed its first ATR 72 into workshops at Orebro Airport. TAM will offer a full range of support for the ATR 72 family of regional airliners, along with existing support for Saab 340s and 2000s.

The MRO is optimistic about the long-term prospects of the popular turboprop. Par Gulle, TAM's managing director, predicts solid and increasing future demand for ATR maintenance in Northern Europe and believes the ATR family will be the leading regional airline aircraft of the future.

Looking further into the future, Gulle says cargo conversions of ATRs by TAM also are possible. "We are evaluating that. With the know-how we have from doing numerous Saab 340 cargo conversions, I'd say a cargo conversion package for the ATR would be a natural next step after the Saab 340."

Garuda's Troubles Spread to MRO

GMF Aeroasia posted a $31 million loss for the first three months of the year, compared with a $3 million profit in the prior-year period. Hit by COVID-19 disruption to its airline customers, especially former parent Garuda Indonesia, the listed Indonesian maintenance company saw revenues fall and its cash decline to just $3 million, from $30 million at the start of the year.

The result is surprising given that in March, near the end of the quarter, the company reported higher demand from third-party customers because some airlines had been unable to land in China for scheduled maintenance.

However, this was not sufficient to offset the huge dip in business from its main customer, which accounts for almost 90% of GMF's sales.

GMF's weak finances have pushed it into breach of some financial covenants, forcing it to request a waiver from creditors and restructuring of its bank loans.

Contracts

ATR won a 10-year **Finnair** contract to maintain 12 ATR 72-500s for Nordic Regional Airlines under a pay-by-the-hour GMA program.

Duncan Aviation extended a deal with **Meggitt** to service/sell/distribute Securaplane batteries for three more years.

Elbit Systems won a five-year, $38 million contract to provide operation, maintenance and logistics for T-6 trainers for the **Israeli Air Force**.

FEAM Aero of Miami was selected by **Air Wisconsin** to provide CRJ200 line maintenance at Chicago O'Hare International Airport.

GE Aviation won a five-year, $180 million **U.S. Navy** contract to provide T700 repair/overhaul for MH-60, AH-1Z and UH-1Y helicopters.

IAI Aviation Group secured a **DHL International** contract to convert another three Boeing 767-300s to cargo; the deal includes an option.

Jet Support Services (JSSI) was selected by **Jetcraft** as a partner to establish a six-month post-purchase maintenance support package for its customers; the program will cover engines, airframes and APUs; operators can enroll for full coverage after six months.

Kongsberg Defense & Aerospace was selected by **Boeing** to provide sustainment and maintenance engineering for five P-8As on order by Norway; the agreement includes mechanic training, local parts distribution and a new service support center.

RUAG extended a contract with **Safran** to maintain fuel control units for Makila-powered Super Puma helicopters through 2021.

Triumph Systems & Support extended its deal with a North America-based independent MRO facility for repair and overhaul of CFM56, CF34 and CF6 engine accessories out of Grand Prairie, Texas, and Wellington, Kansas, for five more years.

Contracts Source: SpeedNews

Lack of Formal Inspection Procedure Linked to PW4000 Blade Failure

Pratt & Whitney's lack of sufficient training for an inspection process set the stage for a PW4077 fan blade to fracture, forcing the crew of a United Airlines Boeing 777-200 to shut the engine down and declare an emergency while en route to Honolulu from San Francisco, the National Transportation Safety Board (NTSB) says in its final report.

The February 2018 incident's roots trace back to 2005, when Pratt developed a thermal acoustic imaging (TAI) inspection process for the interiors of hollow-core PW4000 fan blades. When the process was introduced, Pratt followed "standard nondestructive testing industry practice" and categorized it as "new and emerging," meaning it could be used while formal training requirements were being developed. But Pratt did not develop a formal, extensive training program until after the United engine failure.

From the outset of the inspection program to the time the United Airlines fractured fan blade was inspected and up to the time of the incident, Pratt "did not have a defined training and certification regimen for the TAI inspectors" at the company's East Hartford, Connecticut, overhaul facility, the NTSB says.

Instead, the technicians were given about 40 hr. of on-the-job training. By contrast, eddy current and ultrasonic inspection training programs include 40 hr. of classroom learning and at least 1,200 hr. of practical experience, the NTSB says.

The NTSB found that the lack of a formal TAI training program contributed to technicians misdiagnosing an issue multiple times on the United blade that failed, mistakenly believing the finding was a product of the TAI process, not a problem with the blade.

"At the initial TAI accomplished on the fractured fan blade in 2010, there was a small indication at the location of the origin of the crack," the NTSB says. "Review of the records from the 2015 TAI shows that there was a larger indication in the same area. At the time of each TAI, the inspectors attributed the indication to a defect in the paint that was used during the TAI process and allowed the blade to continue the overhaul process and be returned to service."

The 40.5-in., No. 11 fan blade fractured across the airfoil about 1.44 in. above its fairing at the leading edge and slightly below the surface of the fairing at the trailing edge, the NTSB says. "Laboratory examination of fan blade No. 11 revealed a low cycle fatigue fracture that originated on the interior cavity wall directly below the surface."

The incident occurred as United Flight 1175 was cruising at FL360 en route to Honolulu. "The flight crew heard a loud bang that was followed by a violent shaking of the airplane followed by warnings of a compressor stall," the report says. The crew shut down the affected No. 2 engine, declared an emergency and proceeded to Honolulu without further issues.

Post-incident examination showed that "most of the inlet duct and all of the left and right fan cowls were missing," the NTSB says. Fan blade fragments also caused two "small punctures" in the right-side fuselage.

Soon after the incident, Pratt "reported that they had developed a curriculum for TAI initial and recurrent training," the NTSB says. It also reviewed records for all 9,600 PW4000 112-in.-dia. fan blades that had been previously inspected. A March 2019 FAA airworthiness directive mandated recurring inspections for all in-service blades.

—Sean Broderick

TONY OSBORNE/AW&ST

A 2018 PW4000 fan-blade fracture triggered a fleet-wide inspection effort.

AVIATION WEEK
Fleet&MRO
FORECASTS

DISCOVER
ANALYZE
PLAN
FORECAST

2021 Fleet & MRO Forecasts
Coming Soon

Predictive Intelligence to Drive Results

With Aviation Week Network's **Fleet & MRO Forecast**, gain a 10-year outlook to **minimize risk** and **maximize revenue**.

- Fleets, trends, and projections
- Predictive view of market share
- MRO future demand

Take your business to the next level.

For more information, visit
aviationweek.com/forecasts

or call Anne McMahon at +1 646 291 6353
or Thom Clayton +44 (0) 20 7017 6106

Available for:
COMMERCIAL
MILITARY
BUSINESS
HELICOPTER

AVIATION WEEK
NETWORK

ARSA UPDATE

The Grandness of Nothing

ON MAY 27, THE WORLD WATCHED as two American astronauts waited for liftoff from Cape Canaveral.

Bob Behnken and Doug Hurley were set to ride the SpaceX Crew Dragon capsule into orbit and rendezvous with the International Space Station (ISS). The Falcon 9 reusable launch vehicle was taking on liquid oxygen fuel, the president and vice president of the U.S. were standing by and millions of viewers were watching.

After weeks of anticipation and media buildup, the day had arrived. Everyone watching, including my family and me, was being reminded constantly about the importance of the moment: The first launch of American astronauts on an American rocket from American soil since the retirement of the space shuttle program in 2011.

Then, nothing happened.

Actually, that's not true: Something very important happened . . . that resulted in nothing happening.

Seventeen minutes before the scheduled 4:33 p.m. EDT launch, controllers scrubbed the mission. Though the weather, which had been questionable all day, was clearing, all required minimums would not be met by T-0 seconds. The astronauts and their rocket were staying put.

"People say to me, 'With all of the attention of the world on this launch, with all of the VIPs coming, are you going to feel pressure on this launch?'" NASA Administrator Jim Bridenstine recalled for the media. "If we are not ready to go, we simply do not go. I am proud, so proud, of our teams working together to make the right decision in this particular case."

During the first round of sessions for ARSA's Human Factors training series, I trained on the impact of pressure on performance in aviation maintenance. The element is part of "the Dirty Dozen," the short list of key factors affecting human performance, so it is given special attention.

A key aspect of that session was challenging the assertion that anyone can "work best under pressure." We've all had friends or colleagues who insist they always come through "better" when expectations, time constraints, resource limitations or other "human" factors place the highest strain on their ability to meet outcomes.

Is that true? Maybe, if you are conditioned to perform that way as the NASA team is, but in reality, most of us don't reach those heights.

Higher states of "arousal"—the measurement used by psychologists Robert Yerkes and John Dillingham Dodson in 1908—will produce heightened attention and care and improve performance results up to a point. In particular, the Yerkes-Dodson "Law" suggests that for simple tasks depending on reflexes or instinct (running from imminent danger, perhaps), execution improves as arousal mounts.

There are few simple tasks in modern life, let alone in aviation maintenance. For difficult activities, there are points of pressure beyond which performance degrades. Maintenance of aircraft requires careful attention, effective working memory and clear decision-making. Put simply: A little pressure keeps you focused; a lot turns you into a mess.

"It might surprise you that nobody performs better under pressure," explains the Institute for Human Health and Potential, going beyond Yerkes and Dodson by focusing entirely on higher functions. "Regardless of the task, pressure diminishes our judgment, decision-making, attention and performance."

Accepting that few are at their best under pressure, consider how to mitigate its effects on performance: prioritize and coordinate. Both individuals and organizations should establish—and consistently review—mandatory work standards and the resources required to meet those outcomes. In pursuit of those goals, all persons must focus on their roles ("stay in your lane") and communicate status and needs according to established plans and procedures.

Bring those mitigations back to the launchpad and the "no-go" decision made on May 27. The engineers and technicians relied on specific safety standards, communicated issues and—most important—relied on each other to critically adhere to the requirements of a successful launch. If the weather team says no, the mission is scrubbed—no matter the external pressures produced by the president, the media and the world.

So we all had to wait. Air Force One flew back to Washington, the media packed its cameras, viewers around the world returned to other programming, and Bob and Doug boarded their vehicle for a very earthbound ride home. Everyone came back to do it again on May 30. At 3:22 p.m., the commercially built rocket and crew capsule were successfully piloted into orbit and on course for rendezvous with the ISS.

The launch was a rousing success, a grand event at the end of May. The reason why? Because a few days earlier . . . something even grander happened: nothing.

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

WestJet Airlines

COO Jeff Martin talks with Lee Ann Shay about how the Canadian carrier has weathered COVID-19, hail and the 737 MAX grounding.


WESTJET

How have you handled crisis management?

We had decided pre-COVID that we were going to invest in our OCC (operations control center) and set up an ICC (incident command center) for business continuity. That's something that a lot of airlines talk about but few ever model: Could we run the airline remotely if we had to? So fortunately, we had gotten ahead of this, and our previous CIO Craig Maccubbin had placed the whole airline on Microsoft Teams, which was fortuitous. As our new OCC and ICC were nearing completion, we saw what was happening in Asia, so we activated our ICC probably earlier than others.

Our business continuity meetings involved all of the major airline stakeholders, led by myself. What would we need to do if the airlines should come down to a much smaller size? What grew out of that, thankfully, was our early engagement in procuring personal protection equipment (PPE) for our employees and guests. And then we started setting protocols in place, in advance of COVID, and then the waves started to occur.

Then the available seat-mile reductions started to hit like they did everywhere else, and we soft-landed the airline. Our quick reaction allowed us to put the airline in a stabilized fashion probably right on target of where we hoped it would be.

How did you handle parking the aircraft?

My ops planning team did a phenomenal job as we parked every airplane they managed it so that we didn't have to relocate the aircraft again. So we knew when that airplane landed, we were going into our COVID stabilization mode: The aircraft would not have to be relocated. That saved us millions of dollars of fuel. I have to hand huge accolades to the fleet-planning team in combination with the network and commercial team to do that. Because we knew, like everyone else, that liquidity was going to be ultra important. And every dime that we didn't spend on fuel was going into the bank.

How have the OCC and ICC worked?

The operations control center has many names throughout the airline industry. It's where dispatch resides. The model here is that the OCC manages day-of operations. Embedded in the OCC is a standalone ICC, which is there for emergency command or business disruption. So the two sit side-by-side. The goal is that the OCC will run day-of, and if at any point the OCC is faced with a lot of challenges, like in the case of COVID, we'd bring the day-of into the ICC.

Since COVID, we quite honestly managed the airline from there. We started out having two calls a day that included myself, the CEO and all of the executive leadership team. It was a readout that would consist of 30 sec. to 2 min. from every business entity on: How are you functioning today? What do you need to make sure that the airline can operate? Are you ready to take us into the next phase? We started on March 13 and kept that cadence for almost 60 days. And as we successfully brought the airline down, parked the aircraft and stabilized the network to where we are now, we went to once a day and now we're down to twice a week. It was so important to be talking twice a day across the entire enterprise, because it's not just operations; it was the network, it was commercial, it was sales, it was marketing. It gave us the ability to have the airline on the same page.

While we were doing this remotely, the new OCC-ICC construction was complete. So we moved into the brand-new OCC ICC on June 1. Although most of us are still working remotely and working on Microsoft Teams, we do now have an industry-leading, phenomenal facility. So that's in place for us when we start to bring the network back. Because of this investment, we're going to do it in a better state than we did before from an operations efficiency standpoint. We were the No. 1 airline for on-time performance for April and May for North America.

For May alone, we ran 98.1% on-time. And even though the network is smaller, that tells me the teams are still executing to the strategies and theories that we put in place. So the new facility will only make that even better as we start bringing our schedule back. Guests want an airline that's on time. And that usually mirrors itself in high Net Promoter Scores (NPS), which we've seen a huge increase in this year. Changes to Net Promoter Scores almost identically parallel on-time performance.

Speaking of the fleet, what's parked, and what models are coming back?

Instead of saying what models are coming back, we look at what markets are coming back. Given our network, the Q400s are very important for us. Those 47 aircraft feed our major hubs and tie into the 737s and 787s. So we're slowly bringing back, proportionately, the fleet, and it will change monthly based on where we're finding the demand. It's safe to say we're flying the 787s only transcontinental right now while we await relief from border controls. Pre-COVID, I can tell you we were extremely pleased with the 787s. They have exceeded our analysis and predictions of margins, and our predictions for reliability and our predictions for guest satisfaction and NPS. And I have to attribute that to the really good work that went into the entry-into-service teams.

We took a unique approach. When you procure an asset of that size, you need to make sure that your team is really ready to deploy it. That was a huge step for us, because even though we had the 767, we were increasing the

level of service that we were going to introduce with a business class prior to our previous premium offerings. Before we started revenue service, we made practice flights. We did practice pushes and turns because the aircraft has industry-leading technology. We want to know how to interface with that.

When we went into that first revenue flight, our WestJetters—from inflight to maintenance to tech ops to ground ops—were comfortable with the aircraft. We far exceeded our expectations for the 787. Boeing said our entry into service was one of the best it had seen.

My tech ops team talked to Boeing and every 787 operator that looked similar to WestJet. So we knew the challenges. We knew the uniqueness of the aircraft. We knew the things that we needed to do to make sure the reliability was high. We have 10 firm orders.

How did WestJet come up with the puck-board idea to protect aircraft from summer hailstorms?

Canadians are the hardest-working people in the world, and they're very resilient. They have figured out how to de-ice probably better than anyone in the world. They figured out how to keep a fleet warm. But we've also learned here in Calgary that we're highly prone to hail, especially at this time of year. So when we knew that we were going to park roughly 150 of the 181 aircraft, the team designed the protection for the spoilers, which are highly susceptible to hail on the 737 fleet.

They designed and cut the protection from hockey puck boards—attached to the top of every spoiler across the entire fleet. On June 13, we had one of the worst hailstorms that anyone can recall. The hockey puck boards on the 737 spoilers resulted in zero damage. Other aircraft had some surface damage. The puck board shows how creative this tech ops team can be. They did it with little fanfare and quite honestly protected the whole 737 fleet that was parked here by doing this.

Did the ownership change of WestJet change your aftermarket strategy?

I don't think it has changed our aftermarket strategy. The transition went really well because we had been working in advance of legal close, so we were comfortable with Onex and the managing directors and the team. What we found was another team of partners who are analytically astute and who know the industry well. They're letting us run the airline. We understand the lines—they are the owners—but we operate the airline and we make the strategic decisions.

But that partnership is a testament to how well we landed in COVID and how quickly we made the decisions we did around liquidity, the fleet, the network. It shows that Onex and the leadership team were very much in synch.

Digital Extra *Read the extended interview:* **AviationWeek.com/JeffMartinWestJet**

The Aftermarket's Reco

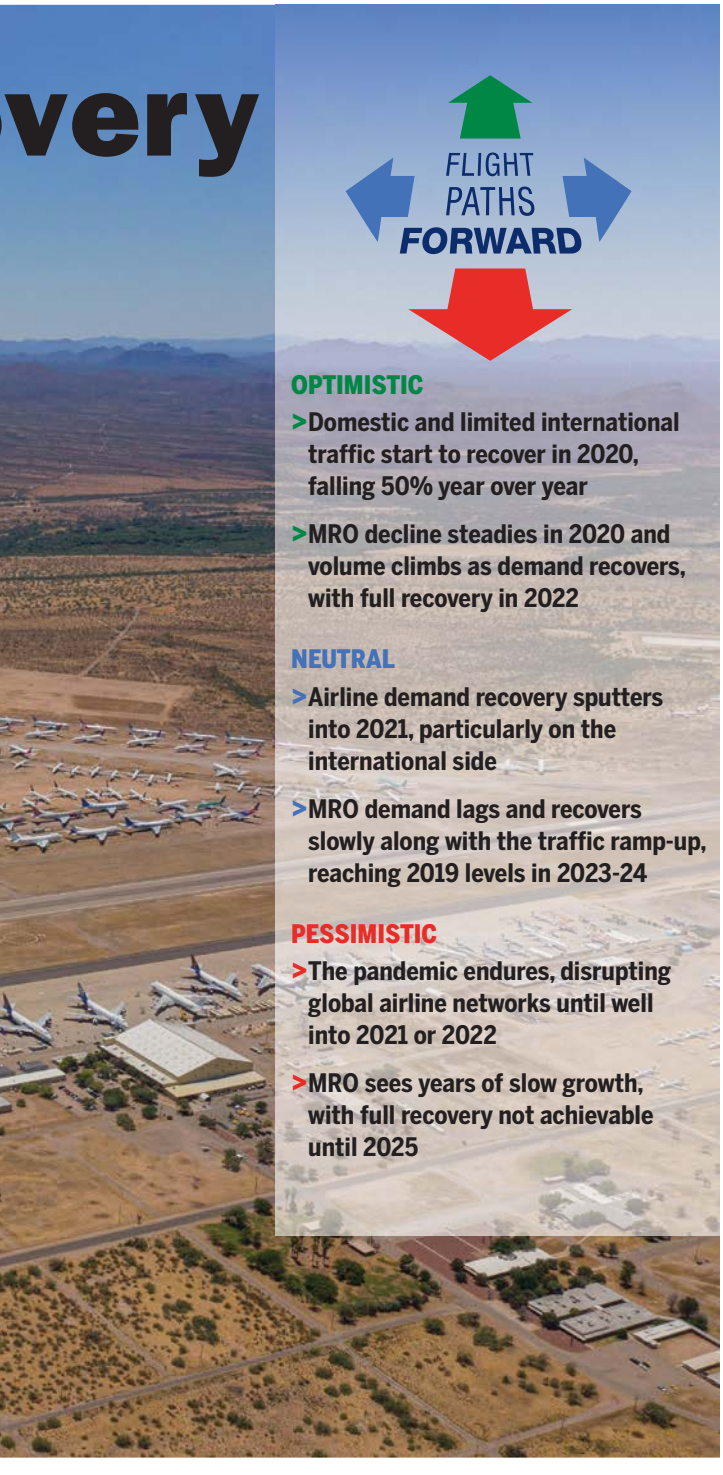
Building scenarios around what **recovery means**

Lindsay Bjerregaard and **Lee Ann Shay Chicago** and **James Pozzi London**

The aviation aftermarket is starting to rebound, but it will be anything but a smooth, steady climb upward. The uneven path is sure to include some jagged spikes that will hurt. While conventional wisdom predicted that the Asia-Pacific market would recover first because it was the first affected by the COVID-19 pandemic, now even that does not seem clear.

On June 24, Guangzhou Aircraft Maintenance Engineering Co. (Gameco) broke ground on new $90 million component and composite repair centers that are planned to open in 2022 to help it further expand its already extensive capabilities. In contrast, the following day Qantas announced that it is cutting 20% of its workforce and does not plan to resume most international flying before July 2021.

What is clear is that a few markers will heavily influence the path forward—a big one is coming in September, when many airlines will adjust their flight schedules based on customer demand and when payroll support funding provided through the Coronavirus Aid, Relief, and Economic Security (CARES) Act, which comes with restrictions on layoffs, is set to expire. The recovery also needs business travelers, who will require both corporate clearance and increased flight frequencies to resume road-warrior travel; when that will happen is unclear, given current restrictions on international travel. What will the travel season be like in the Northern Hemisphere in summer 2021, when airlines are hopeful that travel demand will surge for the vacation season? And of course, the big question mark is the timing of an effective novel coronavirus vaccine, which would restore confidence in travel.



ASCENT AVIATION SERVICES

Ascent Aviation Services has more than 400 aircraft parked at its center in Marana, Arizona, and more at its Tucson facility.

The good news is that the industry appears to be at or near the bottom of the market, with aftermarket suppliers starting to see an uptick in lower cost components, for example. "May was one of the toughest months that we saw because repair activity that had already started was finishing, and there weren't any new inductions involving engine or component repair," says Tommy Hughes, CEO of VAS Aero Services. By the end of May, business was starting to pick up, "especially on the engine side," he says.

However, do not expect overall MRO recovery to be rapid. Hong Kong Aircraft Engineering Co. (HAECO) expects the MRO business to "come back strong and fully recover in the next two to three years," says CEO Frank Walschot.

In other words: Plan for the worst, but hope for the best.

THE FLEET: WHERE WE ARE

Global passenger airlines grounded their fleets in response to a historic drop in demand but are steadily resuming flight schedules, with domestic and short-haul flights returning faster. Airlines are adjusting to projected new (and lower) demand forecasts. These, coupled with airlines in financial difficulty that may not resume operations, means thousands of aircraft most likely won't return to service—with planned retirements of older aircraft accelerating, resulting in a younger fleet.

Oliver Wyman expects more than 2,600 aircraft to be retired in the next year, compared to 550-750 aircraft annually over the last five years. This, along with lower aircraft utilization, could eliminate 53% of the $91.2 billion MRO market in 2020.

Based on "an extreme example, where every aircraft over the age of 20 is retired (8,272 units), the average fleet age drops to 8.5 years from 10.8 today," a Jefferies report predicts. If this were to happen, Jefferies expects a 14% decline in the addressable aftermarket by 2023.

Between May 28-June 12, Aviation Week Fleet Discovery data shows that 2,085 aircraft returned to in-service status and 656 moved out of semi-active parked reserve status, flying 1-2 days per week. Meanwhile, 51 aircraft were retired during this period and aircraft in storage climbed by 444, indicating that airlines are further defining their fleets. As of June 12, 44% of the fleet was in service, the vast majority of which are narrowbody aircraft. Of the parked fleet, 63% is leased, according to Fleet Discovery data.

The oversupply of passenger aircraft is affecting values. On average, narrowbody prices have declined 10-20%, and widebodies have dropped 15-30%, says Adam Pilarski, senior vice president at Avitas, who emphasizes that there can be big differences depending on variables such as aircraft age, type and engines. Freighter aircraft prices have remained stable, he says.

Jefferson Ding, team leader for aircraft technical asset management at lessor Dragon Aviation Capital in Singapore, says he has heard of sale-and-leaseback transactions at prices 30-40% lower than prepandemic rates, as airlines grabbed whatever cash they could. "In the longer term, different classes of assets will come back to normal levels faster than others," he says. "For instance, the [Airbus] A321 will regain value and remain constant due to its suitability to a variety of markets, including the passenger-to-freighter market."

While the cargo market has been a bright spot, do not expect a dip in aircraft prices to lead to a surge in cargo-conversion demand. Air Transport Services Group (ATSG) is "always in the market looking for aircraft," Chief Financial Officer Quint Turner says, but the aircraft purchase price has less of an impact in conversion demand because the feedstock is "less than half the overall cost" of a passenger-to-freighter aircraft conversion, he says. In early June,

ATSG announced an agreement to lease 12 additional Boeing 767-300 converted freighters to Amazon.com Services for 10 years. One was already delivered, and the other 11 will be delivered in 2021. Israel Aerospace Industries completes the conversions in about 100 days, says Turner.

MRO RECOVERY

"Typically, airframe MRO has been more insulated from the downturns we've seen in the past," compared to engines and component MRO, "but of course we're in new territory here," says Greg Colgan, CEO of MRO Holdings. "We saw our 2020 contracted work drop by the end of March by almost 80% for the end of year" from its projections just a month before, he says.

MRO Holdings, which operates Aeroman, Flightstar, TechOps MX and North State, has "recovered and stabilized to some extent for the third quarter," but it is interacting with customers frequently as they develop different scenarios for their summer 2021 schedules," Colgan says. "Because airframe MRO requires careful planning with six- and 12-month schedules, it can have a big impact on third-quarter/fourth-quarter 2020 workloads for them to have fleets ready by summer 2021."

Instead of the 8.5 million maintenance work-hours it was planning for in pre-COVID-19 2020, MRO Holdings now anticipates logging 5-6 million. Because the organization was running its operation and cost structure for 8.5 million hr. when the pandemic started, "We were essentially pushing the top speed of a sports car one minute and then testing braking distance the next minute," says Colgan. The abrupt braking forced it to reexamine processes and procedures, which Colgan thinks will be beneficial.

ATS CEO Matt Yerbic thinks its business bottomed out during May and June, but he expects softness to remain through the rest of the year. ATS received a CARES grant to help with costs through Sept. 30, and does not anticipate returning to 2019 business volumes until 2022.

However, like MRO Holdings, ATS examined its operation when the pandemic struck and has identified opportunities to "reduce costs and drive efficiencies," Yerbic says, initiatives he expects to announce in the third quarter. ATS is operating five maintenance lines now and expects to add single lines in June, July and August, bringing the total to eight—all located in Everett, Washington.

Gameco did not lay off any staff but—like many others—cut costs, postponed hiring and leaned-out processes. "We always had a big number of cargo airline customers, and their demand for maintenance is strong. China Southern allowed us to pull forward some maintenance on grounded aircraft, so our heavy maintenance is now close to plan," says Norbert Marx, Gameco's CEO and general manager. China's domestic air travel market is "showing its strength in recovery," so the company's line maintenance business is recovering in tandem. Marx says work related to lease returns, maintenance on grounded aircraft, and cabin solutions for disinfecting and passenger separation are also picking up.

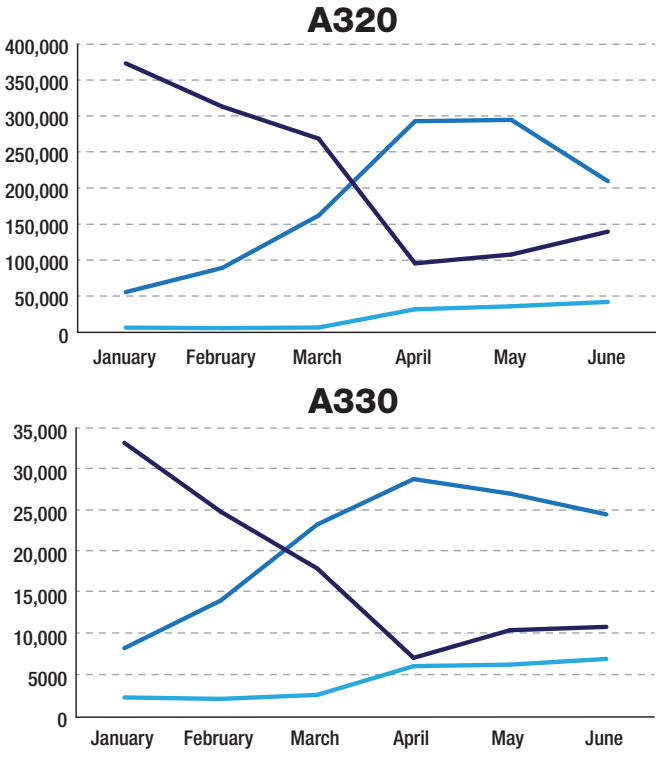
Gameco is adding several new capabilities as well: the start of its first 737-800 Boeing converted freighter on June 16; CAAC Part 145 approval for the first Comac aircraft, the ARJ21 which soon will enter China Southern's fleet; three new lines of A330 heavy maintenance services at the new Beijing Daxing International Airport; and new component and composite shops targeted for a 2022 opening.

"Our financial performance for 2020 and 2021 is expected to be less than 2019 and below the original plan," Marx says. Those were viewed as transition years as the new capabilities and shops came online. But with the pandemic, "it's time to restructure and align the organization," he explains, including implementing change more rapidly.

Ascent Aviation Services is maintaining more than 400 parked aircraft at two airports in the Tucson, Arizona, area and can tear down up to 15 per month. Short-term storage accounts for about 65% of the total, but "we are transitioning some to long-term storage as this crisis continues," says Scott Butler, chief commercial officer of Ascent. While reclamation inquiries "have slowed down a bit, the aircraft we are getting requests for are the 'blue chip' aircraft: younger A320s, 737NGs, 777s, 767s and A330s," he says. He thinks the retirement of older, less-efficient aircraft is partly driven by "a renewed focus on sustainability in the aviation sector."

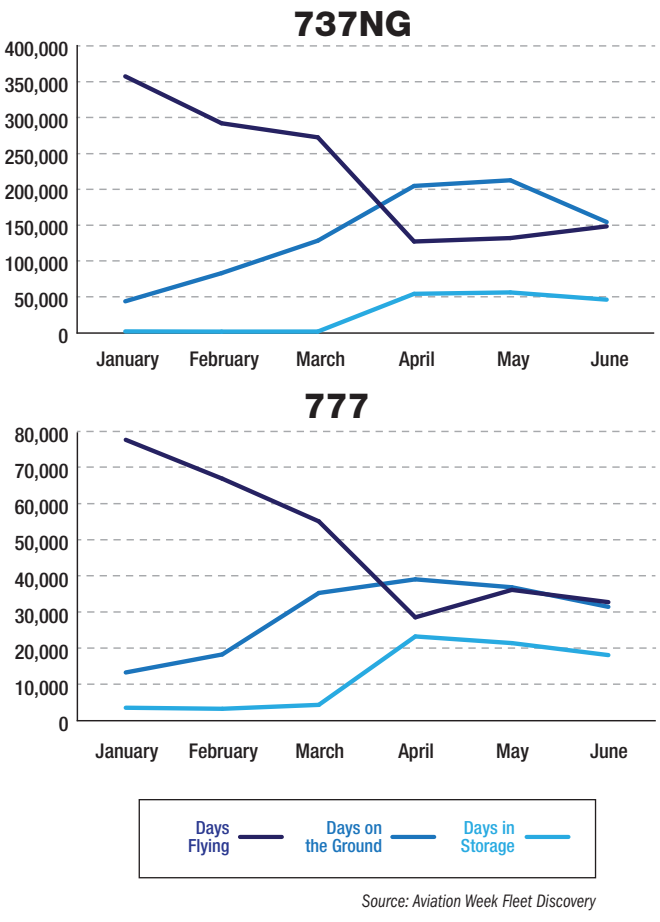
Joramco, the Jordanian MRO, is seeing a strong demand for end-of-lease checks and parking service, which Chief Commercial Officer Fraser Currie thinks will last another

Narrowbody and Widebody



These graphs, based on Aviation Week Fleet Discovery ADS-B tracking data, provide a holistic view of the status of each these four aircraft fleets, which include pre-service, in-service, parked reserve, parked and stored aircraft.

Fleets Status Snapshot



Source: Aviation Week Fleet Discovery

For more information about Fleet Discovery and other Aviation Week Network data products, go to **pgs.aviationweek.com/FleetDataServices**

12 months. He does not "anticipate a significant change to annual volumes, but we do see a change in the seasonal profile of when checks come to us." That's because with many airlines "taking advantage of extended MPD (maintenance planning document) tasks there is a slight shift in the seasonality, with some summer work being pushed to winter and vice versa," says Currie.

Could the shifting maintenance tasks lead to a bottleneck?

Colgan says: "My outlier concern right now is around airframe capacity in 2021 because airlines delaying maintenance now could create a surge later, even with the forecasted aircraft retirements. The size of the surge will clearly depend on the pace of recovery, but we believe there is some form of surge coming."

PARTS

Expect parts repairs and sales of parts manufacturer approval (PMA) parts and used serviceable material (USM) to increase as airlines seek to conserve cash. ATS has seen a 35% reduction in component repair volume but "the number of parts arriving at our facilities for repair works has increased the last 20 days between 120-200%, depending on location, from the trough," says Brian Olsen, president of component and engineering solutions at ATS. PMA sales volumes are still down, but "airline customers have indicated this will improve in July," he says.

"In general, pre-COVID-19, what Naasco found is anyone that maintains responsibility for their own [profit-and-loss statements] aggressively looked for ways to lower the operational costs while improving reliability," says Michael Leslie, CEO of component-repair specialist Naasco. "As the national and international markets begin to open back up, Naasco has seen similar patterns."

On the USM front, the million-dollar question is what will hit the market, and when. "Prices will definitely be impacted but the question everyone has is 'what is the market value of a 737-800 in 6-12 months?' It's all based on supply and demand," says Tommy Hughes of VAS. There's a bit of wait-and-see now because owners want to maximize the value of parts from a teardown, so when to proceed with the teardown to maximize value is a key question for industry players.

Teardown capacity is another issue. "You could have 5,000 aircraft retire, but how many aircraft can be dismantled in the course of 12 months?" asks Hughes.

Kellstrom Aerospace predicts that supply of USM will exceed demand for a while—with the initial surplus coming from widebody aircraft, says David Greenwell, vice president for sales and marketing. This could help cargo operators that fly widebodies.

While Kellstrom has not noticed a threshold for parts price sales, it has noticed "that time for approval of purchase orders has increased as most airlines or MROs have added additional sign-off requirements on inventory procurement," unless it's for AOG or immediate use, says Greenwell.

"We see material costs for airframe material decreasing but do not anticipate this happening with key USM for many engines," he adds. This parallels demand for green-time engines, particularly for popular narrowbody engines such as the CFM56-5B and -7B, as well as the V2500-A5. He expects strong demand for those green-time engines into 2021, which will decrease demand for engine shop visits.

ENGINE POWER

OEMs and independent MROs are seeing a slowdown in engine inductions but increased requests for engine preservation support and maintenance deferrals. Customers are seeking flexibility.

MTU is seeing "a move away from the traditional planning, with fixed maintenance intervals, to more customized and individually tailored solutions," says Martin Friis-Petersen, senior vice president for MRO programs. Some customers are focused on short-term cost savings while others focus on long-term strategies.

Many are seeking to restructure service contracts to maximize their options.

Pratt & Whitney's shops have been upgrading geared turbofan engines to the latest configuration, and the company says that more than half of the fleet is now active.

While the crisis has given shops time for such upgrades, it also is forcing faster innovation. For instance, MTU is

integrating its engine trend-monitoring tool into its engine fleet management software to evolve its predictive maintenance—moving it toward making prescriptive recommendations to help "forecast remaining on-wing time and optimal engine and module removal points," says Friis-Petersen.

HAECO is optimistic about the engine MRO business in the future, as shown by its acquisition in March of Jet Engines Solutions, an engine MRO based in Dallas. The purchase is part of the company's strategy to grow its engines business and "heralds the entry into the narrowbody engine market, including the CFM Leap and Pratt & Whitney geared turbofan platforms," says Walschot. This acquisition follows the opening of a Global Engine Support location in Amsterdam last year.

MERGERS & ACQUISITIONS: WHAT'S UP?

Over the past five years, the commercial aftermarket has been characterized by a steady stream of M&A activity. Viewed by the financial world as a relatively stable industry able to generate strong returns, MRO providers have consistently remained attractive to investors.

One of the sources of this financing has been private equity companies, which have consistently poured money into the MRO segment. In the past 18 months, deals such as the Carlyle Group acquiring StandardAero, Greenbriar Equity Group buying into STS Aviation and Ardian's acquisition of Revima have further highlighted private equity's affinity for the commercial aftermarket.

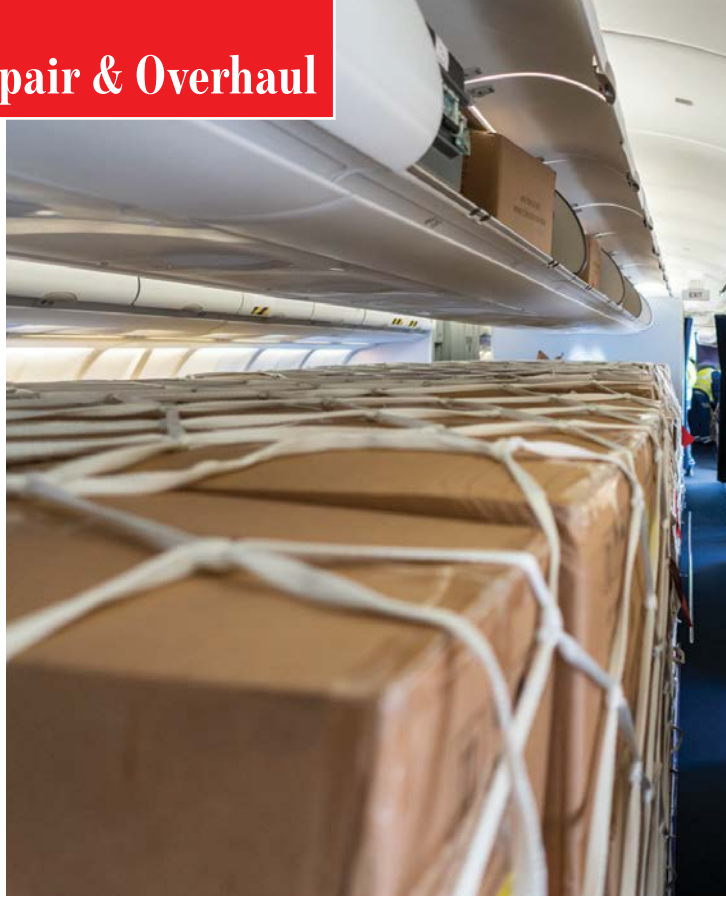
However, given the impact of COVID-19 on financial markets, any deals will take time to develop.

"In the near-term, M&A largely gets put on hold . . . any M&A deal takes two to tango, with a willing buyer and a willing seller," says Azad Badakhsh, managing director of Moelis & Co. "If you're a buyer in the current aftermarket business, it's very hard for an investment team to come up with a base case to take to their respective board or investment committee."

Airline fleet groundings and deferral of maintenance work by cash-conscious carriers will put pressure on many MRO providers, which could force some deals. "Most companies are very loath to sell in the current market environment because it's very unlikely they'll be able to come close to maximizing value," Badakhsh says, but he adds that "there are going to be some distressed sellers who won't have a choice."

With reduced production rates, airframe OEMs are expected to retain an aftermarket focus, and some analysts believe they may look to form more alliances with MROs. Well-backed independents have also been tipped to grow market share through buyouts and investments, and some are viewing the current crisis as an opportunity. It is expected that smaller independents and family businesses may be swallowed up. This is most likely for those focused on repairs for maintenance-intensive legacy aircraft types operating in what will become an even more new-generation-focused market.

Despite the uncertainties remaining, and many companies waiting for better indications of what a market recovery will look like, some independent companies still see an opportunity. Risto Maeots, CEO of Magnetic MRO, says the company would look at possible acquisitions. "We have to come out of this crisis first, but we are also looking at ways to keep growing afterward," he says.



TECHNOLOGY ADVANCES

The MRO industry was focusing on implementing new technologies prior to COVID-19, and the crisis has jump-started efforts at many companies to use technology as a way to cope with travel and social distancing restrictions.

Providers of augmented reality (AR) and remote-collaboration platforms have reported a huge increase in demand since March. Librestream says it has experienced a 745% increase in usage of its Onsight mobile collaboration platform, and Atheer has seen a 200-300% increase in usage of its AR platform by front-line teams, fueled by factors such as travel limitations and a production ramp-up of essential items such as medical equipment and cleaning products.

A number of MROs have started experimenting with or offering services using remote-collaboration technologies. A popular use case has been virtual inspections, both for aircraft and facilities. Lufthansa Technik is offering virtual borescope inspections in the wake of travel restrictions, enabling customers to follow engine inspections live from their locations and to communicate with technicians in real time.

Magnetic MRO recently conducted its first test of a visual aircraft inspection, which consisted of preparing video material of both the airframe and interior using a structured file system so potential customers could efficiently locate and analyze sections of the aircraft. The MRO says this technology will be used in the future both for situations where travel restrictions are in place and in other cases when physical inspections are not possible.

"Challenges the industry is facing can be tackled and solved by the implementation of digital solutions—and [the] aviation industry should be at the forefront in using innovative methods instead of being blinded by the routine," says Tonno Toompuu, engineering manager at Magnetic MRO.

Lufthansa Technik offers a service to enable airlines to quickly convert their passenger aircraft into auxiliary freighters.

LUFTHANSA TECHNIK

"We should maintain focus on [the] ultimate goal and find new ways to work."

MRO Holdings, already exploring virtual technology before the pandemic, used video conferencing on a mobile device to facilitate a regulatory inspection of a facility expansion at one of its repair stations in April. The virtual inspection enabled the regulatory representatives to see everything they would have if they had been on-site, while providing more digital evidence than they normally would have obtained.

On the regulatory side, the FAA released guidance earlier this year on using technology such as cameras and video conferencing for tasks such as conformity inspections and engineering and ground tests. While the guidance does not exclude specific technologies or products, it does note that video quality should be sufficient for the task and provide some method of validating that whatever is being recorded is happening where and when it is supposed to occur.

Other technologies, such as AR and drones, are also seeing more interest as the crisis spurs the industry to embrace innovation. Western Michigan University noted during a recent ATEC webinar that the current situation is an opportunity for technology innovation, with one instructor creating a mixed reality program using an AR headset to enable students to see inside, take apart and reassemble CFM engines.

PTC recently worked with the Air Force 58th Special Operations Group at Kirtland AFB, New Mexico, to use its Vuforia AR software to capture heavy maintenance processes for Bell-Boeing CV-22 Osprey aircraft that can be used for training technical personnel. PTC notes that new social distancing requirements will accelerate the need for new tools and techniques when it comes to training or reskilling technical staff post-pandemic.

HAECO is testing laser-ablation cleaning and robotic painting, AR glasses and drones for aircraft inspection.

Donecle, which specializes in providing automated aircraft inspections by drone, says there has been renewed interest in the ability to share inspection data remotely—both from existing customers and new prospects. "Many of our recent discussions have revolved around our system's ability to immediately upload and share inspection data with colleagues or clients to provide a complete and objective view of an aircraft's structural condition," says Josselin Bequet, CEO of Donecle.

"A second concern is a spike in maintenance work that has been deferred due to the current shortage," says Bequet, noting that some regions already facing skilled labor shortages had to lay off a portion of their workforce due to the COVID-19 crisis. "Several organizations expect to be understaffed in late 2020/early 2021 and automated drone solutions will be a force multiplier, both in terms of physically conducting inspections but also to analyze inspection data and issue reports."

Increased use of data analytics is also predicted. HAECO is developing a "real-time monitoring and big data platform that correlates aircraft sensors and airline data, without aircraft modifications," says Walschot, to enable early fault detection and predictive maintenance.

LOOKING FORWARD

Opinions on the recovery's pace vary, with agreement that the path will be long, with many painful steps along the way. Avitas's Pilarski predicts that airline traffic will not return to 2019 levels until the end of 2023 or early 2024. He sees global economic activity picking up in 2021 but thinks there will be a deeper disconnect between economic recovery and airline traffic due a recession predicted before COVID-19 broke out. If that happens, demand for new aircraft will also drop.

Other industry analysts' predictions also paint a gloomy picture for the rest of 2020. Teal Group's Richard Aboulafia has forecast that aircraft services revenue could be up to 75% lower in 2020 compared to last year, while consultancy Alixpartners, estimates a drop between 60-65% for this year.

In the engine segment, the near term will see large revenue declines, with consultancy AeroDynamic Advisory predicting that engine MRO demand will fall 60%.

While pointing to the importance of market analysis to paint a picture of the future, Andreas Drosdowski, head of maintenance Europe and CEO of Lufthansa Technik Maintenance International, believes line maintenance will be the first segment to pick up. "We see even more storage programs coming up which will generate work," he adds.

Jonas Butautis, director of Australia-based Heston MRO, believes the company may adopt a more regional approach after COVID-19, albeit one still centered on passenger travel. "Our customer pool may change to a more local or regional one, but we will still work with commercial airlines in the region. There are still some 30 times more passenger than cargo aircraft globally, so this visual increase in importance of cargo aviation will not generate a major shift in MRO trends for the industry players."

Keren Rambow, a GE Aviation marketing services executive, summarizes the market position well: "The recovery demand will dictate the levels of aftermarket supply."

OEMs' Customer Support Rankings

CFM topples Boeing as the highest-ranked OEM in latest survey

Lee Ann Shay Chicago

CFM International has become the highest-rated customer service MRO company, beating out Boeing, which held that position for the last two years, based on the third annual Air Transport Aftermarket Customer Satisfaction Survey, done cooperatively by *Inside MRO, Air Transport World* and AeroDynamic Advisory.

All of the engine OEMs, in fact, improved their overall scores this year except for Rolls-Royce, which slipped to the lowest-scoring engine OEM in the survey. Rolls-Royce has been plagued by Trent 1000 intermediate-pressure turbine and intermediate compressor problems that have grounded a portion of the Boeing 787 fleet.

The 787 and 737 MAX groundings probably also contributed to Airbus overtaking Boeing as the best in the airframe category. Airbus was the only airframe OEM whose overall customer satisfaction score improved year over year.

BAE Systems was the top avionics supplier, and Parker Aerospace generated the highest score among the mechanical/electrical suppliers.

Of the OEMs ranked, only seven logged strong satisfaction scores. On a scale of 0-10, with 10 being the highest, those OEMs are CFM (7.5), Airbus (7.3), Boeing (7.2), GE Aviation (engines, 7.1), Pratt & Whitney (APUs, 7.1) and Parker Aerospace (7.0).

THE DETAILS

The survey was conducted from mid-February to mid-May, with 185 qualified responses, including 62 unique airlines from around the world. The number of responses was lower than in previous years, which could be expected because the COVID-19 pandemic was unfurling during that period, and airlines were in sheer survival mode. Only 21 suppliers received enough responses to be statistically valid.

OEMs were ranked in the following categories: ease of doing business, product reliability, technical support, parts cost, parts availability, aircraft-on-ground (AOG) support, OEM repair cost, OEM service center performance, overall satisfaction and likelihood of recommending them to a peer or colleague.

There are regional differences but, in general, European airlines are less critical and North American are far more critical of their supply base, says Jonas Murby, an AeroDynamic Advisory principal.

POSITIVES

CFM made several gains this year, including in ease of doing business, product reliability, technical support and AOG support. Of the nine customer service categories, it had the highest score in five. "They are also comparatively strong in all geographic regions," says Murby.

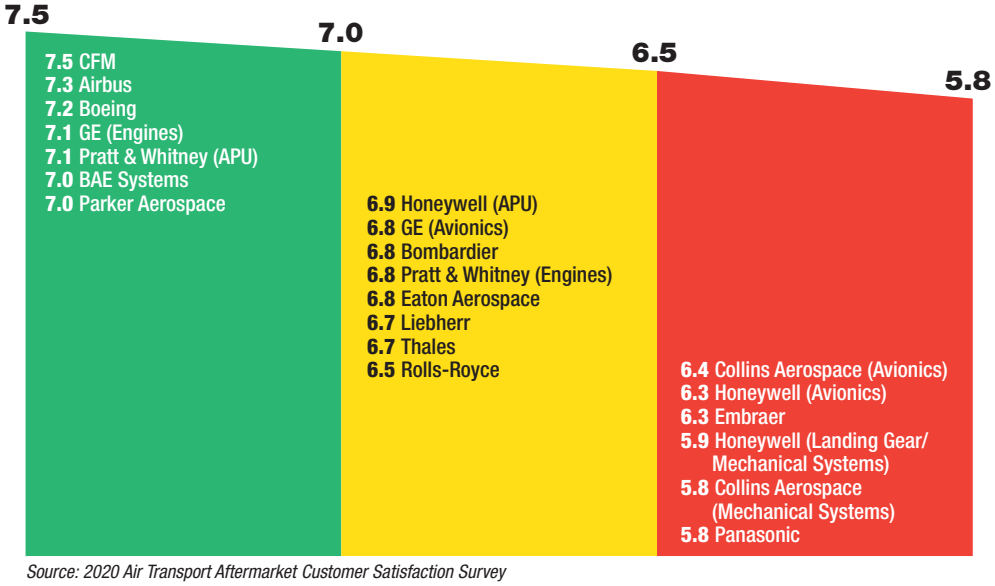
CFM Leap engines experienced early problems, which most likely accounts for its overall score of 6.9 in 2019, versus 7.5 in 2020. However, as CFM has incorporated product improvements, "Leap 1A reliability has improved significantly over the last 12 months in key areas such as engine removals," says a company representative.

To prepare for the Boeing 737 MAX's recertification, CFM says it has been proactively working with customers during the grounding and has "developed an extensive de-preservation checklist" to smooth the process for service reentry.

CFM also has expanded its Leap MRO network, which includes 250 technical service representatives on-site with airlines in at least 50 countries. "The three CFM call centers (China, France and the U.S.) handle more than 2,200 inquiries each month and are required to respond within four hours. This team has maintained better than a 95% response rate to customer commitment," says a company representative.

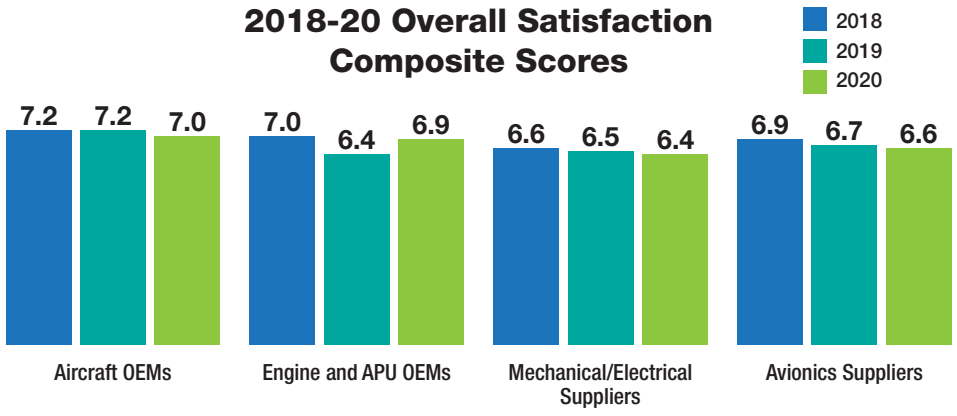
Airbus has also expanded its service network in the last year by "reinforcing our Africa-Middle East region and our

2020 Overall Satisfaction Score by Supplier



Source: 2020 Air Transport Aftermarket Customer Satisfaction Survey

2018-20 Overall Satisfaction Composite Scores



Source: 2020 Air Customer Satisfaction Survey

Dubai-based customer service teams," says Valerie Manning, Airbus senior vice president for customer support. Airbus has more than 1,000 aircraft based in the region.

Airbus had the highest score of airframe OEMs in product reliability and OEM service center performance.

Parker Hannifin has also been putting a premium on customer service in the last several years, which seems to resonate with its customer base. It has expanded its in-region support—including inventory pooling centers in the Middle East, Europe and Asia as well as repair capabilities. It also opened 24/7 customer response centers in Irvine, California, and in Singapore.

Parker Hannifin CEO Tom Williams also established a Net Promoter Score index called Likelihood to Recommend (LTR), which customers are asked about after every significant business transaction, says Austin Major, Parker Aerospace group vice president for business development and customer support. "Customers who have good experiences hold a greater appreciation for the overall value offered by Parker and actively promote our brand. They are more likely to have a strong interest in new product offerings and product improvements, and to consider broadening their business with Parker," he adds.

Parker's leaders and business units are measured on the LTR scores, which Major says have "steadily increased every year since the program's inception."

BAE Systems, which captured the top avionics supplier ranking, had the highest rating of avionics suppliers in five of the categories: product reliability, technical support, parts cost, parts availability and AOG support. It also tied with Thales for the top spot in OEM service center performance and tied with GE Aviation for OEM repair costs.

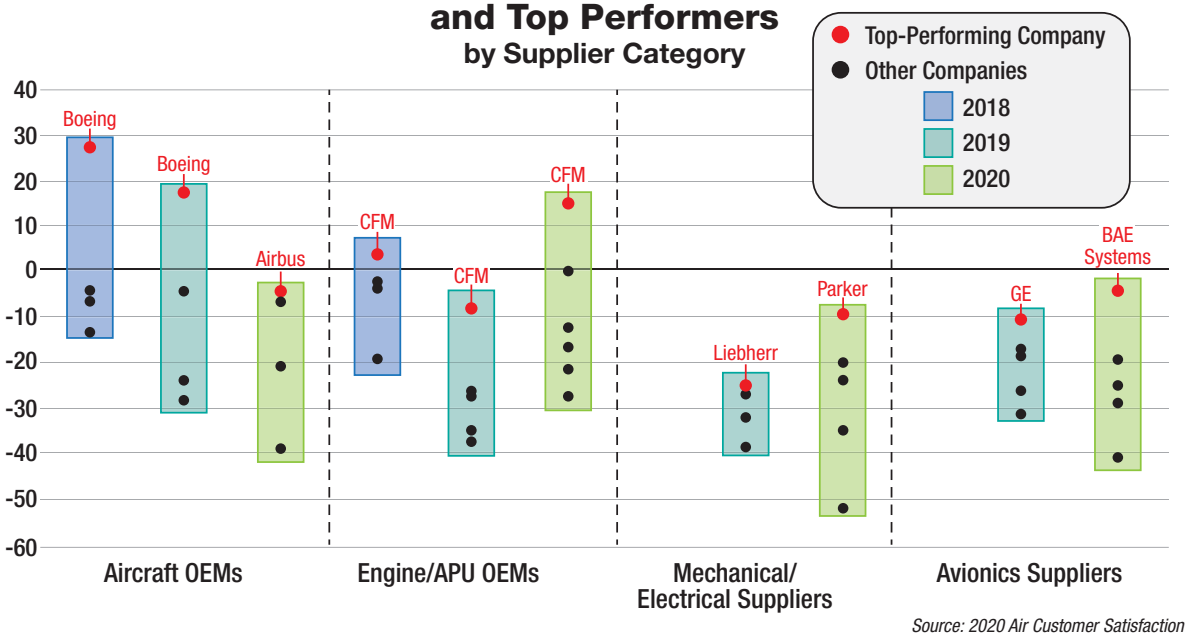
NEGATIVES

Most companies that were going through mergers in the past year have dropped in overall customer satisfaction, raising the issue of whether the merger process distracted from customer service. Many companies in the merger process took a hit in ease of doing business, which seems to be a strong indicator that if things are going well, some factors can be forgiven, but if it's simply difficult to do business, other factors, such as parts prices, see more scrutiny as well.

Collins Aerospace's avionics, which has consistently been known for highly ranked customer service, fell from 7.1 in 2019 to 6.4 in this survey—dropping most in terms of parts costs, parts availability and OEM service center performance.

"UTC was hoping to take Collins' best-in-class customer service and spread it throughout the company, but the opposite happened," says Kevin Michaels, AeroDynamic Advisory managing director. Historically Collins (and predecessor Rockwell Collins) had its leadership and aftermarket headquartered in one place—Cedar Rapids, Iowa. But now leadership and functionality are dispersed, which Michaels thinks could have negatively affected its customer service.

2018-20 Range of Net Promoter Scores and Top Performers by Supplier Category



Source: 2020 Air Customer Satisfaction Survey

Collins' Mechanical Systems unit, which covers everything from cargo systems to actuation, includes disparate systems that were lumped together, "so it's not surprising that they're at the bottom," says Michaels. Collins Aerospace's Mechanical Systems group scored an overall 5.8 this year, as opposed to 6.8 last year.

Interestingly, Pratt & Whitney, also part of the UTC merger and now part of the bigger Raytheon, showed an improvement—an overall score of 6.8 this year as opposed to 6.3 last year. Pratt has been working through the low-pressure turbine (LPT) blade and seal problems—and is now in the process of upgrading the LPT in PW11100G-JM models as part of an FAA and European Union Aviation Safety Agency mandate. Interestingly, of the engine OEMs, Pratt & Whitney scored the highest in AOG support, which could be based on its handling of these problems.

The OEM says that more than half of the GTF-powered fleet is now active, but when several fleets were grounded due to the pandemic, "we aggressively accelerated our MRO capability for the GTF family to incorporate available upgrades in anticipation of the recovery." For some upgrades, "we established 'quick turn' facilities to further accelerate modifications," says a company representative.

Pratt's APU business also made a modest climb in the ratings, from 6.7 last year to 7.1 this year.

However, Boeing and Embraer, which had planned to establish a commercial aircraft joint venture but called it off in late April, both took a hit. Boeing's scores in every product support category fell from last year, and all of Embraer's scores did except for one: Parts costs increased to 6.3 this year compared to 6.2 last year. Whether the joint venture abandonment caused the decline in customer service scores is unclear, because Boeing has also been dealing with the grounded MAX fleet as well as other program delays and leadership changes.

Looking at other scores that fell, Honeywell Aerospace's landing gear division took a dive—dropping 1.1 points to an overall score of 5.9—but its APU business received higher marks, which could partly be attributed to its Forge analytics platform. "Airlines have been willing to pay for it because it works," says Michaels.

NET PROMOTER SCORES

Net Promoter Scores (NPS), which gauge how likely customers are to recommend a product, are tabulated by subtracting the negative responses from the positives ones to derive a net score.

For the last two years, Boeing had been the only aerospace OEM in the survey that logged a positive NPS. Regardless, Boeing's difficult year plunged it into negative territory.

However, CFM's product support efforts lifted its score, making it the only NPS-positive company in this year's survey.

Aviation OEMs lag NPS levels in other industries, and this year was not an exception.

Old Pooling Dog Learns New Tricks

Roadblocks to parts pooling lessen as pooling options expand

Henry Canaday Nashville, Tennessee

With passenger traffic largely shut down, few airlines are worried about spare parts stocks, as they can cannibalize grounded aircraft as needed. Indeed, when an aircraft-on-ground part need arises, the International Airline Technical Pool (IATP) often finds it harder to find airline staff—many of whom have been furloughed—than parts, according to Francesco Tetti, International Airlines Technical Pool senior business manager.

As traffic returns, airlines will need to pool parts and services. It is a smart way to achieve economies of scale in managing important activities, especially stocking parts for emergencies.

Some pools are straightforward part-sharing agreements, while others are just elements in packages of parts, repairs, logistics and technical support backed by an asset manager. For IATP, the extraordinary growth of pools is both confirmation of its original goals and a challenge to future usefulness. With so many pools available, will IATP's approach remain important?

THINKSTOCK PHOTOS

The organization thinks it will be and is already expanding multiple services to complement and exploit increased use of pooling options. As with leading airlines, manufacturers and MROs, IATP is learning new tricks to reduce costs, improve service and ensure safety.

Five years ago, IATP saw decreases in its pooling activities, remembers San Lucktong, director of technical marketing and sales at Thai Airways International and now in charge of IATP's third-party pooling project. "It was because of new aircraft and the business model of OEMs and some MROs that offer power-by-the-hour programs, including support of spare parts," Lucktong explains.

Power-by-the-hour programs establish a one-to-one contract between OEM or MRO and its airline customer and do not allow the airline to share the provider's spare parts with other airlines.

IATP leaders had to find a way to make OEM- or MRO-provided parts available to other airlines to maximize the benefits of its pool services. A project group was formed to help airlines share newly provided parts with other carriers at outstations, where parts from any one airline may be scarce.

IATP is now in discussions with OEMs such as Boeing, Airbus, Collins Aerospace, and global MROs such as Lufthansa Technik and AFI-KLM E&M about accessing their pool parts for IATP members to pool with each other. "They are willing to help," Lucktong says. "But we have to find a way to do it." Current power-by-the-hour contracts with OEM and MRO spare-part pools have limitations on sharing. The question is how to modify them or work within the limitations.

Lucktong expects that OEMs, MROs and IATP members will find a way to share parts with IATP pools. "It saves costs for everybody, and everyone gets more benefit," he says.

IATP has identified five key airlines including British Airways, Delta Air Lines, Thai, United Airlines and Virgin Atlantic and the five major OEMs and MROs mentioned above to work on the challenge.

Some power-by-the-hour support providers have proposed that they supply parts directly to IATP airlines under IATP pooling. Selected Airbus A350 and Boeing 787 parts would be used in a pilot program at certain stations. Five IATP airlines would propose part numbers, previous usage and stations—and power-by-the-hour providers would evaluate and make recommendations.

How long might it take to set up this pool of pools? "We are trying to do it one year from now," Lucktong says.

IATP offers more than just pooling of spare parts. It also offers pools for line maintenance, pools for aircraft recovery and pools of ground tools and equipment.

Line maintenance pooling, like parts pooling, offers the benefits of scale and local specialization. But it is limited by restrictions imposed by some local regulators.

Restrictions can cause various problems. Some nations prohibit a carrier from pooling with another IATP member, requiring it to do its own line maintenance, which is inefficient and costly if the airline has few local flights. Other nations prohibit even self-handling. "Airlines have to use local maintenance organizations," Lucktong explains.

In both cases, IATP attempts to explain to local regulators the advantages of line pooling. "It's not about making money, but helping each other out," Lucktong says.

IATP has had some success in opening up airports for line pooling in recent years. For example, Saudi Arabia now allows it. But the issue is still open in other countries.

Overall, IATP's most strongly growing pools are for line maintenance, despite local restrictions, and for spare parts, despite the flight-hour contracts. Lucktong notes flight-hour contracts mostly apply to new models like the Boeing 787 and Airbus A350 and can last for up to 12 years.

IATP has added six new airline members in the last 12 months, for a total of 118 airline members. The organization also has a select number of supplier members, with that number limited to one-fourth of its airline members.

MRO Market Recovery

Johannes Bussmann, Lufthansa Technik's CEO, talks with Lee Ann Shay about how one of the largest MRO providers in the world is handling business during the coronavirus crisis and what long-term changes could be coming.

LUFTHANSA TECHNIK

What are your predictions for the MRO market?

The biggest hit from my perspective will be on the engine side. Because some airlines are reducing their fleets, especially widebody types, that will offer lots of spare engine life. For four-engine aircraft, I expect a very low induction for a long time because airlines will use green-time engines. At the same time, OEMs and network partners did a good job performing restoration work on Pratt & Whitney geared turbofan and CFM Leap engines, which was a big problem until the end of February—but then capacity opened for them to do this work. They did a good job with materials supply from our perspective so that a lot of these shop visits could take place during the downtime.

Do you think the MRO industry will recover in 12-18 months?

Except for engines and landing gears, for which airlines will look for green-time alternatives, all the other parts of the business will come back to coincide with flight movements. It might be a little ahead or behind with a particular technology group, but in general it will all come back. We are helping customers optimize their cash flow. That pays back much better in the long run than trying to fight for shop visits.

Are you expecting higher demand for used serviceable materials and repairs?

Of course. The availability of used parts will increase because of the number of aircraft retirements. A lot of mature fleets won't come back.

What requests are you getting from customers?

It's predominantly around payment schemes, which is natural. From a technical perspective, whether it's more repairs on a particular component is not relevant at the moment because the utilization of the global fleet is too low. However, I think by the fourth quarter that will come more into the forefront of the discussion.

Do you think the crisis will shift the balance between OEMs and independents?

I don't think there will be a general change in the balance. The existing fleet will stay in play for a bit longer, so that will generate MRO demand once aircraft are operating again. Then of course service plays a different role in that now, which doesn't favor OEMs. But I don't think it will significantly change the market mechanism. Will we see a price war on certain things? I'm pretty sure we will. Financially weak partners in the OEM network might disappear, and if this happens, we'll probably see that in the next 6-12 months.

Will Lufthansa Technik keep all of its facilities across the network?

We operate on a global scale, which usually protects us from downturns because of regional differences, but this time it doesn't help us. But we can participate in the ramp-up, which is happening. In Asia, movements are picking up, and we can benefit from the restart there. It looks like the Western part of the world will come last. From a strategic perspective, there is no change in how we look at the aftermarket.

What changes or innovations are you hoping to see from the business during this unprecedented time?

I think digital innovations will be strong. Traveling restrictions from countries far away drove more table inspections. High-definition videos have proven that you can do those without being in the same room. Long-haul travel will come back last, which is why we will have time to stabilize these ways of working. That's why we think the digitalization of processes will continue and the confidence level in data provided by the aircraft is increasing, which is why I'm sure that this trend will last. At the same time, I think there will be more focus on shorter-term innovation developments. We are reviewing our development portfolio and have parked a lot of projects that have long-term requirements and are focusing on the shorter-term ones.

What's happening with Aviatar?

We brought collaboration with Honeywell Forge online, so we have a lot of airlines testing this. That's the biggest trend: We have more airlines trying out what we offer, which is something you can do without traveling. The customer base is growing, and we're seeing more intense collaboration.

How are you helping customers with their parked aircraft?

We have digital solutions that help airlines with the overview of fleet conditions. Most parking doesn't take place at carriers' home bases, so given the remote positioning, digital tools are especially helpful in fulfilling authorities' requirements. Airlines also want transparency on which parts are installed in which aircraft—they want to know where their interchangeable parts are—and how much life is remaining on them. Should they repair the part, yes or no? They want to optimize the workflows as part of fleet management services.

Video *See more of the interview with Bussman:* **AviationWeek.com/ad-week/video-interviews**

ICAO Postpones Distress Tracking

Member states acknowledge the "industry wasn't ready"

Bill Carey Washington

Most commercial airliners already had satellite communications systems that complied with an international standard requiring an aircraft under normal flight conditions to report its position at least every 15 min., a rule that became effective in November 2018.

The next step in implementing the Global Aeronautical Distress and Safety System (GADSS)—providing a capability for autonomous distress tracking (ADT) position reporting at 1-min. intervals by 2021—has proven more challenging. In March, the International Civil Aviation Organization (ICAO) Council postponed the ADT requirement for new-build aircraft by two years, to 2023.

The ADT topic was raised during the 40th session of the 193-member-state ICAO Assembly last October, "and subsequently the ICAO Air Navigation Commission determined through a series of consultations that industry wasn't ready yet and therefore countries wouldn't be able to realistically enforce the original deadline," says the U.N. agency's communications office.

ICAO's Annex 6, Part I, Section 6.18.1 requirement that new-build aircraft with a maximum takeoff weight (MTOW) of more than 27,000 kg (59,525 lb.) autonomously transmit position data at least once every minute will now enter force on Jan. 1, 2023. The ADT standard is recommended, but not required, for aircraft weighing more than 5,700 kg.

Impetus to establish the GADSS construct to exploit air-ground tracking technologies and develop a timely response to emergencies followed the still unresolved disappearance of a Malaysia Airlines Boeing 777-200ER in the Indian Ocean in March 2014 and the prolonged search for an Air France Airbus A330-203 after it crashed in the Atlantic Ocean in June 2009.

Two months after the disappearance of Malaysia Airlines Flight 370, ICAO convened a special meeting of industry and government experts at its Montreal headquarters, at which the GADSS concept was conceived.

Satellite connectivity provided by Iridium and Inmarsat spacecraft and aviation communications network providers ARINC and SITA already facilitated the GADSS 15-min. "normal" tracking standard. Another means of tracking transponding aircraft—Aireon's space-based automatic dependent surveillance-broadcast (ADS-B) system—entered service in March 2019.

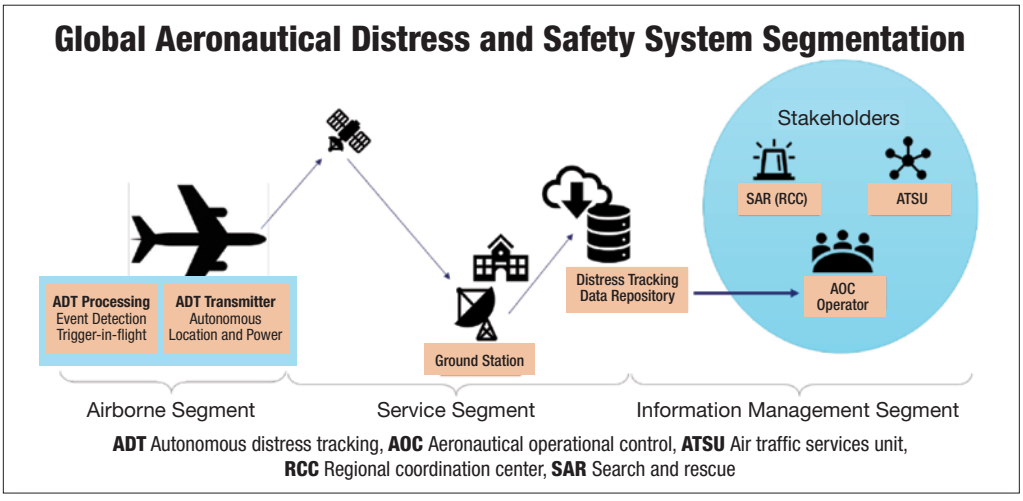
But achieving the next planned GADSS implementation step for ADT at 1-min. intervals and an accompanying requirement for post-flight localization and recovery of flight data presents a challenge, Australia asserted in a working paper submitted to the ICAO Assembly. Cosponsored by New Zealand and South Africa, the paper asked the agency to poll its member states on their preparedness to meet the ADT standard by 2021.

"Full implementation of the ADT and accompanying post-flight localization and recovery requirements is dependent on the development, testing and certification of new technology and equipment for successful installation into new and (optionally) retrofitting existing aircraft," Australia argued.

"In addition, there appears to be inconsistent awareness across states and industry of the GADSS, and a lack of coordination and information sharing between relevant ICAO technical panels and those responsible for SAR [search and rescue], leading to potential misunderstandings and differing interpretations."

Industry sources say Boeing and Airbus lobbied regulators to extend the ADT compliance date to provide more time to modify their production lines for new equipment. The manufacturers, reportedly making vendor selections, did not provide information when asked about their progress toward implementing ADT forward-fit provisions.

An industry standardization group, the ARINC-SAE Airlines Electronic Engineering Committee (AEEC), published technical requirements, architectural options and recommended interface standards for an ADT system



OROLIA

Autonomous distress tracking with GADSS requires coordination by multiple stakeholders.

in August 2019. The AEEC reviewed system architectures and architecture combinations involving ADS-B, satellite communications and emergency locator transmitter distress tracking ELT(DT).

The European Union Aviation Safety Agency (EASA) has taken the lead in refining ICAO's ADT mandate into a regulatory requirement for EU-registered airliners. In February, EASA released Notice of Proposed Amendment (NPA) 2020-03, containing amended certification specifications, acceptable means of compliance and guidance material to implement a regulation the EU published in December 2015.

The EU regulation—CAT.GEN.MPA.210—requires fitting some categories of large aircraft with a "robust and accurate means to locate the point of end of flight in case of a distress situation," says EASA.

ICAO procedural standards for locating an aircraft in distress are contained in Annex 6 Part 1. According to EASA, the European Union's CAT.GEN.MPA.210 regulation differs from the ICAO standards in several ways.

Whereas the ICAO requirements apply to aircraft with an MTOW of more than 27,000 kg, the EU specifies aircraft weighing more than 27,000 kg with passenger seating capacity of 19 or more and all aircraft with an MTOW exceeding 45,000 kg. The applicable event for ADT as defined by ICAO is an aircraft in distress; CAT.GEN.MPA.210 specifies an "accident where the airplane is severely damaged."

The required means for distress tracking will be "autonomous transmission" by ICAO standard and "robust and automatic means" by the proposed European requirement, EASA says.

The NPA 2020-03 comment period ended May 29, and a review of the public input will take anywhere from a few weeks to months, says EASA. The agency will then publish final amendments to the regulation. CAT.GEN.MPA.210 applies to commercial air transport operators based in EU member states, for aircraft manufactured after Jan. 1, 2023.

Still to be released is an industry standard supporting the GADSS requirements for post-flight localization and recovery of flight recorder data. These apply to new aircraft with an MTOW of 27,000 kg and authorized to carry more than 19 passengers, for which an application for type certification is submitted on or after Jan. 1, 2021.

Industry guidance will be contained in Project Paper 681, which is under development by the ARINC-SAE Timely Recovery of Flight Data (TRFD) Working Group.

"The ICAO decision to postpone ADT requirements from 2021 to 2023 does not directly influence the TRFD deliverable. We anticipate completing the Project Paper 681 in early 2021 for acceptance at the ARINC General Session in May [2021]," the working group says in response to an Aviation Week inquiry.

"As a new aircraft model is developed and certified typically within five years, the first airplane model required to have TRFD would be 2026 at the earliest," the working group adds.

Of Fuel Tanks and Microbes

Underutilized aircraft are at risk of microorganism infestation

Paul Seidenman and
David J. Spanovich **San Francisco**

With much of the global commercial airliner fleet idled due to the COVID-19 pandemic, microbial contamination of fuel tanks has become a growing concern. The build up of harmful microorganisms can corrode aluminum and steel surfaces as well as break down the rubber system components specific to the fuel tanks.

LUFTHANSA TECHNIK PHOTOS

Lufthansa Technik research has shown that aircraft with low utilization rates are as vulnerable to microbial buildup in fuel tanks as those in long-term storage.

Harmful biofilm buildup was found within a wing tank being inspected at Lufthansa Technik. Tanks previously infected are more likely to have a follow-up spread of microbial load.

It is not just a problem for aircraft sitting in desert storage for weeks or months. Research by Lufthansa Technik focusing on low-utilization aircraft found that fuel tank contamination is just as risky for aircraft still flying but at low utilization rates, says Ralf Riemann, Lufthansa Technik project leader for fuel tank inspections. "In general, aircraft with low flight cycles are very susceptible to fuel tank contamination and the resulting damage. Long ground times, especially in combination with warm to hot ambient conditions facilitate the formation of microbials and biofilm," he says.

Riemann adds that once an aircraft fuel tank has been infected, a follow-up spread of the microbial load is much more probable, based on Lufthansa Technik's experience. "Long-term storage requires closely monitoring the fuel system to prevent the initial formation and growth of microbial life." He stresses that if an aircraft is "frequently flying with regular fueling," the risk is comparatively low.

However, if an aircraft sits for more than a month, the fuel should be tested with a microbial test kit, suggests Art Smith, AAR Corp.'s chief quality officer. Neglecting to perform recommended inspection procedures will increase the likelihood of microorganisms forming. As an example, he points out that the fuel tanks of an aircraft in storage should be sumped—drained of the water and contaminants that collect at the low point of the fuel tank—and inspected for water and contaminates damage. "Aviation fuel tends to absorb moisture from the atmosphere, so aircraft with more usage of fuel are less susceptible," he says. "If the fuel is constantly used, there is no time for this issue to occur."

Microbial buildup in the fuel tanks can also lead to collateral damage, clogging engine fuel filters, for example. As Anthony Laude, senior systems engineering technical leader at GE Aviation explains, microbial contaminants themselves are usually captured by the engine fuel filter. The filter, which he says is a consumable and easily replaced as a line maintenance item, incorporates a monitoring pressure system that issues an alert to the pilot if it becomes clogged. Should that happen, the filter would go into a bypass mode, and the microbial contaminants from the fuel tanks might reach and block the fuel system tubes and passages. "The blockage would have to be addressed by sending those affected components to a maintenance shop," Laude notes.

The best defense against fuel tank microbial buildup is to comply with the recommendations in the aircraft OEM manuals, which include proactive treatment procedures, says Laude. "The aircraft fuel tank inspection is up to the operators and triggered by the level of contamination detected by fuel sample testing," he notes. "Operators are expected to regularly test their fuel tanks for microbial growth."

To prevent such growth, Laude mentions two chemical biocides that GE Aviation has approved, but one of the products, Kathon FP 1.5, from Dupont, was removed from the OEMs' approved list of fuel additives following repetitive field issues due to misapplications. In fact, a Kathon FP 1.5 misapplication was cited by the UK Air Accident Investigative Branch as the cause of a "serious incident" that nearly resulted in the loss of an Airbus A320 in the UK. The biocide was discontinued for aviation use in March of this year.

Biobor JF, manufactured by Hammonds Fuel Additives Inc., is now the only available GE-approved product, but it is currently not approved for use in the European Union. However, that may change shortly.

"About 15 EU member states have allowed temporary use of Biobor JF in order to help European operators cope with their high volume of parked aircraft," says Laude. "The industry is working on future biocides that will have to be assessed by GE and other aircraft, engine and APU OEMs, and approved by local governmental authorities as well."

Christian Siry, head of Lufthansa Technik's Central Materials Technologies unit in Germany, says problems with microbial buildup can occur when fuel tanks constructed of aluminum alloys are filled with jet fuel. Problems from microbial contamination do not arise from "individual planktonic microbes" in the fuel itself but from the biofilm growing at the interface of condensation water and fuel and from biofilm at the bottom of the tank, he says.

"Corrosion occurs mainly on the bottom of the fuel tank below the growing biofilm. If not detected and removed at an early phase, it can lead to large defective zones," Siry explains. "Fuel filter clogging may take place with potential impact on fuel flow integrity, and the fuel quantity indication system may show signs of fuel quantity fluctuation."

Siry also points out that in some cases there are signs of microbial infestation in other fuel system components, such as high-precision, fuel-wetted flight control units. "A closer look into the fuel system with modern detection techniques has revealed—and suggests—that more interference from microbial loads may occur than previously thought," he says.

Lufthansa Technik's research also shows a strong correlation between the risk of corrosion and microbiology layers in the contaminated area. The reason, he explains, is the formation of well-adhering biofilm zones. "The survival capabilities of biofilms are remarkable, since water and humidity protect them against any toxic and biocidal attacks, enabling them to attack the tank wall through acidic micro-channels formed within the biofilm," says Siry. "The mixing of biocides with the fuel is not resolving the problem once the biofilm formation has been established."

Siry adds that Lufthansa Technik and the University of Hamburg have started a research project to develop a more accurate method for early detection of all microbiological contamination. It also allows for classifying the contamination as critical or not critical.

"The employment of adjusted DNA technology considers the whole environment of the airplane operation—rather than fuel testing only—as an indirect indication of the fuel system microbial contamination problem," he says. "Thus, a comprehensive fuel filter analysis and other fuel system components have already supported early warning indications," he says. The next part of the research is developing an "improved cleaning approach to ensure the reliable removal of the biofilm contamination."

Permanently Grounded

Several widebody stalwarts are set to exit the global fleet post-COVID-19

James Pozzi London

The novel coronavirus has led many carriers worldwide to readjust their fleet plans to preserve liquidity and streamline their operations. Given the cost of operating older, maintenance-intensive widebody aircraft during a period of soft travel demand, some casualties of the pandemic have not been surprising. Older widebodies earmarked for retirement, including the Boeing 747 and the few remaining MD-80s, have seen their exit from fleets accelerated. Older variants of the Boeing 777 and Airbus A330 have also been jettisoned more quickly as a result of the crisis.

While relatively young in comparison, having entered service only in 2007, the Airbus A380 looks set to see a similar destiny, with its fleet size likely to be drastically reduced post-COVID-19. The fate of the A380 was effectively sealed in early 2019 when its manufacturer announced plans to stop production by 2021 because of low customer demand. As of May 2020, there were approximately 228 of the aircraft in service with 14 operators, according to Airbus.

"The current pandemic has severely impacted international travel demand, particularly the large-cabin segment of the market," says Adam Guthorn, partner at the Alton Aviation Consultancy. "The A380, as the world's largest commercial passenger aircraft, has been more negatively impacted than any other type, with several national flag carriers recently announcing full retirements of their A380 fleets," he notes.

AIR FRANCE

Air France, the first European airline to operate the aircraft, retired its last A380 in June, having once operated as many as 10. Pre-pandemic, it had intended to phase them out by 2022. Lufthansa, which has already offloaded half its 14 A380s, does not expect to fly the remaining airframes until at least 2022 and meanwhile will keep them in deep storage. Outside of Europe, the future of the aircraft in the fleets of Etihad, Qatar Airways and Thai Airways has also been the subject of discussion since the COVID-19 outbreak.

In the few years before the Airbus announcement ending A380 production, airlines had begun to reveal their retirement plans, with some—such as launch customer Singapore Airlines—returning its first A380 in late 2017, before the first superjumbo was dismantled about two years later. Guthorn expects these moves to become more common in the future. "While there will surely be some entrepreneurs with interesting business models proposed in the coming years that may find a mission for the A380, we expect the vast majority of these aircraft to simply be retired and parted-out," he says.

Sebastian Podwojewski, a spokesman for German asset manager Dr. Peters, tells Aviation Week that to date, four A380s have been handed back to their respective investment companies by airlines. While hope for a secondary market for the A380 has all but disappeared, given the push toward smaller, more fuel-efficient, long-range aircraft such as the 787 and the A350, Podwojewski believes some of the aircraft's components will be sourced back into the market to help service the remaining active fleet. "As the overall fleet of A380 aircraft is aging, and as further 12-year checks will become due on more of these aircraft, we see reasonable demand for spare parts in the near future," he says.

Air France operated its first A380 in 2009 but recently retired its remaining aircraft.

Angus McKay, an aviation principal at consultancy ICF, agrees that there will be some aftermarket demand but believes it will be narrow. "There will be some limited use of major components and subassemblies for the used market, including landing-gear sets and auxiliary power units, but again, the market will be constrained by a small operating fleet, limited lifespan and low utilization," he says.

McKay believes that the aftermarket for the aircraft, valued at $2.7 billion for 2020 pre-COVID-19 by the Aviation Week MRO & Fleet Forecast, will be even more limited once the crisis subsides. "In broad terms, the aftermarket for the A380, already parlous, is likely to become more dire as utilization for the type dwindles and MRO activities decline," he says.

Cabin Cargo

Lindsay Bjerregaard Chicago

1. Cargo Combos

Company: HAECO Cabin Solutions
Specifications: HAECO Cabin Solutions is offering four adaptations for carrying cargo in the passenger cabin, which it says can be combined for both single- and twin-aisle aircraft to achieve "an ideal operational payload." The first two allow carrying up to 240 lb. of cargo either on top of existing economy seats or on the floor in between rows of seats. It is also offering an all-in-one seat frame that installs in economy seat tracks and can hold 500 lb., and a palletized variant that sits on the cabin floor and can hold 1,000 lb. HAECO says it has been in discussions with at least 50 airlines globally about the modules, including a launch customer in Asia, and that demand is rising.
marketplace.aviationweek.com/company/haeco-cabin-solutions

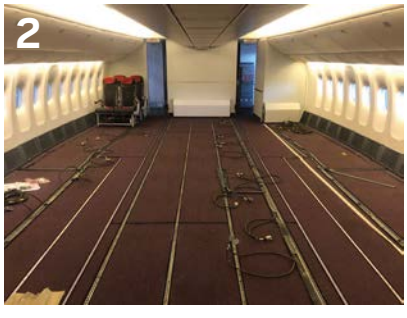

1

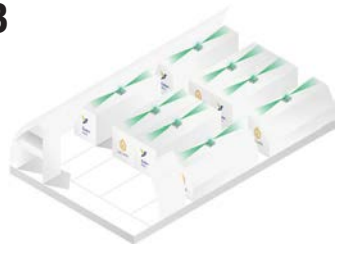
2. 777 'Preighters'

Company: Austrian Technik
Specifications: Austrian Technik has performed temporary conversions of two Boeing 777 aircraft from passenger to cargo configurations to help Austrian Airlines transport more cargo during the COVID-19 crisis. To create these temporary "preighters," Austrian Technik mechanics removed 270 of 306 passenger seats from all travel classes in each aircraft, including disconnecting inflight entertainment-system wiring, which took approximately 500 hr. to complete per aircraft. Austrian says the conversions increase freight capacity by around 35%, and the "preighters" can be converted back to the passenger format once travel demand increases.
marketplace.aviationweek.com/company/austrian-technik

3. Cargo Containers

Company: Colibri Aero/J&C Aero
Specifications: Colibri Aero and J&C Aero have developed cargo containers for widebody passenger cabins that enable quick cargo conversions. The containers, which come in five sizes and are equipped with a smoke detector, are designed to temporarily replace passenger seats and carry up to 1,870 lb. of cargo. The companies say that a typical Airbus A330 cabin could be converted in 24 hr. and will hold 36 containers. These are currently designed for Airbus A330/A340 and Boeing 767/777 cabins, but the companies are planning to upgrade the modification for other aircraft types and size variations. Earlier this year, the companies also launched a cargo seat-bag product that enables cargo to be carried on seats in narrowbody cabins.
marketplace.aviationweek.com/company/colibri-aero


2


3


4

4. Airbus Cargo Modification

Company: Airbus
Specifications: Airbus has developed a modification for A330- and A350-family aircraft that enables airlines to install freight pallets directly onto cabin floor seat tracks. Packaged as an Airbus Service Bulletin, the modification includes removal of economy-class seats and inflight entertainment, installation of cargo pallets and associated safety equipment, and reinstallation of the original passenger cabin elements once airlines choose to revert back to passenger operations. Airbus says the modification facilitates quicker, easier loading/

*Go to **marketplace.aviationweek.com** for more information.*

unloading and reduces wear and tear on seats compared to solutions that entail loading cargo onto seats.
marketplace.aviationweek.com/company/airbus

5. Fast-Tracked Freighters

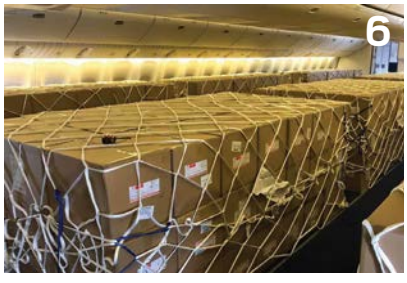
Company: **Lufthansa Technik**
Specifications: Earlier this year Lufthansa Technik (LHT) fast-tracked efforts to gain regulatory approval for passenger-to-cargo modifications due to high interest from airlines. The MRO has more than 15 projects for various aircraft types in the pipeline, including Airbus A330-300 and A380 aircraft. It is now targeting supplemental type certificates (STC) for all major aircraft types, which it hopes to have by September. For now, it is offering tailsign-specific engineering orders, which it says customers can transfer to STCs later without major adjustments.
marketplace.aviationweek.com/company/lufthansa-technik

6. Quick-Turn Conversions

Company: **Collins Aerospace**
Specifications: Collins Aerospace has developed a quick-turn solution to convert passenger aircraft for cargo; it is available for any passenger aircraft model and can be completed in as little as seven days. Collins provides the engineering and certification services, kit parts required for modification and on-site technical support to perform the conversion, which entails removing seats to allow a higher volume of cargo carriage on the main deck floor. Its Integration Engineering facility in Everett, Washington, offers engineering order solutions for rapid conversion and supplemental type certification for cabin modifications to carry greater weight and various cargo types as demand changes. Collins says aircraft can be easily converted back to passenger configuration as desired.
marketplace.aviationweek.com/company/collins-aerospace

7. Medical Cargo Mods

Company: **Magnetic MRO**
Specifications: Magnetic MRO's Part 21J team is offering cabin modifications for COVID-19 medical cargo transportation in passenger cabins. The modifications include fixing cargo boxes on seats with special straps, removal of passenger seats and installation of medical stretchers on various aircraft types. Magnetic MRO is performing these modifications at its Tallinn, Estonia, base or at client locations as travel is allowed, but it is also offering installation kits to customers so modifications can be performed by their own teams. Several modifications have been completed for clients in Europe, Africa and Asia since the COVID-19 crisis started, and Magnetic MRO says it has more in the pipeline.
marketplace.aviationweek.com/company/magnetic-mro



8. Full Freighter Conversions

Company: **Aeronautical Engineers Inc.**
Specifications: For airlines looking to permanently rethink fleet operations, Aeronautical Engineers Inc. (AEI) designs, engineers and certifies passenger-to-freighter conversions, manufactures parts and partners with MROs to install conversions at its authorized AEI Conversion Centers across North America and China. AEI says it has seen an uptick in demand for Boeing 737 Classic freighter modifications since the COVID-19 outbreak, and it has booked 10 firm orders for 737 conversions to start work this year, including projects already begun for AerCaribe, Airwork and Allied Air. AEI has performed more than 500 passenger-to-freighter conversions and developed more than 130 FAA-approved supplemental type certificates.
marketplace.aviationweek.com/company/aeronautical-engineers-inc

*Go to **marketplace.aviationweek.com** for more information.*

By TED COLBERT
Ted Colbert III is The Boeing Co. executive vice president and president and CEO of Boeing Global Services

Needed: Diversity

Make our industry better through inclusion

Right now, there are hopeful signs that we are in the midst of a cultural wake-up call. We're openly acknowledging that the racial inequities of our past still linger while outlining specific steps we can take to heal, learn and grow as a society. Following several recent and highly visible acts of racism, including the murder of George Floyd in Minneapolis, many people are beginning to better understand the daily struggles of those who aren't part of the majority. And throughout the world, a broad spectrum of people across the public and private sectors are speaking up with increased purpose against discrimination.

These actions are to be commended. Combating racism and all forms of discrimination begins with a society that agrees fundamental human rights should be granted and protected equally—and it is up to all of us to make clear what we stand for and what we will no longer accept.

Within the aerospace and defense industry, the case for attracting, developing and retaining a diverse workforce and creating a safe environment that values unique perspectives, skills and experiences could not be stronger. We are a global industry that competes and thrives at the forefront of new ideas and technologies. Our lifeblood is innovation. We are called upon to innovate and operate to make the world better—no small task!

To continue delivering novel products and solutions to our diverse customers we need a workforce with broad experience and exposure to new and different ways of thinking. Yet the lagging representation of diverse populations throughout our industry, at all levels and in all disciplines, is keeping us from reaching our full potential. We've made progress, but we are simply missing an opportunity to be better. We have to ask ourselves: Do the most influential circles and leaders of our industry broadly represent the racial diversity of our customers, either commercial or government? If not, why?

We've made progress, but we are simply missing an opportunity to be better.

Countless studies have shown that diverse teams produce better outcomes, lead to better innovation and increase a company's bottom line. Diverse workforces are better at innovating and solving problems; they also produce higher sales revenues, more customers, larger market shares and greater relative profits than less diverse companies. In 2018, McKinsey & Co. found that companies in the top quartile for racial and ethnic diversity were 33% more likely to have financial returns above their national industry norms. And companies in the top quartile for gender diversity were 21% more likely to have financial returns above their respective national industry medians. However, this is about much more than crunching numbers and making a business case. The real motivator is knowing that creating a diverse and inclusive workforce is the only right thing to do.

So what is holding us back? I certainly don't have all the answers, and at Boeing we're asking ourselves the same question. Like many companies, we're not yet where we want and need to be, but we're taking intentional steps to ensure we're moving in the right direction. For example, Boeing has made investments in our future technical workforce through a partnership with the Thurgood Marshall College Fund, the nation's largest organization representing the black college community. The program introduces students to Boeing's culture and career paths, offers scholarships and provides internships for outstanding students attending Historically Black Colleges and Universities (HBCU). We also offer a competitive immersion program that brings together the brightest students from our partner HBCUs and allows them to explore possible aerospace careers.

Despite this progress, there is more we can and should do as an industry to make our teams more racially diverse, including thinking globally when recruiting talent, creating the environment for an inclusive workplace for people from all backgrounds, investing further in educational programs that inspire our young people and providing students from all walks of life with clear and direct pathways to STEM- and STEAM-related careers. As leaders, we must create the conditions so that anyone of any race can take advantage of the challenging and exciting opportunities in aerospace and defense.

If the first half of 2020 has taught us anything, it's that the world continues to change rapidly and that seeking to understand another's perspective and showing empathy for their experience is a step in the right direction. With this period of unprecedented uncertainty, now is precisely the time when we need the best ideas, regardless of who has them, to solve increasingly complex challenges—for everyone's benefit. I hope you'll join me in championing new approaches that make our industry better, more diverse and more inclusive.

Aviation Week Marketplace is an online service that connects **buyers and sellers** in the MRO industry. *Become a power user by registering at marketplace.aviationweek.com/register. Registration is FREE, enabling you to find hundreds of products like the ones featured below and to connect with more than 8000 companies. You can create a personalized save list, learn about companies' specialties, get contact details and request information at marketplace.aviationweek.com.*

To advertise in the Marketplace, contact **Elizabeth Zlitni at 913-967-1348 or elizabeth.zlitni@aviationweek.com.**

AVIATION WEEK MRO ASIA-PACIFIC

AVIATION WEEK AeroEngines ASIA-PACIFIC

MRO Asia-Pacific Virtual, September 22-24, 2020: Overcoming Unprecedented Change and the Challenge of What Lies Ahead! While live events are on hold, virtual events will provide digital content, networking, and a marketplace where the airline, OEM and MRO supplier communities can discover and showcase new products and innovations, connect with and source new and existing business partners, and share knowledge and best practices. Our virtual platform breaks down physical barriers and builds virtual communities and ensures that **MRO Asia-Pacific and AeroEngines Asia-Pacific** continue to deliver the same high-quality content that our audience has come to expect and will deliver information on the region in terms of industry recovery from COVID-19 crisis, workforce furloughs, layoffs, shop closings, and survival strategies for smaller MRO's and third-party MRO services. **To learn more about the virtual events and register to attend, please visit: mroasia.aviationweek.com.**

Visit **aviationweek.com/events** for more information, including complete exhibitor listings!

AERO TOOL SERVICES, LLC

QUALITY TOOLING SUPPORT & SERVICES

Services and Solutions:
▪ Overhaul Tool Repair ▪ New Tooling
▪ Refurbished Tooling ▪ Tool Rental
▪ Tool Trade-In Program ▪ Preventative Maintenance ▪ Application Support
▪ On-Site AOG Service ▪ Demo Tooling

We also offer a wide variety of consumables, cutting tools, abrasives, and fasteners to help you get any project you have completed!

Components ▪ Connectors/Fasteners ▪ Hydraulics/Pneumatics ▪ Painting/Coatings ▪ Consumables/Supplies

www.aerotoolservices.com
https://marketplace.aviationweek.com/product/quality-tooling-support-services

AEROSPACE PARK AT TRI-CITIES AIRPORT

Shovel-Ready Building Sites with Runway Access

Aerospace Park, located at Tri-Cities Airport (TRI) in northeast Tennessee, Is a 160-acre industrial development offering shovel-ready building sites with access to TRI's 8,000' main runway.

Aftermarket Services ▪ Maintenance, Repair & Overhaul

www.triAerospacePark.com
https://marketplace.aviationweek.com/product/shovel-ready-building-sites-runway-access

AIR CHARTER SERVICE

ACS is a global leader in aircraft charters

A global leader in providing aircraft charter solutions, Air Charter Service arranges more than 23,000 charter flights per year and generates annual revenue of close to $700 million. The company's worldwide network of 27 offices offers a full range of aircraft, both passenger and cargo.

Aftermarket Services ▪ Supply Chain/Logistics ▪ Consulting Services ▪ Leasing/Financial Services

www.aircharterserviceusa.com
https://marketplace.aviationweek.com/product/acs-global-leader-aircraft-charters

AIR MAC, INC.

PNEUMATIC SOLUTIONS FOR AEROSPACE APPLICATIONS

Blower packages
Blowers for vacuuming "de-icing solvents"
off tarmacs for environmental compliance Pneumatic solutions for mechanical tools and equipment Pneumatic low-pressure compressors for cabin testing, flight simulators and air breathing.

1-866-424-7622

Airport Equipment & Services ▪ Ground Support Equipment ▪ Hangars & Equipment ▪ Test Equipment ▪ Tools

www.airmac.com
https://marketplace.aviationweek.com/product/pneumatic-solutions-aerospace-applications

Go to marketplace.aviationweek.com for more information.

AIRCRAFT EXTRUSION COMPANY

At Aircraft Extrusion Company we live and breathe aluminum extruded profiles and tube. Our team combines 30+ years of product and industry knowledge with custom online tools and proprietary parts databases to offer the fastest and easiest way to find extruded shapes.

www.aircraftextrusion.com

https://marketplace.aviationweek.com/company/aircraft-extrusion-company

MRO Americas 2020

AIRLINE ACCESSORY SERVICE CO., LLC

Overhauls performed with integrity in mind.

For 20 years Airline Accessory Service has provided some of the worlds finest airline and corporate aircraft operators with a quality, on time, cost effective alternative to the large shop overhaul service. We offer the "personalized service" approach to providing component overhaul service.

www.airlineaccessory.com

https://marketplace.aviationweek.com/product/overhauls-performed-integrity-mind

Galley Inserts/Safety Equipment ▪ Components ▪ Electrical ▪ Hydraulics/Pneumatics ▪ Landing Gear/Wheels/Brakes

AMARILLO ECONOMIC DEVELOPMENT CORPORATION

Amarillo: All Business, No Bull!

In attitude and approach, Amarillo is unlike most cities. We offer the strategies and resources you and your business need, including:

- Start to finish project management
- No bureaucratic red tape
- A labor force that lives for hard work

www.amarilloedc.com

https://marketplace.aviationweek.com/product/amarillo-all-business-no-bull

Aftermarket Services ▪ Economic Development/Airports

ARTEMIS ELECTRONICS LLC

DMSMS and Legacy Electronics/Avionics through MRO

At Artemis we specialize in Overhauling, Redesigning, Reverse Engineering and Manufacturing of Legacy Electronics and Avionics for Military Platforms Worldwide. Our Agility and Forward Thinking allow us to mitigate DMSMS issues that allow the Warfighter to achieve Maximum Readiness.

www.artemiselectronics.com

https://marketplace.aviationweek.com/product/dmsms-and-legacy-electronics-avionics-through-mro

Maintenance, Repair & Overhaul

AEROREPAIR CORP

AeroRepair, when experience matters

Wheel/Tire, brake and battery R&O programs tailored to support our customer's specific and unique line maintenance operations. Turn-key service.

www.aerorepaircorp.com

https://marketplace.aviationweek.com/product/aerorepair-when-experience-matters

Maintenance, Repair & Overhaul ▪ Landing Gear/Wheels/Brakes

AUXITROL WESTON USA

Temperature, speed and pressure sensors and services

Auxitrol Weston is a world leading supplier of engine and aircraft sensors and services to both original equipment manufacturers and aftermarket MRO shops and airlines. We provide a wide range of highly reliable sensors including high accuracy temperature, speed and pressure sensors.

www.transdigm.com

https://marketplace.aviationweek.com/product/temperature-speed-and-pressure-sensors-and-services

Maintenance, Repair & Overhaul

Go to marketplace.aviationweek.com for more information.

AVAIR

Strategic Solutions For The Aviation Aftermarket

OVER 26 MILLION PARTS BEST-IN-INDUSTRY PRICING AvAir provides expert Asset Management, helping aircraft owners maximize the return on their aviation assets. Inventory is made available to the company's customers worldwide who view AvAir as a trusted provider.

www.avair.aero

https://marketplace.aviationweek.com/product/strategic-solutions-aviation-aftermarket

Aftermarket Services ▪ Asset Management

AVI AVIATION INFLATABLES

DER Approved Major Repairs that Reduces Costs

Major Repairs share the conformity of OEM Designs. AVI is authorized by the FAA to repair evacuation slides. Major Repairs must pass the same rigorous quality & testing requirements as OEM parts, but are significantly lower in price, reduced turn around times, & extend the units operational life.

www.avi-aviation.com

https://marketplace.aviationweek.com/product/der-approved-major-repairs-reduces-costs

Maintenance, Repair & Overhaul

B & W AVIATION - BRAKES AND WHEELS

Aircraft Brakes and Wheels by B & W Aviation

B & W Aviation provides top-of-the-line maintenance for your aircraft brakes and wheels; also, we offer outright and flat-rate exchange programs tailored to fit your requirements, making us leaders in the industry. Furthermore, we work with top manufacturers, assuring you the best quality and efficiency.

www.bwaviation.net

https://marketplace.aviationweek.com/product/aircraft-brakes-and-wheels-b-w-aviation

Maintenance, Repair & Overhaul ▪ Airframes ▪ Landing Gear/Wheels/Brakes

BILT INCORPORATED

Revolutionize Assembly, Maintenance & Training

BILT® 3D Interactive Intelligent Instructions

- Training - assembly - installation - maintenance - repair
- Found at The Home Depot, Walmart, Sam's Club, Costco & more
- Operating in 174 countries & 12 languages
- More than 130 brands
- Not limited like paper & videos

biltapp.com

https://marketplace.aviationweek.com/product/revolutionize-assembly-maintenance-training

Technology

CCX TECHNOLOGIES

Avionics Testing Redefined.

Streamline your avionics radio testing process with CCX Technologies' T-RX™ Avionics Radio and Pulse Testers (T-RX). A giant leap forward, our portable tablets feature large, sunlight-readable color touch screens. And the easy-to-use, intuitive interface helps save time and money.

ccxtechnologies.com

https://marketplace.aviationweek.com/product/avionics-testing-redefined

Tools & Equipment ▪ Test Equipment

CEMB-USA

CEMB Balancing Machines for the Aerospace Industry

CEMB is the only balancing company to integrate an automatic correction unit into our aerospace balancing machines. This integration has provided our customers with a tremendous advantage in their production of engine components.

www.cemb-usa.com

https://marketplace.aviationweek.com/product/cemb-balancing-machines-aerospace-industry

Tools & Equipment ▪ Tools

Go to marketplace.aviationweek.com for more information.

CHORUS AVIATION INC.

We deliver regional aviation to the world.

Chorus is a global provider of integrated regional aviation solutions. As both a large fleet operator and maintenance organization, we provide a full suite of regional aviation support services that encompasses every stage of an aircraft's lifecycle. How can we help you?

chorusaviation.com

https://marketplace.aviationweek.com/product/we-deliver-regional-aviation-world

Maintenance, Repair & Overhaul

DELTA H TECHNOLOGIES

Aerospace Composite Ovens and Heat Treat Furnaces

Veteran / Family Owned and operated, DELTA H provides Industrial Heat Treating Furnaces and Composite Curing Ovens designed exclusively for the aerospace and defense industries. Talk to us about AMS2750E, BAC5621, Nadcap Accreditation, Aluminum, Steel, Titanium Heat Treat, and Composite Curing!

WWW.DELTA-H.COM

https://marketplace.aviationweek.com/product/aerospace-composite-ovens-and-heat-treat-furnaces

Maintenance, Repair & Overhaul

ELBIT SYSTEMS OF AMERICA, MCLEAN OPERATIONS

A/C Maintenance, Engineering, Technical Solutions

Elbit Systems of America is a global tip-to-tail solutions provider. We specialize in commercial and military mid-sized single or twin engine turbo prop/fan aircraft and provide sustainment and specialized upgrade/modification solutions. We are a MRO and Contractor Logistics Support (CLS) provider.

www.elbitamerica.com

https://marketplace.aviationweek.com/product/c-maintenance-engineering-technical-solutions

Manufacturing & Distributing

F&B MFG, LLC

Complex metal forming and welding specialists

F&B is a contract manufacturer specializing in complex sheetmetal forming, hydroforming, welding, heat treating, vacuum brazing, laser cutting & machining, CNC machining, FPI, Water jet cutting in-house tool design & fabrication and assembly. NADCAP accredited.

www.fbmfg.com

https://marketplace.aviationweek.com/product/fb-mfg-llc

Maintenance, Repair & Overhaul

FEDEX AEROSPACE SOLUTIONS

Customized Solutions for your aerospace shipments

When you ship crucial parts with FedEx® Aerospace Solutions, we provide flexibility and multiple service options to keep your supply chain moving. Each of our solutions is tailored to fit your exact needs providing you with global access, visibility and aviation expertise.

greenlight.fedex.com

https://marketplace.aviationweek.com/product/senseaware

Aftermarket Services ▪ Supply Chain/Logistics

GALAXY INTERNATIONAL, INC.

It's all about the Accessories

Galaxy International, Inc, operating since 2000, is an FAA-certified 145 repair station dedicated to the repair and overhaul of mechanical accessories such as exciters, transducers, lube pumps, and APU fuel controls.

www.galaxyinternational.com

https://marketplace.aviahttps://marketplace.aviationweek.com/product/its-all-about-accessories-0

Maintenance, Repair & Overhaul ▪ Components ▪ Connectors/Fasteners ▪ Electrical ▪ Hydraulics/Pneumatics ▪ Lighting

Go to marketplace.aviationweek.com for more information.

GLOBAL EQUIPMENT COMPANY INC.

Global Industrial, Your Rebound Partner

Businesses around the world are adapting to new practices to include reinforcing health and safety measures for all employees and social distancing configurations for office spaces.

Ask us about R3!

www.globalindustrial.com

https://marketplace.aviationweek.com/product/global-industrial-your-rebound-partner

Tools & Equipment

HABCO INDUSTRIES

HABCO MRO – New FAA Repair Station Capability

HABCO MRO - a Certified 14 CFR part 145 Repair Station offers maintenance, repair and overhaul services under Limited Accessories for Airframe and Engine Components. HABCO MRO component repair capabilities include flow, pressure, hydraulic and accessories.

www.habco.biz

https://marketplace.aviationweek.com/product/habco-mro-new-faa-repair-station-capability

Calibration/Weighing Services ▪ Ground Support Equipment ▪ Test Equipment ▪ Tools

H.B. FULLER COMPANY

H.B. Fuller Engineering Adhesives Aerospace group manufactures interior, structural and composite adhesives, such as seam sealers, edge filling, low density void fillers and more. Royal® brand aerospace polysulfide sealants offer outstanding performance in fuel tank, fuselage and access door sealing. Adhesive Packaging Specialties provides custom packaging and delivery solutions for adhesives, sealants, coatings, lubricants and more.

www.hbfuller.com

https://marketplace.aviationweek.com/company/hb-fuller-company

Aerospace materials

INVENTORY LOCATOR SERVICE, LLC

MAXIMIZE AVIATION PARTS & PROFITS

FIND WHAT YOU NEED - utilize our IPC libraries to determine which airframe and/or engine can deliver the most profit per part to your business.

SELL WHAT YOU HAVE - expand your reach to global customers and access a highly targeted market of motivated buyers.

Free subscription at ILSMART.COM

www.ILSmart.com

https://marketplace.aviationweek.com/product/maximize-aviation-parts-profits

Aerospace Materials

JET INTERNATIONAL CO. LLC

Jet International Co. LLC

An aviation industry leader for over 40 years, Jet International has supplied airframe & engine components for commercial & corporate aircraft. We currently support all commercial air transport aircraft manufactured by Boeing, Airbus, Embraer and many others.

www.jetinternational.com

https://marketplace.aviationweek.com/product/jet-international-co-llc

Manufacturing & Distributing ▪ Components

L3HARRIS

L3Harris offers aftermarket and MRO services for a broad range of avionics, recorders, displays, standbys and ADS-B solutions specifically suited for your operational needs, including enhanced Flight Data Monitoring (FDM) and Flight Operations Quality Assurance (FOQA) services through a worldwide, proven web-based platform.

L3Harris.com/avionics

https://marketplace.aviationweek.com/company/l3harris

Airline and Military Maintenance

Go to marketplace.aviationweek.com for more information.

GLOBAL GREEN TECHNOLOGIES CORP

Luminous Aviation Cleaning Solutions

Non-toxic, non-corrosive, VOC-free nanotechnology for interior/exterior cleaning. Luminous Exterior is engineered to provide aerodynamic support and reduce drag with each consecutive application while interior clean, protects, and disinfects all hard surfaces inside the cabin leaving an immaculate shine.

LUMINOUS AVIATION CLEANING SOLUTIONS

www.luminousworldwide.com

https://marketplace.aviationweek.com/product/luminous-aviation-cleaning-solutions

Aerospace Materials

MICROPAC INDUSTRIES

Supplier of mission critical sensors and systems

Over 50 years in the design and manufacture of safety of flight, avionics, position sensing, liquid management and contaminant detection, and power distribution components and systems. Experts in providing specific solutions based engineering capabilities to solve specific customer needs.

MICROPAC

micropac.com

https://marketplace.aviationweek.com/product/supplier-mission-critical-sensors-and-systems

Maintenance, Repair & Overhaul

MID-STATE AEROSPACE, INC.

Aerospace Hardware and Hose Assemblies

MSA is an authorized fabricating distributor for Parker Stratoflex with vast experience in handling fittings and assemblies as well as Stratoflex's Quick-Disconnects coupling, Symetrics and Dynatube lines.

We are also a premier provider of aerospace hardware including AN, MS, NAS, BAC, HI-Loks & Cherry hardware and installation tools.

www.midstateaero.com

https://marketplace.aviationweek.com/product/reliability-accuracy-expertise

Airframes ▪ Connectors/Fasteners ▪ Hardware ▪ Hydraulics/Pneumatics ▪ Parts Distributor

MK TEST SYSTEMS

The next generation of Loop Resistance Testers

The brand new ExLRT revolutionizes the design by downsizing Loop Resistance Testing into size small enough to wear on the hip and adding intrinsic safety and weather proof serviceability. It's as easy to operate as a DMM.

MK TEST SYSTEMS

www.mktest.com

https://marketplace.aviationweek.com/product/next-generation-loop-resistance-testers

Tools & Equipment

NES BEARING CO., INC.

NES Bearing Co., Inc.

Napoleon Engineering Services is a major US bearing manufacturer of OEM and PMA ball and roller bearings for the aerospace industry. Additionally, NES is a leader in bearing reverse engineering services, offering reverse engineering of type certified aircraft ball and roller bearings in support of FAA-PMA certification.

www.nesbearings.com

https://marketplace.aviationweek.com/product/nes-bearing-co-inc

Manufacturing & Distributing

ODYSSEY ENGINES, LLC

REPAIR -LEASE - TEST - INVEST

Odyssey Engines, LLC provides MRO support, engine leasing, field service, engine testing, material management support and asset management. Our core focus is to repair, buy, sell, test and lease engines. We take pride in being your one stop shop for securing all your CFM56, CF6 and JT8D solutions.

ODYSSEY ENGINES LLC

www.odysseyengines.aero

https://marketplace.aviationweek.com/product/repair-lease-test-invest

Airframes ▪ Components ▪ Engines/Engine Systems ▪ Hydraulics/Pneumatics ▪ Landing Gear/Wheels/Brakes

Go to marketplace.aviationweek.com for more information.

OPTOMEC

Maximize your ROI with automated laser cladding.

180% ROI, 1.7 year pay-back for automated repair of gas turbine blades including titanium compressor blades. Less post-processing and superior material properties compared to manual TIG welding.

www.optomec.com

https://marketplace.aviationweek.com/product/maximize-your-roi-automated-laser-cladding

Maintenance, Repair & Overhaul

OTTO INSTRUMENT SERVICE, INC.

Otto Instrument Service - Complete MRO Services Commercial and Military

Founded in 1946, Otto Instrument Service, Inc. is a world leading independent MRO service provider, earning a reputation for providing superior overhaul, repair & manufacturing services for instrumentation, avionics & electrical accessories. Otto is a licensed & authorized Honeywell Service Center.

www.ottoinstrument.com

https://marketplace.aviationweek.com/product/otto-instrument-service-complete-mro-services-commercial-and-military

Maintenance, Repair & Overhaul

PACIFIC AERO TECH

Cockpit Window Overhaul

Pacific Aero Tech is a premier FAA Part 145 Repair Station providing New and Overhauled Cockpit Windows since 1987. In addition to best-in-class frame repairs, we provide OEM-level, FAA-approved repair/overhaul/full rebuild of transparencies for Boeing 737, 757, 767 and 777 aircraft. Our transparency rebuild program offers significant savings to both operators and MROs worldwide. As part of our program, we are actively in the market for "as-removed" and BER units. As a testament to our quality, we are proud to have been awarded the Boeing (Aviall) Supplier Excellence Award eight straight years.

pacificaerotech.com

https://marketplace.aviationweek.com/product/cockpit-window-overhaul

Manufacturing & Distributing

PACIFIC TOOL

Got FOD? We Can Help!

Foreign Object Debris can jeopardize the quality of your repairs. Boeing Standard Tools by Pacific Tool remove FOD from hard to reach places and ensure your aircraft is ready to fly. Pacific Tool stocks 10,000+ Standard Tools to keep your work clean as a whistle. See them all at www.pacifictool.com!

Tools & Equipment ▪ Test Equipment ▪ Hangars & Equipment ▪ Ground Support Equipment ▪ Airport Equipment & Services

www.pacifictool.com

https://marketplace.aviationweek.com/product/got-fod-we-can-help

PATRIOT COMPONENTS

PATRIOT COMPONENTS EXCEEDING YOUR EXPECTATIONS

We are service minded professionals operating as service industry leaders, our service product is client centric. We believe in supporting our clients needs through affordable quality repairs to increase client ROI, this for the betterment of all involved in todays market.

PATRIOT COMPONENTS LLC

www.patriotcomponents.us

https://marketplace.aviationweek.com/product/patriot-components-exceeding-your-expectations

Maintenance, Repair & Overhaul ▪ Components ▪ Hydraulics/Pneumatics

PERFORMANCE PLASTICS

Non-marring Aircraft Maintenance Tools

Performance Plastics, EnduroSharp® product line consists of nonmetallic tools used to remove adhesives, sealants, and coatings from aircraft structures. Providing aerospace maintenance professionals an adhesive removal tool that holds an effective edge, without damaging composite substructures.

PERFORMANCE PLASTICS EnduroSharp

www.performanceplastics.com

https://marketplace.aviationweek.com/product/non-marring-aircraft-maintenance-tools

Tools & Equipment ▪ Tools ▪ Aerospace Materials

Go to marketplace.aviationweek.com for more information.

R&D DYNAMICS

World Leader in Air Cycle Machine Technology

R&D Dynamics offers the most cost effective, low risk solution to your replacement part needs by utilizing our 27 years of engineering experience, designing and fabricating for the OEMS and testing in accordance with the FAA's stringent requirements.We now provide Overhaul and Repair capability with our 145 Repair Facility, Hartford Aero Maintenance.

www.rddynamics.com

https://marketplace.aviationweek.com/product/world-leader-air-cycle-machine-technology

Components ▪ Engineering and Design ▪ Hydraulics/Pneumatics

RAPID FIRE PROTECTION INC.

Rapid Fire Protection Inc.

Rapid Fire Protection Inc. & AdTech Alarm, is a fire suppression and alarm contractor specializing in hazard analysis, design, engineering, fabrication, installation and inspection services with turnkey capabilities to supply all of your industrial fire suppression needs for the aviation sector.

www.rapidfireinc.com

https://marketplace.aviationweek.com/product/rapid-fire-protection-inc

Tools & Equipment

SUPER DUTY FANS

Grab Heat by the Horns

Super Duty Fans are shrouded and guarded super tough industrial ceiling and floor fans. Our fans range from 36' to 59" in diameter and employ a flexible Quad Strap mounting system that allows them to be installed easily and at any angle.

www.superdutyfans.com

https://marketplace.aviationweek.com/product/grab-heat-horns

Tools & Equipment

TEAM TEXAS

Your MRO operations will soar in Texas!

At Team Texas, our mission is to create opportunities for job creation, increased investment, and economic diversification as a team of future-focused and collaborative Texas communities and partners.

Connect with us to learn about the bold opportunities for expanding or relocating your business within the state.

www.goteamtexas.com

https://marketplace.aviationweek.com/product/your-mro-operations-will-soar-texas

Aftermarket Services

THE ASKO GROUP

HVOF Coating for major OEMs & Military

HVOF Tungsten Carbide is the preferred replacement for chrome plating at all major aerospace OEMs. The ASKO Group has been performing this process for over 15 years. We are qualified by Boeing, Collins, and the US Air Force. We perform all of our own grinding and super-finishing in-house.

ASKOGroup.com

https://marketplace.aviationweek.com/product/hvof-coating-major-oems-military

Maintenance, Repair & Overhaul

TITAN TOOL SUPPLY, INC.

Modular Videoscope for Aviation Inspection and Maintenance

Titan Tool Supply's TVG-PRO Videoscope features a single video unit with five different combinations of insertion tube lengths and diameters. Available in lengths of 1, 2 and 3 m; diameters of 2.8, 4.0 and 6.0 mm. All feature 180° or full 360° articulation. A 5" LCD monitor includes five levels of brightness via high intensity LED illumination with 100,000 hours of life.

www.titantoolsupply.com

https://marketplace.aviationweek.com/product/modular-videoscope-aviation-inspection-and-maintenance

Tools & Equipment ▪ Hangars & Equipment ▪ Ground Support Equipment

Go to marketplace.aviationweek.com for more information.

U.S. AVIATION SERVICES CORP. - AEROWASH - LUMINOUS

A global partnership for one green solution.

U.S. Aviation Services Corp., Aerowash Nordic AB and Luminous Aviation are partnering in an effort to reduce the carbon footprint in the aircraft cleaning industry in North America with an exterior wash alternative consisting of advanced robotics and nanotechnology cleaning solutions.

onegreensolutionmro.com

https://marketplace.aviationweek.com/product/global-partnership-one-green-solution

Aftermarket Services

US TOOL GROUP

US Tool: Service to Aerospace Ind. Since 1958

- Production Cutting Tool Reconditioning: Providing All Tool Services, Guaranteed!
- Value Added Services: Foam Cutting, Kitting, Cleco Reconditioning, etc.
- Integrated Supply: We Represent YOU! Vendor Neutral, Cost Savings Programs, Consigned Inventory, etc.

www.ustg.net

https://marketplace.aviationweek.com/product/us-tool-service-aerospace-ind-1958

Tools & Equipment

VELOCITY AEROSPACE

Trusted Repair with Velocity

TCAS "Avoidance" of costly repairs and replacement is our business, with guarantee of non BER and stock units available to keep your fleet in the air and out of harms way.

www.velocityaerospace.com

https://marketplace.aviationweek.com/product/trusted-repair-velocity

Maintenance, Repair & Overhaul

VP BUILDINGS

VP Buildings

Varco Pruden specializes in the computer-aided design of pre-engineered metal buildings and steel systems construction. Working alongside a network of builders, architects, and engineers, Varco Pruden provides aesthetically appealing buildings with optimum functionality.

www.vp.com

https://marketplace.aviationweek.com/company/vp-buildings-inc

Engineering ▪ Hangars & Equipment ▪ Military Maintenance

VSE AVIATION

Newly Added Cargo, Gallery & Hydraulic Capabilities

1st Choice is proud to announce continued expansions to both our KY & FL facilities. We have further expanded Cargo, Galley, Avionic, Instrument and added Hydraulic repair capabilities to support our customers.

www.vseaviation.com

https://marketplace.aviationweek.com/product/newly-added-cargo-gallery-hydraulic-capabilities

Maintenance, Repair & Overhaul

WEST VIRGINIA DEVELOPMENT OFFICE

West Virginia is where you belong.

The West Virginia Development Office provides tools and resources so companies who come to West Virginia can meet their goals and enjoy success. If your company is looking for a fresh start or searching for a place where you can make your mark on the world, West Virginia is a land of opportunity.

www.westvirginia.gov

https://marketplace.aviationweek.com/product/west-virginia-where-you-belong

Aftermarket Services

Go to marketplace.aviationweek.com for more information.

Go to marketplace.aviationweek.com for more information.

AVIATION WEEK NETWORK

Aviation Week is Proud to Thank Our Sponsors of the 2020 MRO Series.

We are all in this together, and we couldn't do it without you!

AVIATION WEEK MRO AMERICAS

AVIATION WEEK MRO ASIA-PACIFIC

AVIATION WEEK MRO AUSTRALASIA

AVIATION WEEK MRO BEER

AVIATION WEEK MRO EUROPE

AVIATION WEEK MRO LATIN AMERICA

MRO MIDDLE EAST

Organised by AVIATION WEEK NETWORK & Tarsus

MILITARY AVIATION LOGISTICS & MAINTENANCE SYMPOSIUM (MALMS)

A PROFESSIONAL AVIATION SERVICES CORP

AAR

AEREOS

AerFin BEYOND SUPPORT

AERO ACCESSORIES

AEROXCHANGE

AerSale

KLM UK Engineering

AIRFRANCE KLM INDUSTRIES

AGSE WESTMONT

AIRBUS

AIRCRAFTERS, INC.

APS A Global Aerospace Partners Company

AJ Levin Airbus Consumable Solutions

AJW

AMETEK MRO

ARG Aerospace Resource Group

Atitech

Avianca A STAR ALLIANCE MEMBER

Aviation AUSTRALIA

ATS

avparts INTERNATIONAL

BOEING

BOMBARDIER | MRO

BCG BOSTON CONSULTING GROUP

BPAERO

Cee-Bee Innovative Aviation Chemistry

cfm The Power of Flight

CHAPPELL SUPPLY AND EQUIPMENT

CHROMALLOY

Collins Aerospace

COOPESA

CTI SYSTEMS

CTS ENGINES

DEDIENNE AEROSPACE

EATON

Wait... There's more to thank!



AVIATION WEEK NETWORK

To learn about upcoming MRO events and what Aviation Week is doing to keep this community connected visit us at events.aviationweek.com

AVIATION WEEK
Intelligence
NETWORK

Stay **Informed.** Stay **Connected.** Stay **Engaged.**

Access authoritative market insights and analysis along with company, program, fleet and contact databases covering the global aviation, aerospace and defense communities with an **Aviation Week Intelligence Network (AWIN) Membership**.

120,000 industry personnel

26,000+ global organizations

Details on 150,000+ commercial, business and military aircraft

16,000 suppliers of more than 175,000 products and services

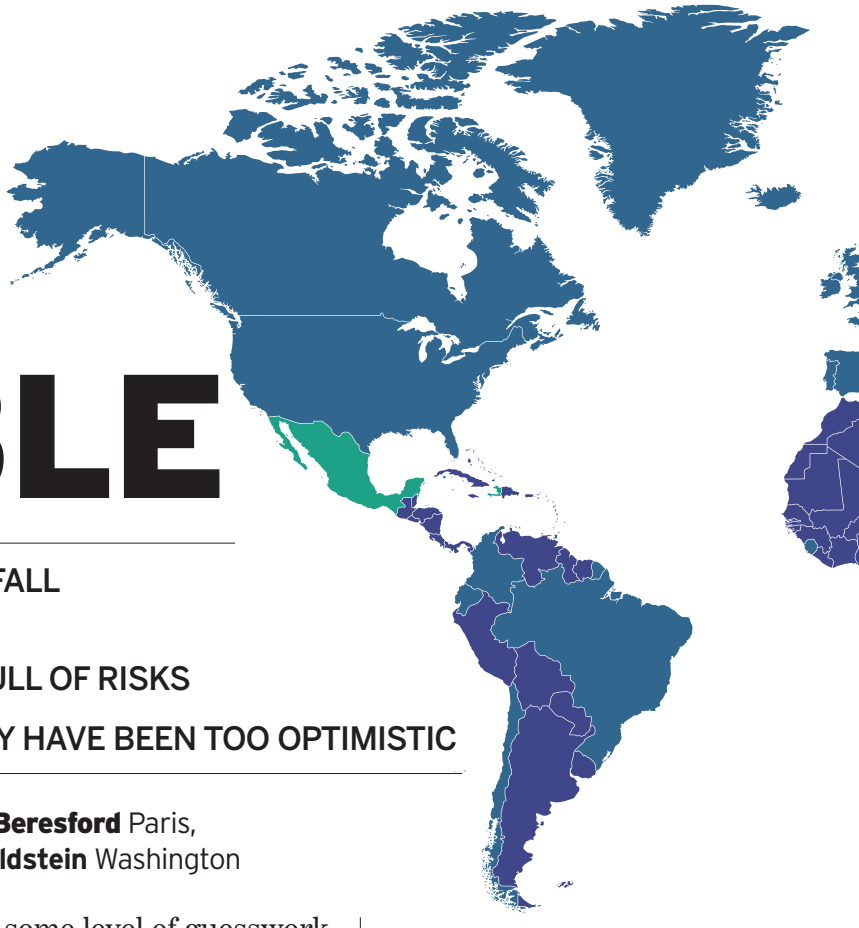
Become a member today.

Visit **aviationweek.com/AWINinfo** to schedule your demo.

Or call **Anne McMahon at +1 646 291 6353** or
Thom Clayton +44 (0) 20 7017 6106

AVIATION
WEEK
NETWORK

THE BIG GAMBLE



- MORE TRAVEL RESTRICTIONS FALL AND MARKETS REOPEN
- EXPENSIVE RESTART PHASE FULL OF RISKS
- IATA WARNS ITS FORECAST MAY HAVE BEEN TOO OPTIMISTIC

Jens Flottau Frankfurt, **Helen Massy-Beresford** Paris, **Adrian Schofield** Auckland and **Ben Goldstein** Washington

The airline industry is used to some level of guesswork, even in good times. No one really knows how demand will evolve, whether a new route will actually perform according to expectations or what the response by competitors will be. No matter how analytical the approach is, no matter how experienced the network planning department, some experiments will always fail.

In good times, airlines typically have the financial wherewithal to deal with some level of underperforming markets. But now, as the industry takes its first steps to emerge from an unheard-of crisis, it faces the worst possible combination: There is no financial margin left for wrong bets on capacity, pricing and network rebuilding, and the uncertainty about when, where and how demand might return is greater than ever.

Only over the past few weeks have some encouraging signs begun to emerge on a broader scale, probably good enough to call the short-term trend a recovery, but not good enough to call it stable upward development. And even as traffic begins to slowly come back, airlines will soon face the winter season, when most carriers lose money even when business is booming.

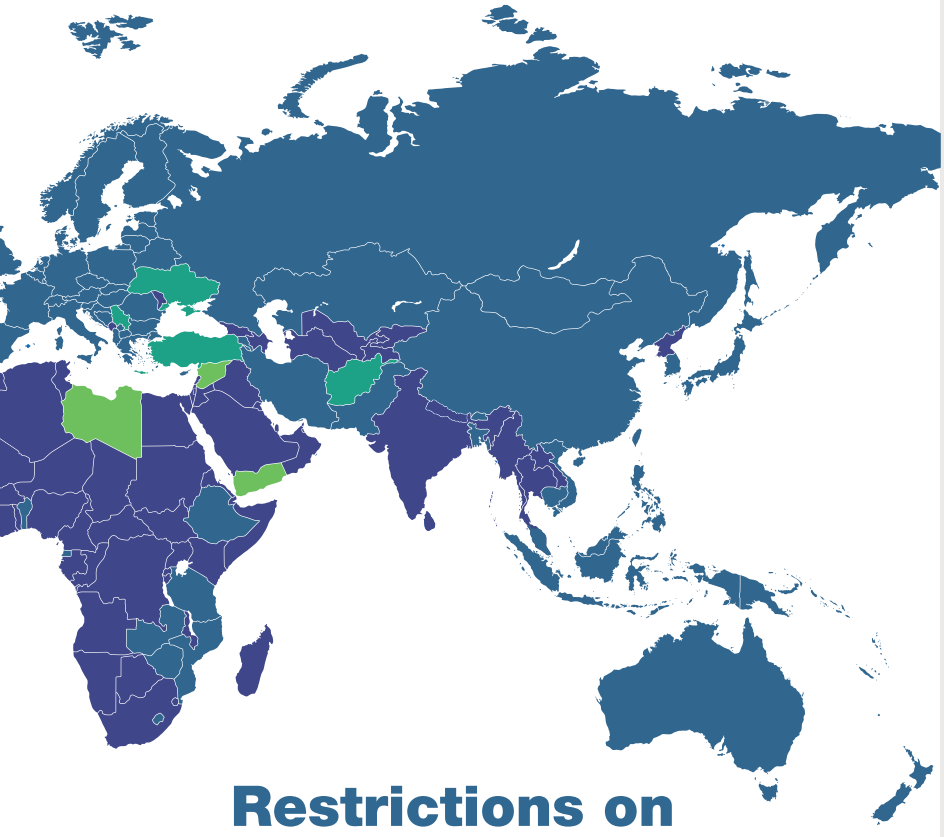
The path forward for commercial aviation depends on one factor first and foremost: an airline comeback based on the return of traffic. Everything is tied to it. When that regains traction, airlines will be able to afford to pay for maintenance and spare parts, resume airport and air traffic control payments and bring back pilots and cabin crew from short-time work schemes that, in many countries, have protected them from being laid off for now. If things go really well, airlines may even consider taking delivery of aircraft in greater numbers—aircraft ordered when some executives imagined continued profitability at least until their own retirements.

Unfortunately, while prospects for the airline industry differ by region, worldwide there is reason for renewed concern. The International Air Transport Association (IATA) warns that a recent rise in COVID-19 cases led to a weakening of bookings in the second half of June and could have a severe impact on the expected recovery of air travel.

A COVID-19 outbreak discovered in Beijing on June 11 has shown what airlines might expect even in countries that have the pandemic largely under control. News of the outbreak prompted outsiders to avoid travel to Beijing, while the city's government forbade people from zones of high infection to leave. The authorities also discouraged departures by people from other parts of Beijing and made them conditional on having had recent, negative infection tests.

By the last week of June, Beijing Capital International Airport was handling only about a quarter as many flights as it had three weeks earlier.

IATA Chief Economist Brian Pearce says the recent increase is leading the association to be "cautious about prospects for the next few months." If it continues, it could delay the ending of travel restrictions for international journeys "beyond what



Restrictions on International Air Travel

Totally Restrictive
Partially Restrictive
Not Restrictive
Latest updates currently under review

Source: IATA

we had expected in the forecast." The European Union's decision to keep travel restrictions to the U.S. in place is one major point of concern, given that U.S. international flying represents 37% of global demand, as measured in revenue passenger kilometers (RPK).

Pearce points out that there is a large downside risk for the expected rebound in air travel. IATA so far forecasts demand to recover to a level around 36% below 2019 by year-end. But if the rise in novel coronavirus cases is not reversed and travel restrictions remain in place, the actual drop in air travel could be 53%.

According to an IATA analysis, around 20% of countries are starting to ease restrictions—but 65% remain completely closed. Where massive state bailouts have been put in place, airlines have largely avoided bankruptcies. "In the absence of substantial government aid, it is very difficult for airlines to survive," says Pearce. Latin America is the most dramatic case, where LATAM Airlines, Avianca and Aeromexico all filed for bankruptcy within weeks.

"Ultimately, until we have a vaccine, one of the suppressors of demand for travel will be the perception of risk on the plane," says Patrick Edmond, managing director of consultancy Altair Advisory. "Reassuring passengers about safety is going to count for at least as much as headline prices."

The number of COVID-19 cases, which is rising particularly fast in parts of the developing world and the U.S., is not the only reason for concern. While businesses expect a V-shaped recovery of the economy in

FLIGHT PATHS FORWARD

OPTIMISTIC

- Better business confidence indicators translate into greater demand for flying.
- With COVID-19 better contained, supported by an efficient vaccine from early 2021, leisure travel returns more quickly than expected as airlines benefit from pent-up demand.
- Airlines surviving with government help benefit from a consolidated market; can establish higher pricing earlier.
- Short-haul flying recovers almost fully in 2021; long-haul returns by 2023.

NEUTRAL

- More countries manage to contain the pandemic, and the industry's health measures prove to be efficient.
- Air travel returns to 40% below 2019 levels by the end of 2020, recovering further in 2021.
- Long-haul flying remains severely suppressed through 2020 but makes a steep recovery in 2021.
- A COVID-19 vaccine is created, though the effects of a global recession continue to affect demand.
- Traffic returns to precrisis levels by 2023; the industry makes its first post-coronavirus profit in 2022.

PESSIMISTIC

- Containing the further spread of COVID-19 takes longer than expected and affects major air transport markets such as the U.S.
- Bookings weaken and international travel restrictions remain in place longer or are reinstated.
- Traffic recovery is delayed and much weaker than forecast; more airlines fail; aircraft production is cut further.
- Slow recovery begins only in 2021 after a vaccine reassures travelers.
- A return to 2019 traffic levels is achieved after 2023.

general, that does not translate into an equivalent rebound of air travel demand, as it should in normal times. "[Corporations] are still very cautious about travel," Pearce notes. But there "may be some upside surprises," he adds. In contrast to business confidence, consumer confidence is still very low. For leisure travel to pick up in any significant way, the industry will need to reverse such apprehensions.

So far, IATA continues to predict that the industry will return to profitability in 2022, with a relatively steep recovery of global airline traffic to a level 36% below 2019 by year-end and 29% below 2019 in 2021.

Global traffic figures for May show a 91.3% reduction over last year, compared to a 94% drop in April. "May was not quite as terrible as April. That's about the best thing that can be said," says IATA Director General and CEO Alexandre de Juniac. Essentially all of the recovery came from domestic travel, particularly within China. There was "no improvement at all in international travel," Pearce notes. IATA members also recorded an all-time-low load factor of 50.7% for the month, a decrease of 31 percentage points compared to May 2019.

Beginning in June, though, many airlines started rebuilding capacity. A bet was placed on the future.

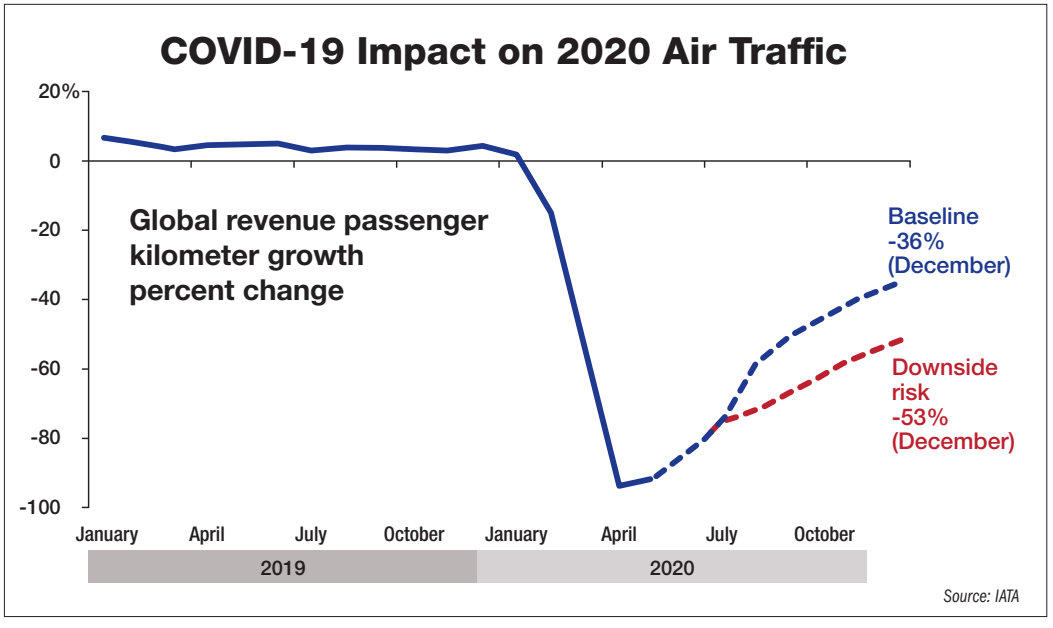
In the U.S., with international travel set to lag domestic in the absence of a vaccine, domestic-focused carriers such as Southwest Airlines will have a natural advantage over their competitors with larger international networks. Prior to the pandemic, Southwest deployed roughly 5% of capacity outside the country, compared to full-service carriers that devote as much as 40% of their capacity to international flying in normal years.

Southwest expects to operate at nearly flat year-over-year capacity by year-end, indicating an aggressive strategy to capitalize on its domestic network and low-cost structure during the COVID-19 recovery. Delta Air Lines, with far more exposure to battered corporate and long-haul markets, plans to steadily grow its domestic schedule back to 55-60% of last year's levels by September, before taking a strategic pause while management evaluates fall demand trends.

American Airlines and United Airlines are planning to push their domestic flying above 50% in July and August, respectively. Still, with so much uncertainty surrounding the return of corporate and international traffic, it is likely that the largest carriers will remain deep in negative year-over-year capacity territory until spring 2021, when the base for comparison will also have been affected by the pandemic.

Ultra-low-cost carriers (ULCC) believe their domestic leisure focus and low operating costs will allow them to grow aggressively during the recovery period, a scenario reminiscent of the years following the 2008 financial crisis, when they expanded while network carriers adhered to strict capacity discipline. Allegiant Air and Spirit Airlines are both targeting nearly flat levels by year-end, while Frontier Airlines is aiming for 80-90%. ULCCs such as Allegiant and Sun Country Airlines will also benefit from low-priced used aircraft. The CEOs of both companies have said they will use them to source fleet growth and spare parts for their Airbus A320 and Boeing 737 fleets, respectively.

American Airlines and Delta have already retired more than 350 aircraft combined, including all of American's A330s, Boeing 757s, 767s and Embraer 190s and all of Delta's MD-88s, MD-90s and Boeing 777s. United has not retired any aircraft, but has parked hundreds temporarily while executives seek more clarity on demand trends.



In Europe, a recovery is underway. According to Eurocontrol data, the number of flights in the network was 12,742 on July 1, about four times the level of just a week earlier. "The recovery is clearly gathering speed," says Eurocontrol CEO Eamonn Brennan.

But that growth is still a drop in the ocean compared to precoronavirus levels, and airlines and consumers alike are cautious about how the next few weeks and months will play out. And not everyone benefits equally, with UK-based airlines still struggling with quarantine rules while some, such as Virgin Atlantic, desperately seek more equity.

"On the positive side, there is pent-up demand coming into the summer. Lots of people would like to be able to go away on holiday," says Edmond. "In Europe the main driver this summer is going to be leisure, not business."

"We would expect a second [COVID-19] wave, should it materialize, to be met with a more granular approach by authorities instead of

nationwide shutdowns," says Bernstein analyst Daniel Roeska. "This should enable airlines to react proportionally and not bring the entire air travel system in Europe to a standstill again."

With demand for air travel tied closely to a country's economic situation, however, airlines are also going to have to make huge concessions on profitability and the all-important ancillary revenues by luring in wary consumers with low prices. It is a message the region's LCCs have already taken to heart. EasyJet said it was launching its biggest summer sale ever as it mapped out the partial resumption of its schedule, with over 1 million flights starting at £29.99 ($38), highlighting the intense pricing pressure it and its peers are facing.

EasyJet has said it expects to be operating at about 30% of its normal pre-COVID-19 capacity in the fourth quarter of its financial year, which runs through the end of September. Ryanair, meanwhile, returned to 40% of normal flight schedules July 1, with a daily flight schedule of almost 1,000 flights, restoring 90% of its pre-COVID-19 route network.

Lufthansa plans to fly to 90% of its domestic and European destinations as well as 70% of its long-haul markets by September, albeit at around 40% of precrisis capacity, so at a much lower frequency.

"I think in the best-case scenario, by the end of the summer if we're back to 50% of normal demand, that would be spectacular," Edmond says.

Beyond the financial and psychological factors affecting passengers, there are operational and financial risks to contend with for the airlines too.

French Bee CEO Marc Rochet says the increased costs and unpredictable revenues of the post-coronavirus ramp-up phase could be fatal to some airlines. "The sleep phase cost a lot of money, but most airlines were able to absorb that," he says. "The take-off phase, however, could be fatal for some airlines because no one knows how long it will last."

"Adapting to the change in demand and the weaker medium-term outlook requires airlines to cut capacity by 10-20%," Roeska writes. "This requires renegotiation with aircraft OEMs and the labor base. The upcoming weeks will demonstrate how successful airlines can shrink their business without carrying too many planes or employees through a crisis that will be felt until 2023-24."

Top 10 Domestic Markets Globally

Ranked by weekly seats for week of June 29

Rank	Market	Country
1	Seoul-Jeju	S. Korea
2	Ho Chi Minh City-Hanoi	Vietnam
3	Tokyo-Sapporo	Japan
4	Osaka-Tokyo	Japan
5	Fukuoka-Tokyo	Japan
6	Shanghai-Guangzhou	China
7	Shanghai-Shenzhen	China
8	Tokyo-Okinawa	Japan
9	Hanoi-Da Nang	Vietnam
10	Shanghai-Chengdu	China

Source: CAPA and OAG

In the Asia-Pacific region, domestic markets have been rebounding well as internal restrictions have eased, and the strongest growth tends to be in countries that have been most successful in controlling the pandemic. The top 10 domestic markets as measured by seat capacity are all in the Asia-Pacific region.

Vietnam, for example, has seen its domestic capacity surge back quickly after essentially disappearing in April. Markets such as India's have progressed more slowly, with the Indian government capping domestic capacity since flights resumed on May 25.

The rapid recovery of domestic markets is likely to continue through this year, providing some relief for airlines in the absence of international traffic. Of course, this is cold comfort to airlines such as Cathay Pacific and Singapore Airlines (SIA) that do not have domestic networks.

International recovery has been more sluggish in the Asia-Pacific region, which is relatively fragmented due to the vast number of countries and a relative lack of intraregional authorities. Some airlines have begun ramping up international flights this month, including Korean Air and the major Japanese carriers. But the key factor will be how quickly cross-border restrictions and quarantine requirements are eased.

A few countries have established travel corridors—or fast lanes—between them for essential travel. South Korea and Singapore both have such arrangements with China. More of these are likely to emerge, first on a bilateral basis and then multilaterally. The next step will be the development of travel bubbles, which would allow nonessential travel with few restrictions. The first of these could be established between Australia and New Zealand later this year.

The Hong Kong and Singapore governments have allowed transit flights to resume, which will put SIA and Cathay in a good position to take advantage of global markets as they reopen. A crucial factor for many Asia-Pacific airlines will be gaining more access to China routes, which have been heavily restricted by the Chinese government during the pandemic.

Varying levels of government support will play a key role in determining which airlines emerge strongest from the COVID-19 crisis. For example, SIA's S$15 billion ($11 billion) state-backed financing package will give it an advantage. In contrast, the Thai government's decision to send Thai Airways to bankruptcy court to restructure shows that governments have less appetite to provide money to airlines with poor financial records. Some Asian nations are still considering airline bailout packages.

Airlines in the region are also pulling whatever levers they can, and many have launched restructuring initiatives or broad strategic reviews. Some of these airlines had already started—or recently completed—turnaround programs, but the new reviews are likely to go much further and yield broader changes. They will examine areas such as workforce, fleet and network as they look to streamline their businesses.

There likely will be some airlines that do not survive the crisis. Many of the region's flag carriers have previously been considered too big to fail, but the massive government spending necessitated by COVID-19 could challenge that assumption.

For now, smaller LCCs appear more vulnerable, particularly those that have not benefited from state bailouts that flag carriers have received. The long-haul LCCs could be particularly at risk due to their reliance on international routes and widebody aircraft. NokScoot is one LCC that has been closed down by its owners, and Tigerair Australia will likely soon follow.

Australian Strategy Pivots, Spending Plans Change Little

> MOST NEW ACQUISITION PROGRAMS WILL BEAR FRUIT IN THE 2030s

> BUT AIR-LAUNCHED STRIKE MISSILES ARE COMING SOONER

Bradley Perrett Beijing

Australia can no longer rule out suffering a major attack within 10 years, the government says. But if Prime Minister Scott Morrison is worried about the risk of war in the 2020s, analysts do not see his administration's new defense strategy doing much about it.

Although a Strategy Update published on July 1 recognizes a rapidly growing threat from China, the size of 2020s defense budgets is hardly changing (see graph). Australia will buy air-to-surface strike weapons to deter an enemy, meaning China, but most other new spending plans will make no difference to capability before the 2030s. Australia's biggest defense acquisition programs are unchanged; the naval ones will deliver results mainly in the 2040s.

Australian defense-policy statements consist of two parts: essaylike descriptions of threats and strategy, which for the past decade or so have tiptoed around the danger from China, and nuts-and-bolts spending plans that have consistently augmented the armed forces, though never dramatically in the short term.

This time, the threat-and-strategy statement is markedly different. It drops the assumption of 10 years' warning of attack, declares that Australia must rely more on itself—implicitly not so much on the U.S.—and pulls the focus of defense policy closer to home, suggesting Canberra is less interested in expeditionary operations.

But this new strategy has not made much difference for the shopping list, says Marcus Hellyer of the Australian Strategic Policy Institute in Canberra.

His colleague Andrew Davies says: "Beyond the headlines of this announcement, there is essentially no extra money and very little in the way of force-structure changes." Near-term spending plans, announced previously, are mostly undisturbed, he notes.

Canberra is, however, maintaining its projected defense budget in the face of economic damage from the coronavirus pandemic. The government says a former target of spending 2% of GDP on the military, to be reached in the financial year that began on July 1, will not be regarded as an upper limit. According to Aviation Week estimates, spending will be 2.2% of GDP in 2020-21 and 2.3-2.4% for the rest of the decade.

The government says Australia "must be able to hold potential adversaries' forces and infrastructure at risk from a greater distance and therefore influence their calculus of costs involved in threatening Australian interests." This can refer only to China—specifically, to its forces that might approach Australia and bases it might build within reach of the country.

Accordingly, Canberra will assess its options for equipping combat aircraft with longer-range strike weapons; spending on this has begun. Options were not listed, but they must suit either of the two types that will constitute the 2020s fighter force: the Lockheed Martin F-35 Lightning and Boeing F/A-18F Super Hornet.

Money that the 2016 white paper set aside for more F-35s to succeed the 24 F/A-18Fs around 2030 is now labeled "additional air combat capability," which suggests the possibility of expansion, not mere replacement. But Hellyer, noting the habitual imprecision of the defense department's planning statements, warns against reading too much into this.

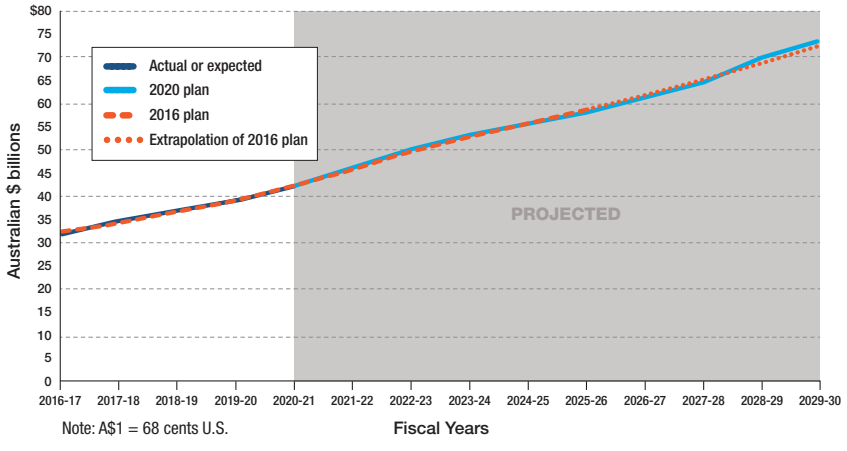
The acquisition of combat drones is now definitely planned, with funding beginning in 2026-27—which may mean an order will be placed a few years later. This improves the chances that Boeing will sell its unmanned Airpower Teaming System (ATS) to Australia. Boeing is developing the ATS in Australia initially for nonkinetic missions.

Canberra says it will pay for "development and acquisition of additional crewed and remotely piloted intelligence, surveillance and reconnaissance (ISR) aircraft," increasing numbers and sophistication in tactical and strategic awareness. But money for this will not flow before 2030.

These are among many acquisitions that vague timelines suggest will occur next decade. A theme among the possible purchases is larger unit numbers for tankers, air-surveillance aircraft, airlifters and electronic attack aircraft.

—With Craig Caffrey in London

Australian Defense Spending



Note: A$1 = 68 cents U.S.

Source: Commonwealth of Australia

Aerospace Manufacturing Conference

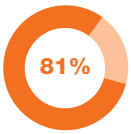
AUGUST 25-26, 2020

Belmond Charleston Place
Charleston, SC

Designed for leaders and decision-makers from OEMs to Supplier Tiers in the Aerospace Manufacturing Industry

The SpeedNews 8th Annual Aerospace Manufacturing Conference will bring together leading manufacturers and suppliers in the aerospace industry to present updates and developments in manufacturing operations, capabilities and processes, innovation within manufacturing, modern machining technologies, and industry automation.

Delegates will gain a full understanding of the latest trends, challenges and forecasts in the aerospace manufacturing industry, and be provided with insider knowledge and examples of products that can have a direct impact on their operations and improve productivity and profitability.



First time Delegates report they would "likely" or "very likely" attend another Conference.

Delegates report they would recommend a Conference to a colleague or peer.

ShowCase Your Products or Services

The **ShowCase** at SpeedNews' Aerospace Manufacturing Conference is offering a select number of manufacturing, technology and product/service providers the opportunity to join this exclusive event. As a ShowCase sponsor, you will benefit from two days of networking, knowledge building and learning about trends, innovations and issues affecting the global aerospace supply chain.

NEW! Take the Stage. Impress the Audience.

Getting noticed is the initial step to selling into the industry. We are selecting three organizations to demonstrate their latest innovation in front of senior leaders and decision-makers. This is an unmatched opportunity to showcase your product to the industry in a 5-minute pitch!

Topics focus on key components driving the industry:

- The future of aerospace manufacturing and our new normal
- Operations: systems integration and agile manufacturing
- How automation and digitalization are transforming manufacturing
- How suppliers need to adopt and adapt to the new manufacturing era
- Additive manufacturing in aerospace from a strategic business perspective
- How can innovation around manufacturing contribute to job creation and workforce diversity

Who benefits from attending?

- Equipment OEMs, sub-tier manufacturers, material and parts suppliers
- Supply chain executives and senior decision makers
- Strategic planning, marketing executives and business development leaders
- Executives in production, operations, research & development, technology and engineering

Sponsorships

Sponsorships enable you to promote your brand, products and/or services on the expansive Aviation Week Network, and on-site throughout the Conference. Customized sponsorships are also available. The earlier you begin your Sponsorship – the more valuable it is! The Aviation Week Network averages more than two million page views per month – that's millions of potential views of your logo if you start today!
To become a Sponsor contact Joanna Speed, Managing Director, A&D Conferences at +1-310-857-7691.

SpeedNews CONFERENCES

2901 28th Street, Suite 100 • Santa Monica, CA 90405, USA
Tel: +1-310-857-7691 • Email: conferences@speednews.com

AVIATION WEEK NETWORK

Register and Learn More at: Conf.Events/AMC

MAINTAINING MOMENTUM

While Airbus' commercial business faces strong headwinds from the novel coronavirus pandemic, the company's military capability is still very much in demand. But can Europe's big defense initiatives—many of which involve Airbus—be sustained with burdened budgets post-COVID-19? London Bureau Chief **Tony Osborne** put those questions to Airbus Defense and Space CEO **Dirk Hoke**.

AW&ST: **What does the defense environment look like post-COVID-19? Will we face more spending cuts, or will spending plans be maintained? And are you confident big defense programs can survive?** A health and economic crisis doesn't erase the necessity of being able to defend your territory. NATO missions are continuing, and the extensive use of our A400Ms and [A330 Multi-Role Tanker Transports] MRTTs during the COVID-19 crisis is a perfect example of how much value military assets can bring in humanitarian missions, when nations are in need. In addition, spending in defense procurement, if you do it right, is always an investment in your own economy and therefore now twice as important.

The defense business was undertaking some restructuring and cost cutting at the beginning of 2020 after a difficult 2019. Where are those plans; will they have to be reconsidered? We have had to slightly adapt our restructuring due to the COVID-19 impact, but the rationale stays the same. In our defense business, many important contracts had been postponed or came later than expected, which has of course had an impact on operational planning. In our space business, we currently see an extremely flat market for telecommunication satellites. We are [the] market leader and confident that the situation will change again. But for the time being we must take the appropriate measures.

How has COVID-19 affected production and output in the various countries, and how have you overcome or are overcoming those hurdles? I would say we were early adapters. Given the experience we had at our commercial sites in China, on which we could build, it took us around a week to clear all production facilities for working under COVID-19 work restrictions. On the defense side, we also delivered aircraft in the lockdown phase and provided our services to the military crews on mission.

It was, rather, the space part, where we had to reschedule satellite launches due to the temporary closure of the launch site in Kourou [in French Guiana]. And for the desk jobs, many were working from home during the lockdowns in order to avoid [having] too many meetings at the offices at the same time. They are now coming back to their desks. We could demonstrate that also in crisis times we are a trustful partner for our customers.

Airbus proposed a compromise deal for the Eurofighter following Germany's decision on a Tornado replacement. Is Berlin showing interest in your proposals; could we see some of these Eurofighters on contract soon? Let me state that we are very proud of being part of the Eurofighter family. There are some good opportunities ahead. Recently we signed the contract for equipping 115 [German and Spanish] Eurofighters with brand-new Captor-E radars. In the autumn, we are confident [we will] sign a contract for 38 Eurofighters to replace the German Tranche 1 fleet.

Additionally, we are in discussions for planning a Tranche 5 [implementation of] the Long-Term Evolution Program. What the final decision on Tornado will be, we will see only after the elections in Germany [at the] end of 2021. In the meantime, there are further opportunities in Spain, Switzerland and Finland. The Eurofighter clearly is the backbone of European air defense.

What progress is being made on the Future Combat Air System (FCAS)? Can you talk about some of the technological hurdles, where there needs to be or has been progress to reach the next phase? There is a tremendous drive in the project. All parties, on both the political and industrial sides, are pushing for progress and can be proud of what has been achieved in less than three years after being mentioned the first time in the French-German declaration on July 13, 2017. We need to keep this spirit up to achieve our ambitious timelines. In terms of technologies, we are at the early stage of a long journey (see page 55).

Overall, we are looking into a wide range of technologies in the areas of combat aircraft capabilities, digitalization and data analysis, as well as connectivity and communication. Airbus is the only company in Europe that has extensive know-how in all

HERVE GOUSSE/AIRBUS

three areas. Nevertheless, as we are talking about requirements needed in 2040, we are far away from having definite answers yet. The FCAS is very much an incremental journey with an open end—that's what makes the program so challenging, but also so exciting.

You made representations to Madrid regarding the involvement with Indra on the FCAS. Is there any sign of that changing? Is there a point when you begin working together and sideline the differences? Spain is a very welcome partner in the FCAS program and is one of our Airbus home nations. I really believe that the FCAS project is large enough for the whole European defense industry. To make it a success, it is important that everybody contributes where he has the largest experience. In terms of system integration, it is undoubtedly Airbus—especially in Spain, where we have a large industrial footprint, are producing the Eurofighter, A400M, tankers and the light and medium transport aircraft. I think it is understandable that we expressed our incomprehension to the Spanish government.

Are you any closer to securing a contract for the Eurodrone development? Are you concerned that France could still be swayed down the U.S. route? In June we handed over our best and final offer and are expecting a decision by the nations after the summer break. Germany, France, Spain and Italy worked with us on the capabilities from the onset, so the complete design is according to their wishes. Therefore, in terms of performance, capability and European sovereignty there is no serious competitor on the market. What is clear is, the later the order comes, the more the delivery dates are slipping. I don't think that's in anybody's interest.

Are you making any proposals for Germany's Pegasus signals-intelligence (sigint) platform since Berlin withdrew from using Triton? Will you offer the Integrated Standby Instrument Systems (ISIS) system on a manned platform? That's now in the hands of the German government. Over the years of the project we developed many skills and capabilities in Germany that are required in any sigint platform. That applies especially for the ground control station, which we also deliver for NATO's [Alliance Ground Surveillance] project. Therefore, we stand ready [for] implementing our know-how once the decision has been taken. Nonetheless, I am still convinced that Triton would have been the most capable platform for the envisaged missions.

On MRTT, where do you see the next market for that platform? How many more orders could come from the European Multinational Multi-Role Tanker Transport Fleet/Unit (MMF/MMU)? Is the agreement with Lockheed on MRTT making progress on marketing for U.S. needs? What is your hope for that? Only weeks ago, we delivered the first MRTT to the joint NATO fleet. I don't want to speculate about numbers, but pooling resources as is already the case with military transport capacities is a blueprint for the future. The U.S. surely is the largest accessible market for military tankers. We have the best aircraft in this class. And besides our own Airbus footprint, we have Lockheed Martin as an equal partner in the country. We stand ready. In the end the question will be whether the U.S. is ready for this, too.

Regarding A400M tactical capabilities and exports, any progress on both? The A400M has meanwhile proven to be a real workhorse in the services, and flight testing again has made good progress in recent months. Simultaneous paratrooper jumps out of the side doors are now certified, and the helicopter air-to-air refueling is advancing well. The aircraft is simply best-in-class. Other nations recognize this very well, but it is currently a difficult environment to predict when the next exports are coming in.

The A400M has been proving itself to its operating nations, but exports for the airlifter have been tough to pin down.

ANDREW LINNETT/UK DEFENSE MINISTRY

Given that space has been declared a warfighting domain by several nations, are you seeing an uptake in defense interest in space, or is that something still warming? When we see how dependent mankind is on assets in space, it is high time to act and find ways to protect them. Some countries are making progress already. Others are still undecided on their strategy. As Europe's largest space company, we can make suggestions. But what is valid for the world applies also in space: You can't defend space or your assets there as a single country. What we need is a common approach. And it is needed sooner rather than later.

AIRBUS DEFENSE AND SPACE

ENCOURAGING COOPERATION

> EU IS MULLING OVER THIRD-NATION ACCESS TO PESCO AND EDF

> EUROPEAN DEFENSE TOOK A DECADE TO RECOVER FROM THE 2008 FINANCIAL DOWNTURN

> NATO NATIONS ARE CONCERNED ABOUT A SECOND TRUMP ADMINISTRATION

Tony Osborne London

The European Defense Agency identified the need for increased European aerial refueling capability in 2012, resulting in creation of the Multinational Multirole Tanker and Transport Fleet, equipped with the Airbus A330 MRTT.

Over the last six years, an alphabet soup of defense initiatives has emerged from European leadership in Brussels.

These European mechanisms for defense cooperation may have been slow to gain traction, but they are encouraging more pooling and sharing of assets, bolstering research and development funding, encouraging nations with similar requirements to work together and most of all, helping nations avoid repeating the mistakes governments made in the aftermath of the 2008 global financial crisis.

And soon they could help Europe's embattled defense industrial base bounce back, once the dust from the novel coronavirus pandemic has settled.

Agencies such as the European Defense Agency (EDA) and initiatives such as the European Defense Fund (EDF), Permanent Structured Cooperation (PESCO), Preparatory Action on Defense Research (PADR) and the European Defense Industrial Development Program (EDIDP) have emerged from the European Union (EU) and European Commission's (EC) call for EU member states to take more care of their own security and be less reliant on the U.S.

The initiatives are leading to new partnerships that would have been unlikely in the past, aiming to fill capability gaps that no single European nation alone could have achieved.

The big question is whether governments can overcome nationalist tendencies and be more willing to cooperate. And if so, will the projects produce something tangible?

European defense cooperation has existed in different forms for decades, through development of the Panavia Tornado by Germany, Italy and the UK; the Franco-German work on the C-160 Transall airlifter; and the MBDA Meteor missile shared between Germany, Italy, France, Sweden and the UK.

The difference this time is that such relationships were forged by national governments, but the new wave of cooperation is being stimulated centrally with EU and EC money, to improve coordination between the nations in an attempt to change the perception that such collaborations can sometimes cost more overall. The joint efforts are now being applied to a multiplicity of programs, large and small, and not just to those considered unwieldy or complex.

Consider the creation of the Multinational Multirole Tanker Transport (MRTT) Unit, which will see six nations—Belgium, the Czech Republic, Germany, Luxembourg, the Netherlands and Norway—jointly operating a fleet of Airbus A330 MRTT refueling tankers. More than eight years in the making, the pooling and sharing initiative emerged from the EDA and boosts the number of aerial refueling

boosts the number of aerial refueling tankers available to European nations, with governments paying for flight hours on an annual basis. The first of the tankers was delivered to the Netherlands in early July.

There has been cooperation in demonstrations of unmanned systems and sensor technology for increased maritime awareness through the Ocean2020 project, a PADR initiative, and with enhanced airlifter and helicopter training through a series of EDA-arranged training exercises (*AW&ST* July 20-Aug. 2, 2015, p. 63).

The push for deeper European defense cooperation emerged in the years after the deep post-2008 economic downturn that prompted many European governments to adopt austerity budgets, introducing sweeping cuts to public spending that sharply curtailed capability. Budgets in some of the smaller nations were reduced by as much as 30%, according to research by the German Council on Foreign Relations. Overall, about €24 billion ($27 billion)—equivalent to around 11% of Europe's total defense spending—was cut in the years following 2008.

"It took until [2019] for defense spending [by] NATO's European members to recover in constant dollar terms back to the level where it was when that 2008 financial crisis hit," Bastian Giegerich, director of defense and military analysis at the London-based International Institute for Strategic Studies, tells Aviation Week.

When allied air forces began flying missions over Libya in 2011, they lacked aerial refueling, electronic-warfare and intelligence, surveillance and reconnaissance capabilities to find targets, and ended up relying heavily on U.S. assets that Washington had been reluctant to provide.

The lessons only began being heeded when the European security situation deteriorated rapidly.

The Arab Spring, which had caused the collapse of the Muammar Ghaddifi government in Libya and was continuing to ripple through North Africa and the Middle East causing instability on the edges of the Mediterranean, was quickly followed in 2014 by the Russian-backed insurrection in Eastern Ukraine and Moscow's annexation of Crimea.

"This succession of events really highlighted to European leaders that they needed to get their act together," says Daniel Fiott, security and defense editor at the EU Institute for Security Studies.

As treasuries across Europe began to trickle money back into defense budgets, further alarm was generated by the rhetoric of U.S. President Donald Trump, who having berated several NATO members for not meeting the alliance's defense spending target of 2% of GDP, single-handedly "undermined alliance cohesion and coherence," says Giegerich. Trump raised doubts about the U.S. commitment to NATO's Article 5, which states that an attack on one ally is an attack on all. That shock, "and the possibility that if Trump is reelected [this November] . . . he could do something radical within NATO," has prompted a continued drive to modernize European capabilities, suggests Fiott.

Britain's departure from the European Union provided the EU and EC with the impetus for reinforced defense cooperation; London had long resisted such attempts.

"The UK line was always that the EU shouldn't try and develop certain mechanisms or capacities that they would see as potentially duplicating NATO," says Fiott.

In the fall of 2016, European Commission President Jean-Claude Juncker told EU member states that Europe needed to "toughen up" and not "piggyback on the military might of others."

He added: "We have to take responsibility for protecting our interests and the European way of life."

According to the EC, the lack of defense cooperation between member states costs between €25-100 billion because of issues such as duplication of effort. It also notes that 80% of procurement and 90% of research and technology are run on a solely national basis. The EC claims that enhanced cooperation between member states could reduce annual defense expenditures across Europe by 30% through pooling procurement.

The Franco-German, Italian and Spanish EuroDrone is one of the programs envisaged to receive support from the European Defense Fund.

MBDA

Twister, a PESCO project, is looking at technologies to defeat future ballistic and supersonic cruise missiles and hypersonic weapons, bolstering Europe's missile defense capability.

Junker's words were followed up a year later with the EC's formation of the European Defense Fund for joint research and development of defense projects.

The EDF was set up to incentivize joint development projects and provide co-financing if several member nations bulk-buy capabilities between them. This was preceded by the PADR and the EDIDP, a series of preparatory programs paving the way for the EDF (*AW&ST* June 12-25, 2017, p. 28).

"[The] PADR and EDIDP test the way the institutions and the funding mechanisms work and help to generate some buzz in industry," says Fiott.

The MMF has options on three more A330 MRTTs, should more nations beyond the existing six wish to join the program.

These programs began to deliver benefits in June, when the EC announced €205 million of funding to support 16 PADR and EDIDP initiatives. Projects including the development of a low-observable tactical unmanned aircraft system, research into high-resolution observation payloads for satellites, and studies for a beyond-visual-line-of-sight land-based battlefield missile system have been funded, a steppingstone toward creation of the EDF.

Direct support is also envisaged for two large-scale projects, including the EuroDrone medium-altitude long-endurance aircraft system being developed by France, Germany, Italy and Spain and for the European Secure Software-Defined Radio (ESSOR) program.

Some of the PADR and EDIDP initiatives are linked to the other major initiative, PESCO.

Run by the European Defense Agency and the EU's External Action Service, PESCO calls on European member states to make binding commitments to invest in and develop defense capabilities. PESCO projects are likely to receive funding from the EDF. There are currently some 47 PESCO projects supported by 25 member states.

Several of the projects are aerospace-related programs. One is the Timely Warning and Interception with Space-based TheatER surveillance program (Twister)—led by France and supported by Finland, Italy, the Netherlands and Spain—to develop a capability to track and counter emerging threats, including hypersonic gliders and supersonic cruise missiles. Another, Airborne Electronic Attack, led by Spain with support from France and Sweden, calls for the joint development of a pod-mounted electronic attack and countermeasure capability for combat aircraft. PESCO programs are also focused on training, joint forces activity and cyberwarfare.

AIRBUS DEFENSE AND SPACE

There are, however, debates as to whether the PESCO initiatives will deliver new capabilities. Some are seen as vanity programs, others may merely be national programs for which some nations have roped in other partners in a bid to secure funding. A review of the PESCO projects is currently underway.

The European Defense Agency also led on development of pan-European helicopter training exercises to improve interoperability and standardization.

"We can't prove that cooperation delivers anything, and we don't know

TONY OSBORNE/AW&ST

European Cooperative Aerospace and Defense Programs

Project	Mechanism	Lead Nation	Supporting Countries
Helicopter Hot-and-High Training	PESCO	Greece	Italy, Romania
Beyond-Line-of-Sight Land Battlefield Missile Systems	PESCO	France	Belgium, Cyprus
European Medium-Altitude Long-Endurance Remotely Piloted Aircraft Systems (Eurodrone)	PESCO/ EDF	Germany	Czech Republic, France, Italy, Spain
Tiger Mk. 3 European Attack Helicopter	PESCO	France	Germany, Spain
Counter Unmanned Aerial System	PESCO	Italy	Czech Republic
Airborne Electronic Attack	PESCO	Spain	France, Sweden
Timely Warning and Interception with Space-based Theater surveillance (Twister)	PESCO	France	Finland, Italy, Netherlands, Spain
European Global RPAS Insertion Architecture System	PESCO	Italy	France, Romania
European High-Atmosphere Airship Platform (EHAAP) – Persistent Intelligence, Surveillance and Reconnaissance (ISR) Capability	PESCO	Italy	France
Open Cooperation for European Maritime Awareness (OCEAN)	PADR	Italy	Industry from Spain, Germany, Sweden, Poland, France, UK, Lithuania, Estonia, Portugal, Greece, Netherlands, Finland
European Detect and Avoid (DAA) (EUDASS)	EDIDP	Sweden	Industry from France, Italy, Spain Germany
Low-Observable Tactical Unmanned air System (LOTUS)	EDIDP	Greece	Industry from Cyprus, Spain, Netherlands
Persistent Earth Observation for Actionable Intelligence Surveillance and Reconnaissance (Peoneer)	EDIDP	Italy	Industry from Czech Republic, Denmark, France, Estonia, Italy, Sweden, Lithuania, Spain
LynkEUs concept of operations for beyond-line-of-sight battlefield missiles	EDIDP	France	Industry from Belgium, Cyprus
Future Integrated Training Solution for TOP gun (FITS4TOP)	EDIDP	Italy	Industry from Denmark, France, Spain, Romania
Responsive Electronic Attack for Cooperative Task (REACT)	EDIDP	Spain	Industry from Italy, France, Germany, Sweden
Combined Radar, Communications, and Electronic Warfare Functions (CROWN)	PADR	Spain	Industry from France, Germany, Sweden, Netherlands, Italy, Lithuania
Projectiles for Increased Long-Range Effects Using Electro-Magnetic Railgun (PILUM)	PADR	France	Industry from Belgium, Germany, Poland, Italy
Multinational Multi-Role Tanker and Transport Fleet (MMF)	EDA	Netherlands	Belgium, Czech Republic, Germany, Luxembourg, Norway

PESCO Permanent Structured Cooperation
EDF European Defense Fund
PADR Preparatory Action on Defense Research
EDIDP European Defense Industrial Development Program
EDA European Defense Agency

Source: European Commission

Digital Extra *See defense alignments and more on our European defense cooperation interactive map:* **AviationWeek.com/EuropeanDefense**

the criteria for having good cooperation and for having bad cooperation," says Christian Molling, research director for the German Council on Foreign Relations.

PESCO has also ruffled feathers. Last year, Pentagon procurement officials wrote to the EU threatening to apply sanctions, incorrectly assuming that PESCO initiatives would prevent U.S. industry from pursuing business in Europe. The EU is currently exploring whether third nations—non-EU nations—can access PESCO and EDF initiatives. Initial proposals to allow third-nation access have been received favorably by some member states, but the discussions are bound up in deliberations about the next EU budget.

The U.S. may have been alarmed at the longer-term goals of EDF and PESCO, which by providing political and financial incentives boost productivity, innovation and the competitiveness of the European defense industrial sector. "[It] strengthens the argument to buy European and do things together," says Giegerich.

"That is a long-range threat . . . that may explain why the U.S. administration had such an allergic reaction to the EDF and PESCO last year," he adds.

EU and EC-led plans are not the only cooperative initiatives taking place. Two new combat aircraft programs have taken shape over the last three years, linking unlikely bedfellows with very different views on defense. France, Germany, and Spain are working on the Future Combat Air System (FCAS), while the UK is leading its Tempest project with Italy and Sweden.

THALES ALENIA SPACE

The European High Atmosphere Airship Platform, a PESCO project, is likely based on Thales Alenia Space's Stratobus, a solar-powered airship for operation in the stratosphere.

Such flagship programs could have "a structuring effect on defense industrial capability in Europe for the next couple of decades," says Giegerich. The nations will have to reconcile their differences, though France and Germany, the leading nations on FCAS, have markedly different approaches to defense exports, doctrine and deterrence.

Hopes from industry that the two projects could be combined may be wishful thinking. There may be only a short window of opportunity for that to happen, perhaps 18-24 months, suggests Giegerich, before too many decisions on each of the projects are finalized. FCAS was born out of French and German ambitions to become pillars of European defense. With the entrance of Spain into the initiative, the program is likely to be eligible for support from the EDF in the future.

It is conceivable that Tempest could benefit from such funding in the future, too, if the EC allows so-called third nations.

TONY OSBORNE/AW&ST

How defense cooperation evolves is likely to depend on how nations emerge from the COVID-19 pandemic and whether they choose to make cuts to defense, taking an austerity approach as in 2008, or to reinvigorate their economies with fiscal stimulus. The arguments for such cuts will be challenged in the current environment, suggests Giegerich. "While COVID is obviously a massive interruption to [European government] plans, none of the security problems that existed before have gone away," he notes.

In May, the defense ministers of the four major EU states—France, Germany, Italy and Spain—wrote to European leaders urging their nations to strengthen cooperation through efforts such as PESCO.

"Security and Defense must therefore remain a top priority," the letter states. "We want to live up to our responsibilities and be able to face present and upcoming challenges, at home and abroad. . . . Hence, we have to maintain, strengthen and develop our ability to act and react autonomously, as a Union."

The crisis has prompted governments to sit up and look at their strategic capabilities, critical industries and security of supply, says Fiott, and may prompt some nations to look closer to home again for their defense relationships.

"The U.S. will always be a go-to player when it comes to certain capabilities," says Fiott. "Dealing with the U.S. on one hand is really good. You get access to high-tech equipment and you can use it to undergird your defense relationship."

But buying from the U.S. means countries are exposed to the full force of U.S. legislative power.

"You can't have any kind of autonomy in defense if ultimately Washington is able to veto you, the use of capabilities or even the exploitation of technology," Fiott says. "That's certainly an issue that [European] governments are thinking about."

Another concern is that a deep economic recession in the U.S. could prompt Washington to reconsider its posture in Europe and speed up its repivot to China. U.S. plans to withdraw some 9,000 troops from Germany has sent ripples through NATO.

The post-COVID-19 era could also provide an opportunity to put European defense mechanisms to good use. Reports that the EDF budget would be slashed as a result of the coronavirus crisis have proved unfounded.

France, Germany and Spain are cooperating to develop a modernized version of the Airbus Tiger attack helicopter, and are looking to benefit from EDF funding for the program.

The EC plans to invest €9 billion in the EDF over the next seven years, down from the originally planned €13 billion, although this is still subject to approvals by EU member states.

"There is now a time to make that argument that the EDF and the European military mobility initiatives should be fully funded and should perhaps even be beefed up compared to original plans," says Giegerich. "The ball is now in the court of the EU member states."

"We are really fortunate in having already a lot of initiatives in place," says Fiott. "It is not like we have to waste the next two, three, four years dreaming up new schemes."

European Defense Community Is Facing Down Tanker Shortfalls

EUROPEAN AIR TRANSPORT COMMAND

The first of eight Multinational Multirole Tanker and Transport Fleet A330s arrived at Eindhoven Air Base on July 1.

> FIRST MRTT ARRIVAL BOOSTS EUROPEAN DEFENSE COOPERATION

> THE MMF HAS OPTIONS FOR THREE ADDITIONAL MRTTS

Tony Osborne London

The arrival of the first Airbus A330 Multi-Role Tanker Transport for the Netherlands-led Multinational Multirole Tanker and Transport Fleet (MMF) has been hailed as transformative for Europe's aerial refueling capability. But it arguably also marks a major step forward for Europe's defense cooperation ambitions.

Unlike other shared assets such as NATO's E-3A Component for airborne early warning and its Hungary-based Heavy Airlift Wing, the formation of the MMF was born out of the European Defense Agency (EDA), a European Union organization to promote closer defense integration. EU defense initiatives are now being strengthened through programs such as Permanent Structured Cooperation, Preparatory Action on Defense Research and the European Defense Industrial Development Program, both precursors to the European Defense Fund (see page 44).

The EDA identified shortfalls in Europe's aerial refueling capability in 2012 after European air forces had struggled to maintain operations over Kosovo in 1999, Libya in 2011 and Mali in 2012. They were challenged not only by a lack of tankers but also by operations of too many varied aircraft types and too few clearances for aircraft taking fuel from tankers.

The MMF aims to address these issues. Its eight aircraft—potentially expandable to 11 if more nations join—will be shared by six European nations that have paid for a set number of annual flying hours.

The Netherlands and Luxembourg were the first to take the plunge, signing up for 2,000 and 200 hr. a year, respectively. They were subsequently joined by Belgium, with 1,000 hr., Germany with 5,500, and the Czech Republic and Norway for 100 hr. each.

By purchasing hours rather than platforms, small countries that are unable to afford a tanker can still gain access to one, and the single fleet slims down the number of different tankers being used by the various nations. With the arrival of the MRTT, the Netherlands will retire its aging refueling-boom-only McDonnell Douglas KDC-10s, and Germany will phase out its hose-drogue-only Airbus A310 MRTTs.

"This is a prime example of European defense cooperation done in close coordination with NATO, which shows that once a capability shortfall has been jointly identified, European nations can pull together, work on a common project aimed at filling the gap and eventually deliver," says Jiri Sedivy, chief executive of the European Defense Agency.

Camille Grand, NATO assistant secretary general for defense investment, says the fleet will not only have a "profound impact" on European air-to-air refueling capacity but also "help contribute to a fairer transatlantic burden sharing at NATO."

European defense materiel agency OCCAR is managing the MMF acquisition phase and the first two years of the Initial In-Service Support on behalf of the NATO Support and Procurement Agency (NSPA). Following the acquisition phase, the NSPA will be responsible for the life-cycle management of the fleet. As with other NATO-led fleets, the lead nation is responsible for regulatory approvals, so all the MRTTs will wear the national roundel of the Netherlands.

Five of the aircraft will be based at Eindhoven Air Base in the Netherlands, while three more will be located at a forward operating base in Cologne, Germany. The aircraft will be flown by the Multinational Multirole Tanker Transport Unit (MMU), which is manned by personnel from each of the participating nations, while operational activities will be controlled by European Air Transport Command, which pools and shares the aerial refueling and air transport assets of Belgium, France, Germany, Italy, the Netherlands and Spain.

But even with the new fleet, European countries will still face shortfalls in tankers. According to statements released by the EDA, even with the new MMF fleet, Europe will have the equivalent of 90 Boeing KC-135 Stratotankers but requires the equivalent of around 130-135 KC-135s to meet the aerial refueling needs of its air services.

Part of this shortfall could be addressed with technology such as automated aerial refueling (A3R), a capability being developed by Airbus that could be retrofitted into the MMU's fleet in the future. The MRTT's A3R capability is scheduled to be certified in 2021 (*AW&ST* May 4-17, p. 51).

The MMU is expected to begin flying its first operational missions on behalf of the member states starting in September and will be tasked with aerial refueling, strategic transport and aeromedical evacuation flights. The unit's second aircraft will arrive by the end of this month, while the third and fourth aircraft are undergoing conversion by Airbus at its Getafe facility near Madrid.

The program may also break ground to be the first MRTT user to be equipped with a detachable refueling boom that is being developed by Airbus as part of a contract amendment.

Usually, the refueling boom would be a permanent fixture, but the amendment calls for the ability to remove the boom to save weight and fuel when flying nonaerial refueling missions.

ASTRA RISING

CPL. TIM LAURENCE/ROYAL AIR FORCE

Britain's Royal Air Force is stepping into a period of major transformation as it prepares to introduce the Boeing E-7 Wedgetail airborne early warning platform, Protector unmanned air systems and a more networked approach to operations. But it also faces challenges: The novel coronavirus is affecting the daily lives of personnel and also threatens the international order, while an upcoming wholesale review of UK foreign policy could reshape the country's defense capabilities. Air Chief Marshal **Mike Wigston** sat down virtually with Aviation Week's London Bureau Chief **Tony Osborne** to discuss the way ahead.

SAC MATTY SMITH/ROYAL AIR FORCE

AW&ST: **How has the RAF risen to the COVID-19 challenge?** We are fortunate because day in, day out we do dangerous, dirty and difficult things. From a national perspective, we have had to make sure that we were contributing to the essential national effort to slow down the spread of the virus. Also essential is our Quick Reaction Alert in the UK and overseas territories, ongoing operations in the Middle East, humanitarian operations and NATO air policing. My eye is also on the future health of the force—in six months, one year, two years. Another essential consideration is depth aircraft maintenance. Having serviceable aircraft tomorrow is separate from depth maintenance. Aircraft go into depth [maintenance] for a year sometimes, but I really do need that aircraft out in a year. So for me, that is as essential as training or recruiting.

The government guidelines apply to us as much as to any organization. Different units have had to take stock and pause for days or weeks to work through the government guidelines to ensure as low as practicable risk, and then pick themselves up and get on with it. By and large, I am incredibly pleased with the way the force has responded. I'm very comfortable we are doing this in a safe way but still delivering air and space power to protect the nation. I am not saying that we're at 100% of our capacity—there have been areas where our throughput is slowed, or our capacity is limited—but we are in the 60-80% sphere rather than 20-30%.

I have told the team that if anyone is sitting waiting until September for this to end, you should just forget it. This could be the situation for the next 18 months to four years. So for all of you that are at 70% of full capacity, you need to work out how you make back that final 30% because this is going to be our working environment. This is a long-term game now.

Has COVID-19 affected the exercise program and deployments? The most significant impact has been on our international exercise program because we have not been able to move large numbers of people for training exercises. What we have done is continue to meet our NATO commitments: In April, we deployed a Typhoon squadron to Lithuania for Baltic Air Policing, which sends an absolutely crystal clear message to our NATO partners and allies around the Baltic that it is a region that matters to the UK and that our collective security matters to the UK. I think doing that in a COVID environment really reinforces that message.

We have also moved some exercises onto a virtual plane. In some respects, we've probably accelerated our plans around network exercising, less so with squadrons and front-line pilots, but more for our headquarters organization.

We have done that recently with the French Air Force. We must also not lose sight of the fact that our operational commitments around the world have continued—our support helicopters are in Afghanistan and Mali. And of course, the full range of air power platforms and capabilities are at work in the Middle East.

In recent years, we have seen deployments to Japan and Korea, but more recently that attention has been focused on the Euro-Atlantic region. Are you looking again at the Far East? I can say without a shadow of a doubt that we're going to be continuing that drumbeat of deployments out into the Indo-Pacific region. This year, we have observers on the Five Power Defense Arrangement exercises, like Bersama Padu and Bersama Lima. And next year, because it is the 50th anniversary of the signing of that arrangement between Malaysia, Singapore, the UK, Australia and New Zea-

The UK's F-35s, flown by a joint Royal Air Force/Royal Navy force, will deploy to the Far East during 2021 on HMS Queen Elizabeth.

land, we are going to deploy Voyager and Typhoon, and I know that there will be warships involved as well. While it is not yet decided, we have high ambitions for where HMS Queen Elizabeth and Carrier Strike Group 21 will go, too.

What threats/challenges will face the RAF post-COVID? How do you characterize them? I think the consensus is the pandemic has accelerated trends that we were already observing. When you think about everything, from digitalization and automation all the way through to the Great Power rivalry between China and the U.S., it holds true that COVID has accelerated things by three, five or up to 10 years. For us, that will be something of a key theme for the integrated review when that gets going again.

The other big strategic factor is, of course, economies. The global economic impact from COVID will prompt governments to reassess their spending. Also, it will mean that already-fragile states will probably become even more fragile, and regions will become more insecure. So there will be a greater role for like-minded countries like the UK in protecting global security and helping it back into prosperity.

What are your hopes for the ASTRA initiative? ASTRA is the campaign plan for building the next-generation Royal Air Force. It covers everything from big equipment programs and infrastructure to the way we look after our people and the conceptual component, all the way through to grassroots initiatives where people can identify ways to change the way they go about their business and the way they work. I am focused on the Future Combat Air System, the replacement for Typhoon, and how that will operate as a system, some elements piloted, some expendable, as well as swarming drones and loyal wingmen. There is also a significant investment program for our infrastructure and our domestic infrastructure so we can look after our people better. It matters now, and we need to get on with it now. If we were to talk about big reshaping themes, the air force must become data-driven.

We have talked for long enough about an information-enabled air force. This is the point where we've got to take that step, and that means every part of the enterprise should be network-linked. We currently have too many separate systems on too many separate networks, so there is an absolute pressing need to become that network-enabled force that we have been speaking about for a long time. We must also step properly into the synthetic environment and utilize what the world of gaming now offers for the training of not just aircrew but for all of our people, all the way [from] mission planning and mission rehearsal through to augmenting the actual live missions. The final big shift where we will look different is in space. With significant growth in threats to our national interests in space, we are already monitoring what is going on. And there is more we can do to build our situational awareness, but there is no doubt in my mind that in a few years' time we will be working actively to protect our national interests in space and defend them.

Like many air forces, the RAF has had a challenge with recruitment. How is this being addressed? I would challenge your question because the one thing that we've been remarkably successful at in the last few years is recruiting. We were on track for 100% of officer recruiting and high 90% for other ranks.

Where I have always got my eye is on retention. The RAF is victim to the ebb and flow of the external employment market, and over the last 10 years it has been a pretty tough environment for us to retain the talent we need. By and large we have, but I would rather see my retention figures improve a little.

Is the air force facing a capability gap in its ISTAR fleet with the early retirement of the Sentinel radar reconnaissance platform in March 2021 and the E-3D Sentry in 2022? On Sentinel, there are challenges in upgrading the system as it is becoming increasingly obsolescent and has a level of technology that is making it difficult to keep it going. It is still operationally relevant today, but we are reluctantly sticking to that 2015 decision. There were several factors to that, and the capability gap was one of those. It is a unique capability, given the platform that it is on, but there are other ways that we can achieve the same effects—but nothing quite matches that airframe.

On E-3D, we have a phased reduction of the fleet, drawing it down over the next couple of years as we build up the [E-7] Wedgetail. If there is a [capability] gap, it will be where we are just moving crews and technicians across. And we haven't yet finalized the plan because we have not gotten the absolute detail on the Wedgetail delivery. The people who will be operating and maintaining Wedgetail are largely the same people who are operating and maintaining the Sentry, so at some point we're going to have to switch off Sentry and move people across to Wedgetail, with a training element in that.

What capabilities/systems soon to be introduced are you most looking forward to getting into service? Tempest is a really important program because it is replacing Typhoon, but it is also important because it underpins the future of the British defense and aerospace industries. The UK is world-leading: We are one of a tiny handful of nations that can still bring together all elements to build a sixth-generation combat aircraft. So when we get to that point, the decision to go ahead with building that Future Combat Air System is a national strategic decision.

From what I've seen, the early work on some of the technology that we're going to be fielding is world-beating. In concert with that will be autonomous wingmen and the swarming-drones work that we are doing. Some of the results of those swarming trials are quite remarkable and are exceeding our early expectations. We have been able to demonstrate that what was a very rudimentary early capability is not something we are going to leave on the shelf until Tempest comes along. I'm going to be augmenting Typhoon and [F-35] Lightning [aircraft] with these [capabilities] this decade. And if I can, I'll have them fly off the Queen Elizabeth alongside the F-35s, too.

Tempest's Global Push

- TEMPEST ACQUISITION PLAN WILL ENTER ASSESSMENT PHASE IN 2021
- TECHNOLOGY IS WIDENING OPTIONS FOR INTERNATIONAL PARTNERS

Tony Osborne London

The UK is looking beyond Europe and its traditional partners as it pushes toward a critical milestone for the Tempest Future Combat Air System.

With deadlines looming to submit a business case for the initiative at the end of the year, the UK Defense Ministry and the Team Tempest industry consortium of BAE Systems, Leonardo, MBDA and Rolls-Royce—which are supporting the UK Future Combat Air System Technology Initiative (FCAS TI)—are working to mature technologies and develop a business model that will pave the way for how partner nations and industry will interact and combine their development efforts.

The aim is to develop a next-generation, low-cost combat aircraft that could be combined with additive capabilities such as unmanned loyal wingmen to replace fourth-generation platforms like the UK Royal Air Force's Eurofighter Typhoons or the Swedish Air Force's early-model Saab Gripens in the mid-2030s, and to do it in at least half the time it took to bring the Eurofighter to front-line service.

The UK has global ambitions for the aircraft and is hoping it can build on its international relationships post-Brexit to find future partners and customers for the platform.

"What we are doing is talking to governments about what we're doing. We are thinking about what their needs might be, and we are making sure that we can keep the door open for as long as possible in as many different ways as possible so they can partner with us in a meaningful way," Richard Berthon, the UK Defense Ministry's Combat Air Acquisition program director tells Aviation Week.

There are challenges ahead, however. The aftermath of the novel coronavirus pandemic is likely to cast a long shadow over public spending, while a review of UK foreign and defense policy may send ripples through plans for future defense capabilities. Yet defense and industry officials are confident that plans for Tempest can prevail through these challenging times.

"I'm confident that there's a really strong understanding of the benefits of investing in Combat Air," Berthon explained. "The message is well understood in terms of the benefits from international partnering for the industrial base, to investing more in research and development . . . as well as military capability elements."

He notes that the industry efforts have already led to the creation of some 1,400 jobs even before the program has entered its next phase, with more to follow as the program advances.

"If we are coming out of Brexit and COVID-19 and want to stand on a world stage, defense has to matter, and air power has to matter," says Chris Boardman, managing director for BAE Systems' Air business.

"I am not complacent," he says. "I do recognize that the coronavirus pandemic has brought big social and economic problems, but I am confident that the requirement is not going to go away."

For the last five years, the UK has been reskilling capabilities and developing technologies through its FCAS TI program that could be fed into a future combat aircraft. These efforts were finally made public with the unveiling of the Combat Air Strategy and Team Tempest at the 2018 Farnborough Airshow. Since then, the British government has signed a 10-year

Under current plans, the architecture of the future British combat aircraft should be decided this year. It is likely to look very different from the designs unveiled two years ago.

TEAM TEMPEST

memorandum of understanding with Sweden and agreed on a statement of intent with Italy, last July and September, respectively.

Studies currently underway with both nations will help identify the requirements of each nation and ensure that the needs of Italy and Sweden are understood as the Tempest program proceeds to the next step.

In late July, the Swedish defense ministry will submit budgetary documentation to allow it to begin development work on next-generation combat aircraft between 2021 and 2025, including studies, technology development and demonstrator activities with international partners.

"Discussions are more at the government, air force and [defense ministry] level at the moment," explains Norman Bone, chairman and managing director of Leonardo UK and the head of Leonardo's defense electronics business. "Industry [from all three countries] have been talking, but we have not all been in the room with the three parties . . . though we are not far away from that," he says.

"In Italy and Sweden, we feel we have got something in common . . . an aligned view of what is required, and we think our industrial bases are complimentary," Berthon says.

How the nations and industry will work together is still to be formalized, but Berthon is looking for an "agile and organic" approach that is "fast enough to keep pace with the program."

"What we shouldn't do is replicate the way we set up [Eurofighter] Typhoon," Bone explains, noting that the Eurofighter program's workshare approach—with each partner-nation building elements of every aircraft and assembling them in four different countries—does not lend itself to the low-cost, export ambitions of Tempest.

"Having an export-centric platform that can be spiraled to national requirement is going to be at the core of what we are trying to do here," Bone adds. "That is the reason we are designing this from the inside out."

The model will need to be able to adapt to new partners. UK is eying additional nations to join the program, in particular Japan, which is looking for a collaborative partner for a fighter that will replace the Mitsubishi F-2.

"You need to have partners who are willing to go on the same journey with you in a pretty comprehensive sense," Berthon explains. "There is also an opportunity for others to partner in a way that suits them."

Tempest partners will need to believe in doing things in a "different and more efficient way," suggests Boardman, with "less guaranteed workshare, independent of capability, more best athletes, more new capability and more proven TRL [Technology Readiness Level] to be able to do that activity."

Technology is one of the key enablers that will allow the Tempest to keep the "door open to new partners for longer," Berthon suggests.

Although the milestone business case will likely narrow down the architecture of the aircraft, digital technologies mean that some key decisions can be held off until technologies can be matured.

"We can retain more choice for longer, and that's really helpful," Berthon explains. "The people working on Eurofighter had to set a concept decades before the capability would enter into service."

One of those systems will be the Tempest's open mission system, the BAE Systems-led Pyramid, which, according to Berthon, will allow for different configurations within the combat air system. "I think that creates the opportunity for a lot more agile partnering," he says.

Baseline architecture for Pyramid was recently completed and shared with the Tempest partners, officials tell Aviation Week. And even though its development sits outside the Tempest development, "it is a fundamental building block," Boardman says, noting that BAE has been working on the building blocks for the Tempest for the past 15-20 years, mainly through its unmanned programs such as the Mantis, Taranis and Magma.

Today, the company is further maturing technologies around next-generation cockpits and payload bays, but a key focus is how the Tempest could be produced.

"The factory of the future is about low volume and low cost . . . how you break the norm of the past, which says you have to have high volume to get low cost," Boardman explains.

An area of interest for BAE is a process called cobotics whereby workers cooperate with robotics to complete certain tasks. Specially developed workbenches can be adapted for tasks and assist the workers through a particular process using technologies such as augmented reality.

Boardman says BAE is already trying out new manufacturing techniques for wiring and looming on the Typhoon and testing the cobotic benches at several manufacturing and assembly points.

At Leonardo, the company's efforts are focused on a future multifunction array radar, defensive aids and sensor fusion. Late last year, the company revealed it had developed radar-warning receiver technologies that are four times more accurate than existing sensors, are 1/10th the size, and have considerably reduced power requirements. While the company's work on the Captor-E active, electronically scanned array radar for the Eurofighter uses the gallium arsenide semiconductor, the company is experimenting with other materials, including gallium nitride and silicon germanium for future sensors on the Tempest.

Bone says developing the sensors will be a close collaborative effort with Saab and Leonardo teams in both the UK and Italy.

"One will probably take the lead, but the other two will be very important in the design of it, and that will

BAE SYSTEMS

BAE Systems is investing in its vision of a factory of the future that will make extensive use of additive manufacturing and cobotics for cheaper production and assembly.

be the same for most of the key sensor activity," he says.

The next step for the Tempest is an assessment phase in which the technology developed by the FCAS TI will be matured and tested. Then it will be demonstrated that it can function as part of a system, potentially in flight on Team Tempest's planned Boeing 757 testbed announced last July. That aircraft, to be supplied through a contract with Leonardo by 2Excel Aviation has already been sourced and is currently in storage, ready for conversion work and flight tests during the early 2020s.

UK officials dismiss the need to merge the Tempest initiative with those of France, Germany and Spain's own FCAS. In June, Airbus Defense and Space CEO Dirk Hoke told the London-based Royal Aeronautical Society that maintaining two programs in Europe could be a "bad solution" for both the UK and the European Union, repeating the 1990s error of Europe having three combat aircraft developments in parallel: Eurofighter, Gripen and Rafale.

"I don't see this sort of inherent logic that everything must merge together," Berthon said. "There are many factors around the industrial and technology base and the partnering histories that each of us has globally. . . . The UK has a different military strategy from anywhere else, as does France, as does Germany, and that has driven us to where we want to be."

He notes the requirements of the FCAS are radically different from that of the Tempest. Derivatives of the French, German and Spanish aircraft will need to operate from an aircraft carrier and perform the nuclear deterrence mission, both of which could bring additional complexity and cost to the program.

Having two programs in Europe maintains "a degree of competitive pressure on our industries," Berthon suggests. Such competition, he says, has been helpful by not leading Europe into a monopoly on supply.

Additive Technologies Advance for Future UK Air Power

Tony Osborne London

BIDDERS PUSHING FOR A ROLE TO BUILD A TECHNOLOGY demonstrator for the UK's Lightweight Affordable Novel Combat Aircraft (LANCA) are waiting to see if their design proposals will be approved for the next phase of the initiative.

Three industry teams were selected last summer (*AW&ST* July 29-Aug. 18, 2019, p. 18) to take forward development of the LANCA air system, an unmanned air vehicle that could act as additive capability accompanying future combat aircraft into operations. LANCA would perform a range of tasks, including serving as a loyal wingman, gathering intelligence or acting as a weapons carrier. The Royal Air Force envisions a platform costing 1/10th of current combat aircraft and developed in one-fifth of the time. The idea is like that of the Kratos XQ-58 Valkyrie for the U.S. Air Force's Skyborg program, Australia's Boeing-led Airpower Teaming System and remote carriers for the French, German and Spanish Future Combat Air System.

Since then, the industry teams—which include Boeing Phantom Works International, working with Marshall Aerospace and Defence Group and Cranfield University; consortium Team Black Dawn, Callen-Lenz and Bombardier Belfast; and Northrop Grumman UK with Team Avenger, led by Blue Bear Systems Research and yet to be disclosed partners—submitted their proposals for the £4.8 million ($6 million) Phase 1.

The LANCA program is being led by the UK Defense Science and Technology Laboratories in conjunction with the Royal Air Force's Rapid Capability Office.

The UK Defense Ministry is evaluating proposals in readiness for the second phase of the project, called Mosquito, which is worth £30-50 million. Mosquito would see one, possibly two of the candidates being matured into a full-size flightworthy demonstrator potentially undertaking a flight-test program. Aviation Week has been told there was stiff competition for the LANCA program: Some 45 bidders entered Phase 1 and were subsequently scaled down to nine. Around eight bids were then tendered, of which three were chosen.

Few details have emerged about the proposals, although Boeing Australia confirmed through social media that it had secured a "first-of-type permit" from the Australian government to share design material for its Airpower Teaming System with the UK, suggesting the Boeing proposal may borrow heavily from that platform. Progress is also occurring on a drone swarm system announced by former Defense Secretary Gavin Williamson in February 2019: Demonstrations in March using five unmanned air vehicles proved a collaborative capability between the platforms, people close to the program told Aviation Week.

Spanish Onboarding Builds Future Combat Air System Momentum

- FCAS TECHNOLOGY DEVELOPMENT FOCUSES ON SEVEN PILLARS
- INDUSTRY AND GOVERNMENTS ARE NEGOTIATING FOR DEMONSTRATION PHASE 1B

Tony Osborne London

Spanish industry is gearing up to play its role in the development of the European Future Combat Air System.

As the country's national Future Combat Air System (FCAS) coordinator, defense-electronics firm Indra should in the coming weeks join the initial concept studies, already contracted in February to Airbus and Dassault Aviation by the governments of Germany and France, respectively.

The Spanish industry onboarding process builds up further momentum behind the FCAS initiative to replace the Eurofighters operated by Germany and Spain and the Dassault Rafales flown by France—a project that was little more than a political idea three years ago.

In mid-June, Spanish companies signed agreements with the country's government to work on the seven pillars of research that are paving the way for the development of demonstrators for the New-Generation Fighter (NGF), the remote carriers—unmanned air systems that will accompany the NGF into the fight—and the adaptive combat cloud network that links together the elements of the FCAS, including weapons.

The wider FCAS program consists of six pillars of technology that focus on the NGF, the different remote carriers, collaborative combat using the airborne network and propulsion primarily for the NGF, sensors and very-low-observability technologies. A seventh pillar is "interpillar consistency," says Bruno Fichefeux, Airbus' head of the Future Combat Air System. "This sits above all the others, to make sure they are not siloed but coordinated efforts."

France and Germany have so far jointly contributed €155 million ($175 million) to industry for the so-called Demonstrator Phase 1A (*AW&ST* Feb. 24-March 8, p. 29). Spain will throw in an additional €77 million in the coming weeks.

This phase aims to identify the technologies needed and the "best-performing architecture" for the system to be taken forward for development. A decision is expected at the end of 2021, after a process that will size the NGF and decide the scale and types of remote carriers that will be needed to fly alongside it.

"We will need to keep some options open even once we have selected the architecture," Fichefeux notes. "It is a long time from 2021 to 2040, and there will be a lot of new technologies and capabilities popping up that we will want to include, so we don't want to freeze the design too early."

Industry and the national government have now begun negotiations on Demonstrator Phase 1B. This phase will build on the work of 1A but will feature a much larger price tag and will prepare technologies for the demonstrator phase, to emerge in Phase 2, which will see flights of technology demonstrator aircraft, engines and remote carriers in 2026. Around the same time as the flight-test cam-

Airbus' notional design for the New-Generation Fighter is depicted in this concept image operating with small, remote carrier platforms.

AIRBUS DEFENSE AND SPACE

paign, Phase 3 will be triggered to support the testing of the demonstrators and the beginning of the initial phase of FCAS development. According to investor presentations by Indra, a preliminary design review will take place in mid-2027, followed by full development and industrialization beginning in 2030.

The first three phases of the FCAS program are expected to cost around €8 billion, the Indra presentation states.

The Spanish government sees the program as a "state project," Secretary of State for Defense Angel Olivares Ramirez told aerospace business leaders on June 17.

"This program has all the characteristics that allow us to venture that we are facing a great technological revolution, which will have considerable effects in the field of defense and in the capabilities of the armed forces, industry and the civil sphere," Olivares Ramirez added. He went on to call for Madrid to back the program with the funding needed to support it through its initial steps: €110 million in the first year and €250 million annually beyond.

"Confirming the strategic interest in FCAS by Spain, despite the pandemic crisis, was a very positive statement," Fichefeux says.

There is growing confidence that France and Germany also recognize the strategic importance of the program, particularly in the wake of the COVID-19 pandemic and the likely economic impact it will bring.

Indra will work on the development of sensors, the combat cloud network and a simulation laboratory called Simlab with the Spanish Air Force. Airbus Defense and Space in Spain will support the development of NGF aircraft and work on low-observable technologies. ITP Aero will be involved in engine development, while the Satnus Consortium—of GMV, Sener Aeroespacial and Tecnobit-Grupo Oesia—will work on the unmanned remote carriers. Similar industrial setups have already been established in France and Germany: MTU and Safran are working on the NGF's future engine, Thales is working with Airbus on the combat cloud, while MBDA is leading efforts on remote carriers and engines, given its experience in air-launched weapons.

Meanwhile, a team of German defense electronics firms—Diehl Defense, ESG, Hensoldt and Rohde & Schwarz—formed the Future Combat Mission System consortium to work on the networked sensors and systems.

"In each pillar, there is cooperation between the three nations," Fichefeux explains. As the technology matures, the program will use the "best athlete" principle to define who is best suited to carry out the work, develop the architecture and certify the system. "This is currently the governance model we are defining for each and every pillar depending on the nation's capabilities," Fichefeux notes.

Work is progressing on the development of technologies for FCAS, and efforts on the manned-unmanned-teaming element of the FCAS program have been "really disruptive," Fichefeux says.

"The target of affordability is having a huge impact on the design approach and the development logic of the program."

"Other nations are following similar trends," he says. "The U.S. and other countries are pushing the development of loyal wingmen, [which] opens completely new areas for operational scenarios. These drones can clean or screen the area, minimizing the risk to the fighter."

Onboard intelligent systems will help the pilot decide which remote carrier is best placed to perform a particular task.

Concerns about the levels of artificial intelligence to be used on FCAS have prompted a German debate on the ethical and responsible use of such technology in a combat aircraft. Airbus and the Bonn-based Fraunhofer Institute for Communication, Information Processing and Ergonomics established an independent panel of experts to help set ethical and internationally applicable legal guidelines into the FCAS and its onboard systems (*AW&ST* June 1-14, p. 32).

Airbus says it is also furthering its development of the communications technologies that will support the combat cloud, which Fichefeux says will still be available to the pilot even when operating in denied or heavily jammed environments. He says the system will be adaptable, depending on the tactical situation. Close to the front line, the aircraft's thirst for data will be fed by satellite links and communication nodes such as those on Multi-Role Tanker Transport aircraft. In a jammed environment, the critical node will be the NGF itself, communicating between the remote carriers and networked-enabled weapons.

"This collaboration between the drones and between the different fighters in the denied bubble is also a combat cloud," Fichefeux explains.

Industry is exploring a wide range of options for the remote carriers, including systems larger than those displayed at last year's Paris Air Show, where MBDA and Airbus displayed proposed systems around the size of a large cruise missile. But Fichefeux says the design space is open for larger systems such as that proposed in Boeing Australia's Airpower Teaming System and the UK's Lightweight Affordable Novel Combat Aircraft "Mosquito" work.

Whatever the architecture selected, it will apply to all three of the customer nations. In May 2018, each signed off on the High-Level Common Requirements Document, which has led to a common specification rather than a differentiated approach for each nation as on previous programs. Since then, the air chiefs of each nation, meeting virtually on May 7, agreed on further cohesion, signed a Common Understanding on Connectivity to support the development of better interoperability for legacy platforms such as the Eurofighter and Rafale to be integrated with the FCAS. They have also agreed on common operational criteria to support the process of assessing the potential architectures.

Low cost of operation is a key requirement of the nations as well, Fichefeux says, in part because the nations want the FCAS system to be successful on the export market.

"The target of affordability is having a huge impact on the design approach and the development logic of the program," Fichefeux says. "We plan to fully leverage the capabilities of what digitalization has to provide and work on optimizing development cycles." Cost-effectiveness will also be a critical factor in the development of the remote carriers, several of which will be designed to be expendable.

U.S. Air Force Launches Fielding Plan for Skyborg Weapons

> AIR FORCE RESEARCH LABORATORY PLANS FAMILY OF SKYBORG UNMANNED AIRCRAFT SYSTEMS

> LEIDOS IS MANAGING THE AUTONOMY MISSION SYSTEM

AFRL VIA YOUTUBE

An Air Force concept of a future Skyborg system depicts an unmanned aircraft firing an AIM-120 missile from an internal weapons bay, signaling an air-to-air role.

Steve Trimble Washington

The next combat aircraft to enter the U.S. Air Force inventory will not be a manned sixth-generation fighter or even the Northrop Grumman B-21.

By fiscal 2023, the Air Force expects to deliver the first operational versions of a new unmanned aircraft system (UAS) called Skyborg, a provocative portmanteau blending the medium of flight with the contraction for a cybernetic organism.

The Skyborg family of aircraft are expected to fill an emerging "attritable" category for combat aircraft that blurs the line between a reusable UAS and a single-use cruise missile.

As the aircraft are developed, Skyborg also will serve as the test case of a radical change in acquisition philosophy, with ecosystems of collaborative software coders and aircraft manufacturers replacing the traditional approach with a supply chain defined by a single prime contractor.

The Air Force also plans to manage the Skyborg aircraft differently than other UAS. Although Air Combat Command (ACC) is considering the Skyborg family as a replacement for pre-Block F-16s after 2025 and MQ-9s after 2030, the aircraft is not likely to fit neatly into an existing force structure with dedicated Skyborg squadrons.

"Even though we call Skyborg an attritable aircraft, I think we'll think of them more like reusable weapons," says Will Roper, assistant secretary of the Air Force for acquisition, technology and logistics.

The Skyborg propulsion systems—including expendable subsonic and supersonic jet engines—will be rated with a fraction of the service life expected of a fully reusable UAS or manned aircraft.

"We'll do whatever number of takeoffs and landings they're 'spec'd' for, and then we'll attrit them out of the force as targets and just buy them at a steady rate," Roper says.

Starting in fiscal 2023, a concept of operations for a formation of four Lockheed Martin F-22s will include Skyborgs as part of the manned aircraft's load-out.

"I expect that the pilots, depending on the mission, [will] decide: Does the Skyborg return and land with them and then go to fight another day, or is it the end of its life and it's going to go on a one-way mission?" Roper explains. In some cases, the pilot may decide a target is important enough that it is worth the loss of a Skyborg, even if its service life has not been used up, he adds.

As the concept evolves, a diverse array of Skyborg aircraft designs will likely find roles beyond the air combat community, Roper says.

"I don't think it'll just be fighters," he says. "I think they'll fly with bombers. I think they'll fly with tankers to provide extra defensive capability. That's what I love about their versatility and the fact that we can take risks with them."

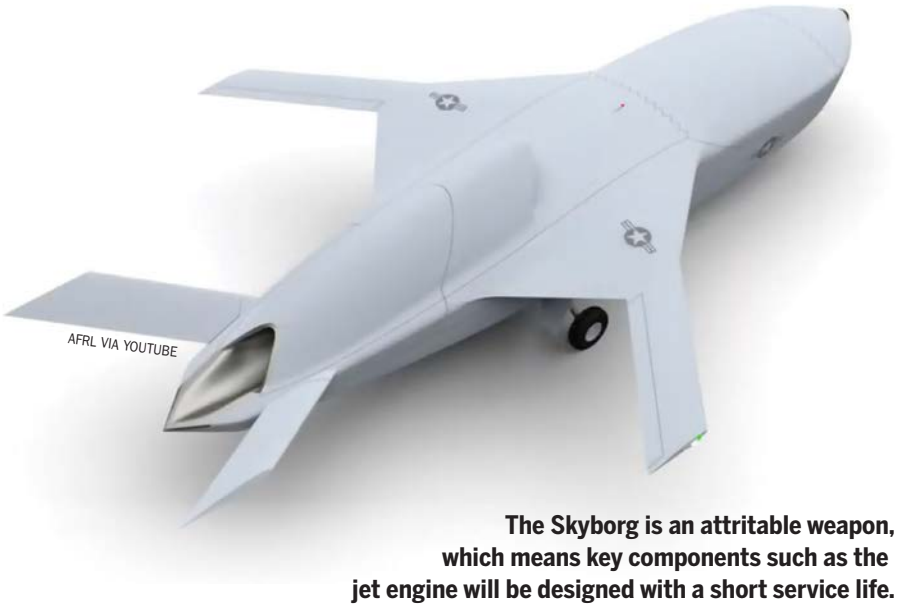
Skyborg is often presented as the epitome of the "loyal wingman" concept, in which one or multiple UAS are controlled or managed by a manned aircraft to perform a variety of surveillance, support and strike tasks during a mission. But the aircraft also could have the ability to operate independently of a manned aircraft, with the capability to launch and recover hundreds of such systems without the need for runways or even bases.

"If [China and Russia] know that they have to target only tens or even hundreds of ports and airfields, we have simplified their problem," says ACC chief Gen. Mike Holmes. The new class of attritable aircraft, he says, are designed so that "we can still provide relevant high-tempo combat power to be freed up from a runway."

If Skyborg is the future, the development phase is set to begin shortly.

The Air Force Research Laboratory (AFRL) had anticipated awarding a contract for the Skyborg Prototyping, Experimentation and Autonomous Development program on July 8, but the deadline passed with no announcement.

The AFRL already has a stable of potential concepts. The Kratos



The Skyborg is an attritable weapon, which means key components such as the jet engine will be designed with a short service life.

XQ-58A Valkyrie, which has flown four times since March 2019, is the most visible example of the AFRL's Low-Cost Attritable Aircraft Technology platform. Meanwhile, the Low-Cost Attritable Aircraft Platform-Sharing project quietly kept several UAS industry leaders involved in design studies, including Boeing, General Atomics Aeronautical Systems Inc., Lockheed Martin and Northrop Grumman. Each company selected will be awarded a contract with a maximum value of $400 million over a five-year ordering period.

But the core of the Skyborg program is the software; specifically, the military aviation equivalent of the algorithm-fed convolutional neural networks that help driverless cars navigate on city streets.

In announcing Leidos on May 18 as the Skyborg Design Agent (SDA), the AFRL selected the same company that delivered the software "brain" of the Navy's Sea Hunter unmanned surface vehicle, which navigated from San Diego to Honolulu in 2018. As SDA, Leidos' role is to deliver a software core that uses artificial intelligence to learn and adapt as the aircraft flies.

The autonomy mission system core—as integrated by Leidos from a combination of industry and government sources—will be inserted into multiple low-cost UAS designed by different companies, with each configured to perform a different mission or set of missions.

That is how the Skyborg program is set up today, but that is not how it started. Roper created the original "Skyborg" term and concept when he led the Strategic Capabilities Office within the Office of the Secretary of Defense in 2012-17. Roper transferred Skyborg to the AFRL, where it was renamed Avatar. A year after taking over Air Force acquisition in 2017, Roper changed the name back to Skyborg and created a program office in October 2018.

In March 2019, Roper revealed the Skyborg concept to a group of reporters a week before the AFRL issued the first request for information to industry about the program. At that time, Skyborg was still organized more traditionally, with plans to select a single contractor to serve as a prime integrator. By early 2020, program officials reorganized Skyborg into modular hardware and software subcomponents built on an open architecture that requires no prime integrator.

As the acquisition strategy has evolved, so has the Air Force's thinking about how to use the Skyborg family of systems.

"The whole idea was [that] the contested environment is going to be challenging, it's going to be uncertain, and so it makes the most sense to have something that doesn't have a pilot in it to go into the battlefield first," Roper says. "But once you agree that's a self-evident operational concept, it opens up the door for a lot of nontraditional thinking for the Air Force."

After a 2-3 year experimental phase, the AFRL plans to deliver an early operational capability in fiscal 2023. Follow-on operational Skyborgs could be funded within the Next-Generation Air Dominance (NGAD) project or through a separate program of record. The Skyborg concept even has links to the Air Force's architecture for the Advanced Battle-Management System (ABMS). "AttritableONE," which is defined as having "multirole attritable capabilities," is one of about 30 product lines in the ABMS architecture.

"Skyborg and the AttritableONE teams are closely coordinated for planning and collaboration purposes," the AFRL informed industry in response to questions about the Skyborg solicitation.

The aircraft supplier must deliver a highly flexible design. Leidos, the design agent, will provide the autonomous mission system that will serve as the pilot, flight control computer and mission systems operator for the aircraft. But the "size, weight, power and cooling details for the Skyborg core autonomy system have not been finalized," the AFRL told the bidding companies.

"The majority of the system will be software-based and integrate with the sensors onboard the host aircraft," the AFRL says. "Extensive collaboration between the Skyborg system design agent and the participants in this [contract] is expected."

The Kratos XQ-58A, which achieved first flight in March 2019, is one of several potential members of the Skyborg UAS family.

Swiss Fighter Referendum Campaign Gains Momentum

> GOVERNMENT DESCRIBES FRAUGHT THREAT ENVIRONMENT

> 6 BILLION SWISS FRANCS BUDGETED FOR FIGHTER PURCHASE

Tony Osborne London

Campaigning has begun in Switzerland for a referendum that will decide whether the country will purchase new combat aircraft for the 2030s.

Voters will go to the polls on Sept. 27 and will be asked whether the landlocked, neutral country, one of the richest in the world, should renew its fighter fleet.

For the second time in six years, the country's voting system will be used to make a critical decision about air defense. Back in 2014, voters were presented with a 3.3-billion-Swiss-franc ($3.5 billion) proposal to replace the Swiss Air Force's fleet of Northrop F-5 Tigers with the Saab JAS 39C/D Gripen. But voters narrowly rejected the plan: 53% chose to veto the proposals, dramatically resetting plans for air force modernization (*AW&ST* May 26-June 2, 2014, p. 27).

This time, the decision will be more binary. Rather than asking whether a particular procurement should go ahead, as it did with both the Gripen and the earlier F/A-18C/D Hornet (1993) procurements, the referendum question simply asks whether the country should procure new fighters, a single fleet that will replace the country's 30 C/D-model F/A-18 Hornets and 26 Northrop F-5E/F Tigers.

Switzerland has budgeted 8 billion Swiss francs for the Air2030 program, which in addition to aircraft will also introduce a long-range, ground-based air defense system. The latter is not the subject of the referendum.

The country's Federal Council has approved the plans with 6 billion Swiss francs budgeted for the fighters and 2 billion Swiss francs for the ground-based system. Selection is expected either at the end of 2020 or during early 2021.

The government-backed "Security-Yes" campaign says that voting against the proposals could leave the country's airspace unprotected after 2030 as both the Hornets and Tigers reach the end of their useful lives.

"Switzerland needs new fighter jets to protect the population and guarantee aviation security," Defense Minister Viola Amherd said as she launched the campaign.

Campaign literature describes a more fraught threat environment than when the Gripen was voted down.

"Although there are currently no armed conflicts around our country, the security situation is deceptive," the literature warns. "The emergence of new types of warfare does not supplant the old threats but complements them. These dangers therefore require a variety of answers and defense strategies."

The "No to New Fighter Jets" campaign does not rule out the need for an air defense capability but argues that a smaller and lighter aircraft such as the Korean Aerospace Industries T-50/FA-50 or the Leonardo M-346 jet trainers—as few as 12—would have achieved the desired capability at lower cost and in a more environmentally and noise-friendly way. But the No campaign claims that the Swiss Department of Defense, Civil Protection and Sport has not considered such an option.

The No campaign, whose logo consists of a silhouette of a Lockheed Martin F-35 emblazoned with the word "No" in Switzerland's three main languages of French, German and Italian, argues that purchasing a multirole combat aircraft with a 24-billion-Swiss-franc price tag over the lifetime of the program is "irresponsible" and that the money would be better used for social programs. The campaign also cites concerns about buying from the U.S. and the "unpredictable" administration of President Donald Trump, and asks: "What would happen if this angry nationalist suddenly decided to ban some states from using U.S. fighter jets and have software disabled from a distance?"

Four fighters are still in the running for the Air2030 requirement, including the Eurofighter, which Airbus in Germany has proposed. France is pushing the Dassault Rafale, while the U.S. is offering both the Boeing F/A-18E/F Super Hornet and the Lockheed Martin F-35A. All four aircraft underwent trials in-country between April and June of 2019 (*AW&ST* April 22-May 5, 2019, p. 34). Both the U.S. Raytheon Patriot and the French-Italian Eurosam SAMP/T long-range surface-to-air missile have also been evaluated.

The No campaign's literature cites issues with all four fighter candidates, with particular criticism reserved for the F-35 and the ongoing challenges associated with availability, security and cost of operation. The Super Hornet is being slammed for its physical size, leading to questions about the need for extensive modernization to infrastructure, while questions about the Eurofighter relate to operational concerns in Germany and alleged corruption around Austria's procurement of the platform. The critique for the French Rafale is more reserved, however, citing weapons-release issues during operations over Syria.

Switzerland's remaining 26 F-5E/F Tigers will be replaced as part of the Air2030 program, along with the air force's F/A-18 Hornets.

TONY OSBORNE/AW&ST

BOEING PHOTOS

BUILDING TRUST

Leanne Caret, president and CEO of Boeing Defense, Space and Security, spoke via teleconference with Aviation Week editors in the run-up to what would have been the Farnborough Airshow.

AW&ST: **In addition to the turnover among Boeing executives, the company's stock and reputation have taken a beating in the past year. How is Boeing a different company today than it was 18 months ago?** I am confident in the Boeing Co., and we have an enormously bright future. It's because of the incredible women and men who work for this company and bring their best every day. We have become a very introspective company, very pragmatic. We're owning our mistakes, and we're committing to address those. That is the centerpiece of what you have to do to have trust, especially in an industry as critically important as ours is, where people are flying and using our products every day, whether commercially or defending nations and allies.

How has COVID-19 affected the goals that Boeing Defense set at the start of the year? The defense industry has been deemed mission-essential. We need to make certain we're continuing to deliver product to our customers, we keep our supply base healthy, and we all have an eye to the future. I really appreciate the partnership and conversations we've had with the Pentagon. You've heard [Boeing CEO/President] David Calhoun mention that, after what has happened in the commercial aerospace market, the defense business is important to the Boeing Co.—has been and always will be.

After COVID-19, what does the future hold for defense spending? We have a very pragmatic view of the future. I don't anticipate significant budget increases. We have always planned that at some point we could see a regression in defense budgets.

Boeing defense chief Leanne Caret and outgoing Air Force Chief of Staff Gen. David Goldfein have been working to fix the remote vision system of the KC-46 (background) by fiscal 2023.

Wall Street is expecting about a 2% increase in revenue for Boeing over the next couple of years. That is on the lower end of where your peers are. They are in the mid-single digits. What rate of growth do you see? I think it's important to note where we are in the life cycle of many of the products in our portfolio. Where you will continue to see opportunity for us as we move into production on some of those key franchise programs that we won a few years ago is the [T-7 advanced trainer, MQ-25 unmanned carrier-based refueling aircraft and MH-139 helicopter].

We're all going to see the marketplace adjust as a result of COVID-19. Around the world, we've already seen some delays and some very large competitions that have been slighted because customers are having to assess where they

are. I want our team to have as its centerpiece meeting our customers' needs and expectations, and I believe that the outcome of that will be growing the business and strong financial performance.

Many big programs are coming down the line, such as the Low-Cost Attritable Aircraft, the Advanced Battle Management System, the Next-Generation Air Dominance or the Future Vertical Lift programs. The Pentagon is emphasizing procurement with more control over intellectual property, fewer hooks into the sustainment phase and more competition. How will Boeing adapt to that over time? Will it require fundamental changes? In the last decade, we were focused on redefining how we designed and built aircraft. We were anticipating that the customer was going to commoditize the type of product that we have traditionally built. We have a foundation in model-based systems engineering to bring the collective best from industry together, so that when a system is in the field, we have developed it with maintainers in mind.

That's where our build process has really paid off. In 2016, we had not won the T-7 or MQ-25 contracts or certainly not had any thought of the F-15EX yet. All three of those used this concept, which is to use advanced engineering and design toolsets to address the customer's vision. We placed our bets on changing the way we did business, and we have positioned ourselves nicely.

Please update us on the KC-46. Where do things stand with the foreign object debris (FOD) situation? I'm not going to be happy until we're perfect, and we're not perfect yet. My focus is to make sure we don't deliver any aircraft with FOD to the U.S. government. If that means I need to hold back a delivery because a member of our team identified an issue, we're going to do the right thing. The most important thing is to deliver a perfect product to the customer. I think it is a testament to the steps that we have taken that we will not pass a defect to our customer. It speaks to the culture change that we have instituted over the last 1.5 years. Quite frankly, we have used KC-46 as the bully pulpit to redefine what we want to do as a company, and I'm really proud of the team for leading the way.

Is Boeing on track for fixing the KC-46's remote vision system (RVS) in fiscal 2023? We are looking to demonstrate RVS 1.5 later this summer. It is a building block to what we call RVS 2.0. We have put in place a standard and an agreement that we are all aligned around, that really transcends what the original contract anticipated in terms of RVS. What we are incorporating positions this fleet for not only a leap forward in technology but for autonomous operations in the future. We are on track in this partnership with the U.S. Air Force and the Air Force Research Laboratory. And yes, the timeline is in 2023.

Boeing hopes its T-7A advanced trainer will boost the defense division's financial performance.

What is the outlook for selling F-18s internationally, given the potential for pandemic-related budget reductions in the future? We've secured a number of orders with F-18s that have kept our production line hot. Coupled with that, we're doing the service life modernization program with the U.S. Navy, where we're bringing every one of the aircraft back through and increasing capabilities that eventually will include Block 3 capabilities. We have seen signs that campaigns in Canada, Finland, Germany, India and Switzerland are sliding a bit to the right. None of them have been, to my knowledge, canceled or stopped.

One of the things that we've seen them dealing with is the impact of COVID. Many times, they have the budget, but the budget may go out a longer period of time. Or right now they are impacted by staff shortages. These are some big opportunities, and I think the F-18 is positioned nicely, both from the aspects of an acquisition cost and the cost per flying hour.

What is the outlook for the F-15? We just did our F-15 Qatar flight a few weeks back. We have continued to demonstrate the ability of the F-15 with our Saudi and Qatari customers and the U.S. Air Force. We're really excited about that opportunity, and it won't be your grandma's F-15.

Boeing is a bit late on delivering the Space Launch System (SLS), and it was left out of NASA's competition to build a lunar lander. What are you doing to turn those programs around? On Space Launch Systems, I am really proud of the team for the amazing capabilities they developed with the world's largest rocket. She's sitting on the stand at Stennis Space Center. After watching how this team has battled through the COVID crisis, I'm looking forward to having a hot-fire [test] later this year. Early on, we struggled on SLS from an execution phase. There were also different challenges from a funding perspective and other things. Over the course of the last 1.5-2 years, the team has been hitting its milestones and commitments.

On the civil space side, SpaceX beat Boeing to the punch on the first Commercial Crew mission. Are you looking to change your approach? On Starliner, we did not execute the full mission profile, and the right thing to do is to refly. I think that's the right decision, and the teams are focused on that. Our partnership with NASA dates back more than 60 years, and we're incredibly proud of this heritage. But our future isn't defined by our past. It's about making certain that we can continue to innovate and deliver today. This year marks 20 years for the International Space Station.

I just couldn't be more thrilled for the team as Doug [Hurley] and Bob [Behnken] were able to join the other astronauts aboard this station. Human space exploration is not for the faint of heart. It changes mankind. We are going to continue to be a great partner, and we're going to continue to advocate for everyone's success when it comes to human space exploration—because it is that important for all of us.

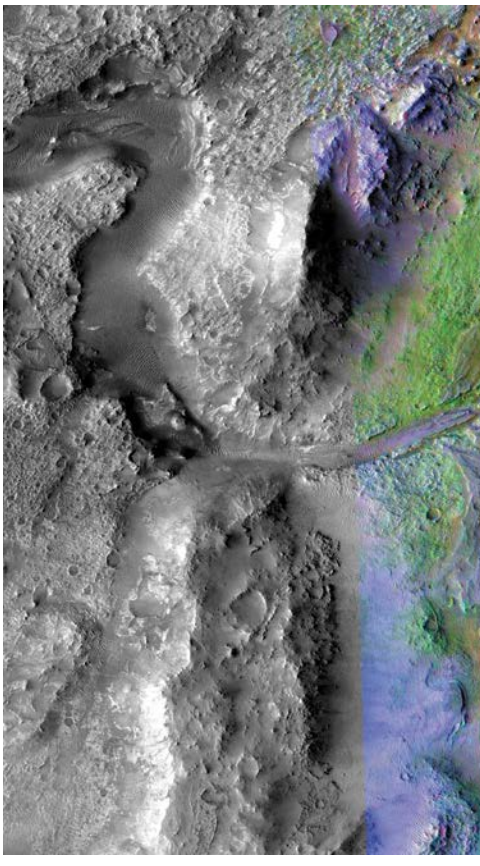
NEXT STOP JEZERO CRATER

> ROVER EXPECTED TO LAND ON FEB. 18, 2021

> ANCIENT RIVER DELTA FIRST TARGET FOR STUDY

Irene Klotz Cape Canaveral

NASA/ESA



The Hubble Space Telescope caught this view of Mars from 54 million mi. away in 1999.

The most important thing about Jezero Crater, the landing site for NASA's upcoming Mars 2020 Perseverance rover mission, is that billions of years ago it was Jezero Lake, a deep body of water replenished by rain, ice or snow that may have teemed with microbial life.

The lake is long gone—a victim of Mars' extreme climate change—but microfossils may be locked inside Jezero's spectacularly preserved river delta, where the rover's mission will begin, and other sites such as potential ancient hot springs on the rim of the 28-mi.-wide (45-km) crater.

Perseverance is scheduled to launch from Cape Canaveral AFS between July 30 and mid-August aboard a United Launch Alliance Atlas V rocket. Like the Mars Science Laboratory Curiosity rover, which arrived at Gale Crater in August 2012, Perseverance will make a parachute, retrorocket and sky crane descent, touching down on the flat floor of Jezero Crater on Feb. 18, 2021.

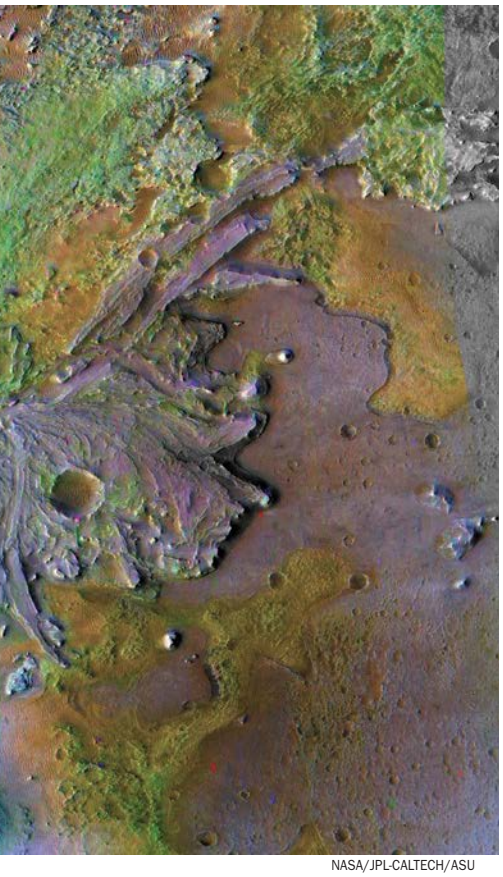
Engineers at the Jet Propulsion Laboratory (JPL) in Pasadena, California, added two new technologies for Perseverance's entry, descent and landing.

One is Range Trigger, which will be used to time the parachute's deployment based on navigation position, resulting in a smaller landing target. The other is Terrain Relative Navigation, an autopilot that can determine the spacecraft's position over the Martian surface by comparing images from a downward-pointing camera on the rover with stored images taken by Mars orbiters. It then quickly selects the best reachable, safe landing site and commands the spacecraft's descent stage to fly to that point. The system can change the rover's touchdown point by up to 2,000 ft.

"In the very last stages of descent, Mars 2020 has the ability to steer away from any hazards. We didn't have that," says Curiosity project scientist Ashwin Vasavada.

Perseverance, NASA's fifth Mars rover, closely resembles Curiosity, whose mission was to determine if the planet most like Earth in the Solar System ever had the ingredients for life.

"NASA has had a very deliberate, strategic Mars exploration program, with a combination of orbiters and landers and rovers," says Vasavada.



NASA/JPL-CALTECH/ASU

This image of Jezero Crater captured by instruments on NASA's Mars Reconnaissance Orbiter shows spectral data pointing to minerals altered by water in and around the ancient delta.

"The rovers, in particular, were sent to follow up on the things we saw from orbit and some of the big questions we've always had about the presence of liquid water on ancient Mars and the possibility of life."

Following the 1997 Mars Pathfinder mission, the Spirit and Opportunity rovers were dispatched to confirm the present of past liquid water. Those rovers, which operated from 2004 to 2018, led to a broader quest by the Curiosity rover to assess other factors for habitability, such as the presence of carbon and other organic molecules.

"At the time, we weren't confident enough to kind of repeat Viking and send something directly to go discover life somewhere," says Vasavada. "We wanted to learn more about what makes an environment habitable, and if any of those environments ever existed on Mars."

Curiosity, whose mission is ongoing, has found carbon and minerals altered through long-lasting water, setting the stage for Perseverance, the first life-detection mission since the 1976-80 Viking missions.

Curiosity's landing site features a 3.4-mi.-high mountain, called Mount Sharp, rising from the floor of Gale Crater. "We've found really no break in the habitability of Mars . . . as we've climbed layer by layer up through Mount Sharp," says Vasavada.

Curiosity has covered more than 1,300 ft. of stratigraphy, representing hundreds of thousands to millions of years of Mars' history. "There is basically a continual record of lake sediments. That tells us there was persistent liquid water in ancient Mars, and that's about the best-case scenario in terms of what we thought might be on Mount Sharp," says Vasavada.

"We're very optimistic to take the next step to look directly for signs of ancient life," he says.

EXTRAORDINARY CLAIMS

Astronomer and astrobiologist Carl Sagan once famously said "extraordinary claims require extraordinary evidence," a mantra NASA intends to fully embrace in its first attempt to find life on Mars since the Viking missions. So while Perseverance will analyze rocks and soils in situ for potential chemical and geomorphic fingerprints of life, it will pack up 30-38 of the best samples for a return trip to Earth on a later mission.

"Our bar is high for the identification of a sign of life on another planet—as it should be," says Katie Stack Morgan, Perseverance deputy project scientist. "But I think we also have to open our minds to the possibilities of what life could look like on another planet."

Scientists will be scanning for patterns, textures and substances that cannot be readily explained without the influence of life. "Every time we see something on the surface of Mars that gets us asking those questions, we go through the list of possibilities," says Morgan.

"If we get to the point where we are really struggling to explain a phenomenon or something that we see with abiotic processes, that's when we start to say, 'I think this could be a potential biosignature,'" she adds. "Our job is to identify things that are worthy of additional study on Earth with the full arsenal of analytical capabilities that we have here in our laboratories."

Though scientists have been studying about 125 meteorites that came from Mars, they have longed to analyze pristine Martian rocks and soils. "Samples from Mars have the potential to profoundly change our understanding of the origin, evolution and distribution of life on Earth and elsewhere in the Solar System," says Lori Glaze, NASA Planetary Science Division director.

"Even now, NASA continues to study Moon samples brought back by the Apollo program more than 50 years ago," she adds. "We expect samples of the red planet to provide new knowledge for decades to come as we study them with state-of-the-art laboratory equipment we couldn't possibly take to Mars right now."

'WELCOME TO JEZERO'

Jezero Crater is located at 18.4 deg. N. Lat., 77.7 deg. E. Long. in the Nili Fossae region of Mars, straddling the area between the planet's heavily cratered southern highlands and the flatter regions of the north.

Perseverance's landing site on the crater's flat floor is just east of a dramatic, fan-shaped ancient river delta that orbital data shows is replete with clays. Deltas form when rivers enter open bodies of water and deposit rocks, sand and potentially organic carbon in layers.

Jezero Crater once held a lake filled to a depth of up to 820 ft. by at least two river systems stemming from the Nili Fossae region. The lake was about the size of Lake Tahoe in the U.S. Sierra Nevada mountain range.

"An ancient lake is a fantastic place to pursue our goal of looking for possible Martian life," says project scientist Ken Farley. "On Earth, lakes are filled with living creatures, and evidence of that life is often preserved in the mud and sand deposited on the bottom of the lake. So we use the rovers' instruments to explore the rocks in the ancient lake bed."

At some point, Jezero Lake breached its northeast rim and water flowed out, creating an open lake system with both inlet and outlet streams.

Jezero Crater, located on the inner rim of one of the largest and oldest impact basins on the surface of Mars, also contains some of the most ancient rocks in the Solar System, 3.5-4 billion years old, as well as a record of diverse geologic processes, including volcanism, impact cratering and properties associated with surface and sub-

surface water, which reveals how the planet evolved over time.

It also sports carbonate minerals around the crater's inner rim. Carbonates can form in shallow lakes, another potential site for life.

"Part of the reason we picked Jezero Crater as the landing site was because it has such a well-understood environment that we could see and understand from orbital images alone," says Morgan. "We know we have a delta, we know we had a lake in Jezero Crater, and we know this crater is perched on the rim of a giant impact basin. . . . That really helps us plan and plot out the course of our sampling exploration.

"We think that Jezero was home to a variety of different potential habitable environments," she adds. "We don't know for sure what biosignatures on Mars are going to look like, but we can look to our own Earth rock record to give us an example of what we might expect to find."

For example, a 3.4-billion-year-old rock from Australia has been found to contain stromatolites, which is a fossilized microbial mat built layer by layer in shallow water.

"If you look at that rock you wouldn't know for sure that it was a potential biosignature. But when you couple the textures as well as the chemical composition, the mineralogy and the distribution of organic carbon, you can start to build a case that rock could only have formed under the influence of life," says Morgan.

NASA/JPL-CALTECH

A NASA orbiting sample container like this concept model will hold tubes of Martian rock and soil samples collected by Perseverance and returned on a future mission.

"This is exactly the type of thing that we do here on Earth to make a case for biosignatures in our own rock records. And for the very first time . . . we can do that on the surface of Mars," she adds.

In addition to caching samples for return to Earth, a multinational, multimission campaign planned for 2026-32, Perseverance will address some overarching science questions, such as how the surface and climate of Mars evolved over time and how rocky planets form and differentiate.

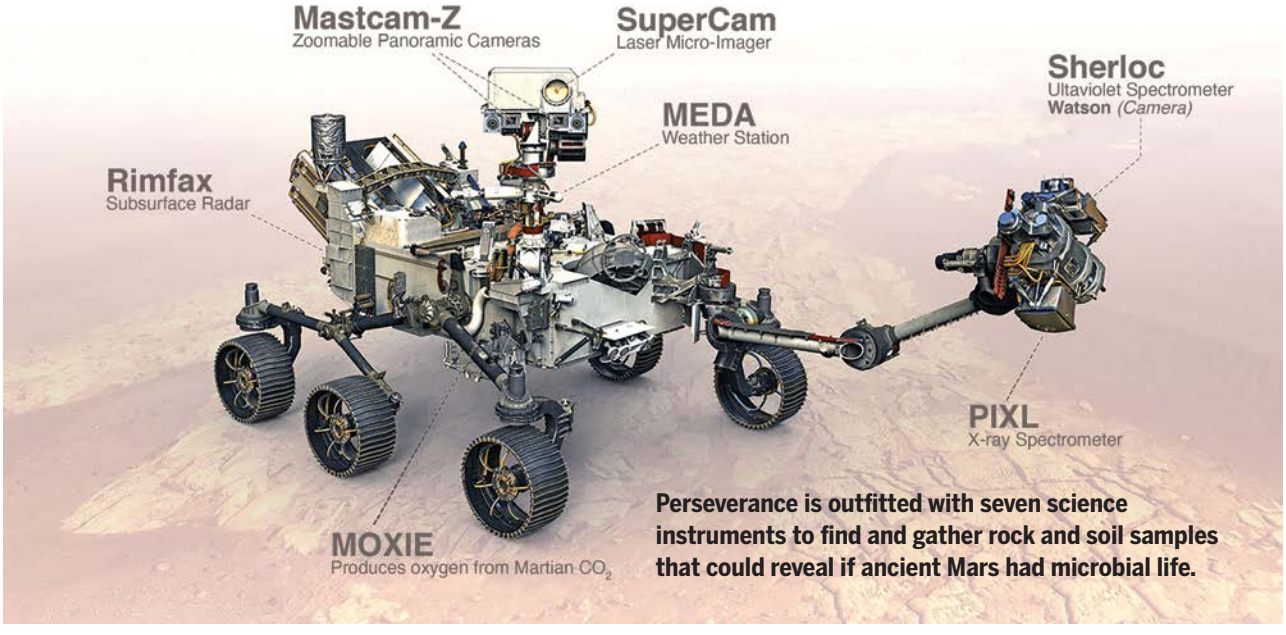
Perseverance is outfitted with a payload of seven instruments, including radar to study the subsurface and chemical-mapping instruments attached to the end of the rover's robot arm.

"Curiosity has the ability to detect organic carbon, and it has detected organic carbon. But we haven't been able to necessarily link the presence of the organics . . . to particular textures or patterns that we see in the rock that we think could have been left behind by life," says Morgan. "It's the connection of the textures and the composition that allow us to make a compelling case for a biosignature. The instruments on Perseverance allow us to do that really for the first time on the surface of Mars."

The Mars 2020 mission also includes two technology demonstrations: a small helicopter, which will attempt the first aerial flight on another planet, and an experiment to convert carbon dioxide pulled from Mars' atmosphere into oxygen. The test could lead to instruments to support human missions to Mars, providing air for breathing and propellant for fuel.

After Perseverance explores the ancient river delta, it will attempt to visit the shoreline of the ancient lake and then on to the crater's rim. "Jezero Crater formed when a large object collided with Mars, excavating rocks from deep in the Martian crust," says Farley. "Those rocks would have been hot shortly after the impact. . . . Deposits from any hot springs would be another target in our search for possible ancient life on Mars."

NASA has invested approximately $2.4 billion to build and launch the Mars 2020 Perseverance mission. Operating costs during its two-year primary mission are about $300 million.



NASA/JPL-CALTECH

Perseverance is outfitted with seven science instruments to find and gather rock and soil samples that could reveal if ancient Mars had microbial life.

Aviation Week's Virtual Global Networking and Learning Event for the Urban Air Mobility and eVTOL Communities.

AVIATION WEEK

UAM VIRTUAL

AUGUST 11-13, 2020

Join the best and brightest from across the global Urban Air Mobility sector. Network with suppliers and access knowledge from industry leadership.

Confirmed Speakers include:

Simon Brienco
Lead, Advanced Air Mobility, Jaunt Air

Parimal (PK) Kopardekar PhD
Director, NASA Aeronautics Research Institute (NARI), NASA Ames Research Center

Tom Prevot
Director of Engineering for Airspace Systems, Uber

Megan Prichard
Launch General Manager, Uber

Gene Reindel
Vice President, HMMH

Anthony Rushton
Director of Engineering, Airspace Systems, Elevate, NATS

Felipe Varon
CEO & Founder, Varon Vehicles

Prof. James Wang
Professor and Director of eVTOL Research & Innovation Centre at NTU, Singapore, and Founder of Vtolwerke LLC

JANICKI INDUSTRIES
Sponsor

Association of Aerospace Industries (Singapore)
Supporter

EMBRAER X
EMPOWERING PEOPLE, TRANSFORMING BUSINESS.
Supporter

COMPLIMENTARY REGISTRATION.

Secure your place today! uam.aviationweek.com

#AWUAM

AVIATION WEEK NETWORK

Mars Landers, Past and Future

So far, the U.S. has been the only country to successfully land and operate spacecraft on Mars, dispatching eight rovers and landers to the red planet since the 1976 Viking missions. The U.S. also has had one landing failure. The European Space Agency attempted two landings on Mars, both unsuccessful. Russia sent three landers to Mars in the early 1970s, one of which touched down successfully but then ceased communications.

Here is a look at missions that have landed and attempted to land on Mars, as well as upcoming projects by the U.S., China and Europe to once again explore the planet most like Earth in the Solar System. Mars is half the size of Earth but has about the same amount of surface area as its dry land mass.

The Planetary Society, a Pasadena, California-based space exploration advocacy organization, compiled this map of Mars landing sites and likely crash sites. It is the first compilation to include landing-site elevation data. The base topographical images were assembled from data collected by the Mars Orbiter Laser Altimeter instrument on the now-defunct Mars Global Surveyor spacecraft.

—Irene Klotz, Cape Canaveral

Successes, *Failures* and Future

Viking 2
NASA lander
Launched: Sept. 9, 1975
Landed: Sept. 3, 1976
Last contact: April 11, 1980
Utopia Planitia
47.643 deg. N., 134.288 deg. E., -4,495 m

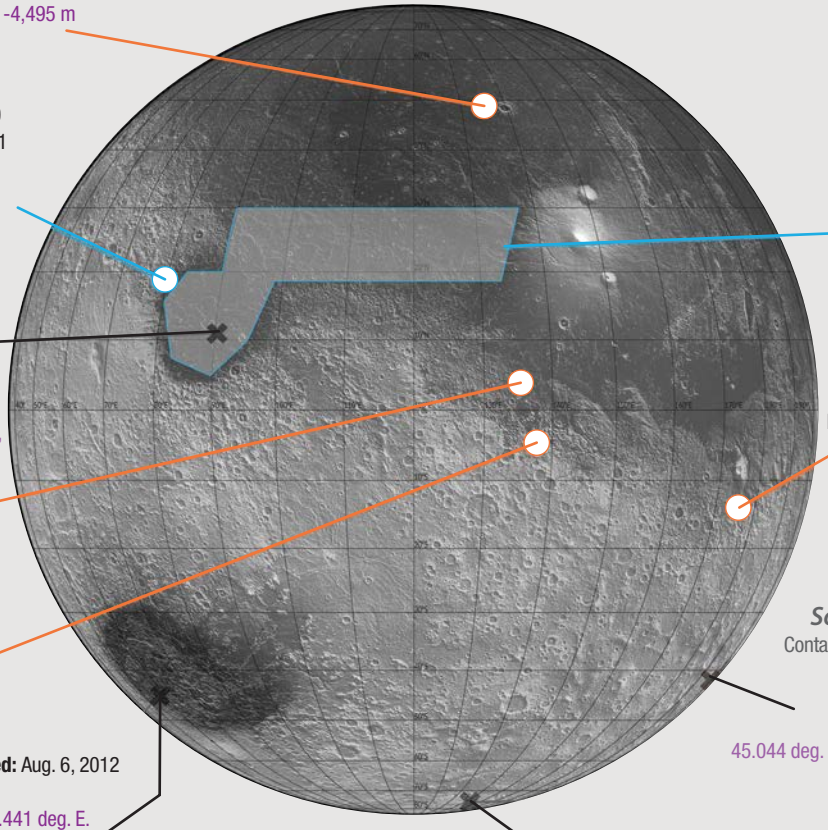
Perseverance
NASA rover
Launch: expected July 30, 2020
Landing: expected Feb. 18, 2021
Jezero Crater
18.4386 deg. N., 77.5031 deg. E., -2,640 m

Beagle 2
ESA lander
No contact since separation
Launched: June 2, 2003
Last contact: Dec. 25, 2003
Isidis Planitia
11.5288 deg. N., 90.4314 deg. E., -3,725 m

InSight
NASA lander
Launched: May 5, 2018
Landed: Nov. 26, 2018
Elysium Planitia
4.502 deg. N., 135.623 deg. E., -2,613 m

Curiosity
NASA rover
Launched: Nov. 26, 2011 **Landed:** Aug. 6, 2012
Roved: >22 km
Gale Crater 4.5895 deg. S., 137.441 deg. E. -4,501 m

Mars 2
Soviet lander and rover
Entered atmosphere too steeply
Launched: May 19, 1971
Crashed: Nov. 27, 1971
Helios Chaos Near 45 deg. S., 58 deg. E., -5,000 m



-8,000 m -6,000 m -4,000 m -2,000 m 0 m +2,000 m +4,000 m +6,000 m +8,000 m

Topography
Relative to Martian Datum

1 deg. of latitude on Mars = 59.3 km
1,000 m = 3,280.84 ft.

Spirit
NASA rover
Launched: June 10, 2003
Landed: Jan. 3, 2004
Roved: 7.73 km
Last contact: March 22, 2010
Gusev Crater
14.5692 deg. S., 175.4729 deg. E., -1,936 m

Mars 3
Soviet lander and rover
Contact lost after successful landing
Launched: May 28, 1971
Last contact: Dec. 2, 1971
Terra Sirenium
45.044 deg. S., 202.019 deg. E., +1,626 m

Mars Polar Lander
NASA lander
No contact since entry
Launched: Jan. 3, 1999
Last contact: Dec. 3, 1999
Planum Australe
Near 76.57 deg. S., 165.2 deg. E., +3,000 m

EMILY LAKDAWALLA/PLANETARY SOCIETY

Predecessor Probes Set Stage for Perseverance

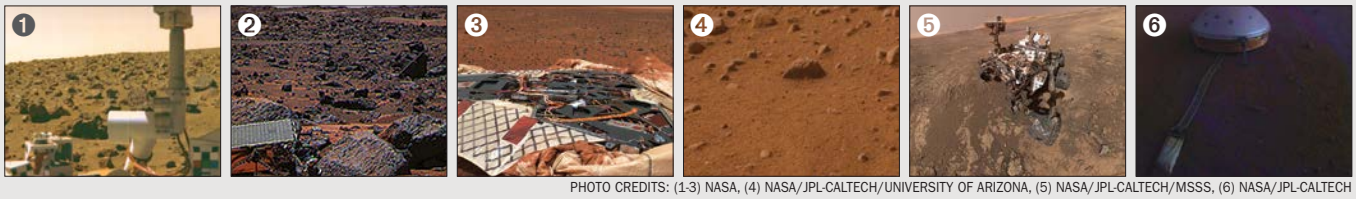
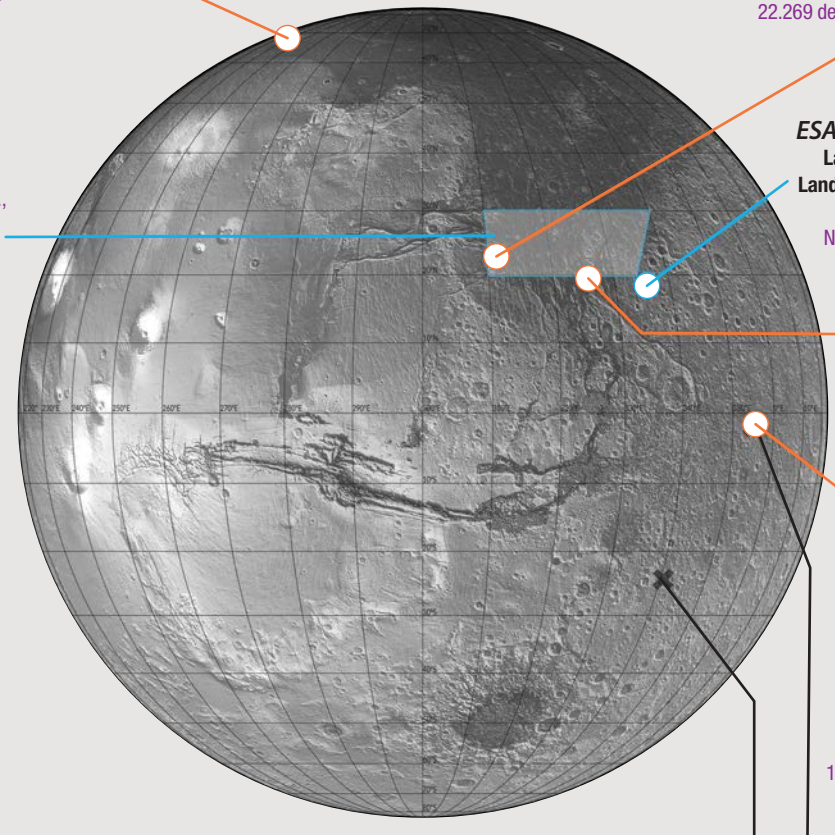


PHOTO CREDITS: (1-3) NASA, (4) NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA, (5) NASA/JPL-CALTECH/MSSS, (6) NASA/JPL-CALTECH

❶ The Utopia Plantia landing site imaged by Viking 2.
❷ The Mars Pathfinder's Sojourner rover using its Alpha Proton X-ray Spectrometer on a rock named "Moe."
❸ Spirit, one of two Mars Exploration Rovers, landed on the floor of Gusev Crater.
❹ The Phoenix lander explored subsurface ice at Mars' northern polar region.
❺ The Mars Science Laboratory Curiosity rover snapped a selfie from its Gale Crater landing site.
❻ The InSight lander used its Instrument Context Camera to image drifting clouds at sunset.



Phoenix
NASA lander
Launched: Aug. 4, 2007
Landed: May 25, 2008
Vastitas Borealis
68.2188 deg. N., 234.2508 deg. E., -4,130 m

Tianwen-1
Chinese rover
Launch: expected July 2020
Landing: expected early 2021
Site 1: Chryse Planitia
20-30 deg. N., 310-330 deg. E.,
Site 2: Elysium Planitia
19-30 deg. N., 90-134 deg. E.,
or within **Isidis Planitia**
4-20 deg. N., 80-98 deg. E.

Viking 1
NASA lander
Launched: Aug. 20, 1975 **Landed:** July 20, 1976
Last contact: Nov. 13, 1982
Chryse Planitia
22.269 deg. N., 312.048 deg. E., -3,637 m

Rosalind Franklin & Kazachok
ESA rover & Russian lander
Launch: expected Aug.-Oct. 2022
Landing: expected April or July 2023
Oxia Planum
Near 18.14 deg. N., 335.7 deg. E., -3,000 m

Pathfinder & Sojourner
NASA lander and rover
Launched: Dec. 4, 1996
Landed: July 4, 1997
Last contact: Sept. 27, 1997
Ares Vallis
19.33 deg. N., 326.47 deg. E., -3,681 m

Opportunity
NASA rover
Launched: July 8, 2003
Landed: Jan. 24, 2004
Roved: 45.16km
Last contact: June 10, 2018
Meridiani Planum
1.9462 deg. S., 354.4734 deg. E., -1,387 m

Mars 6
Soviet lander
Contact lost upon landing
Launched: Aug. 5, 1973
Last contact: March 12, 1974
Margaritifer Sirius
Near 24 deg. S., 340.5 deg. E., -500 m

Schiaparelli
ESA lander
Contact lost during descent
Launched: March 14, 2016
Crashed: Oct. 19, 2016
Meridiani Planum
2.0524 deg. S., 353.7924 deg. E., -1,444 m

The UAE and China Head to Mars

> EUROPE'S EXOMARS WILL NOT FLY UNTIL 2022

> CHINA TO MAKE SECOND ATTEMPT TO REACH MARS

Irene Klotz Cape Canaveral

NASA's Mars 2020 Perseverance mission, slated to launch by mid-August, will not be the only spacecraft on the interplanetary highway to Mars this summer.

In its deep space debut, the United Arab Emirates (UAE) hopes its Mars Hope orbiter will begin the seven-month journey to Mars on July 14—the beginning of a three-week launch window that opens every 26 months when Earth and Mars are favorably aligned for interplanetary flight.

Hope is outfitted with three science instruments for detailed studies of the Martian atmosphere, but the mission's primary goal is to spur development of the UAE's science and technology sector, particularly among Emirati youth.

The mission was developed by the Mohammed Bin Rashid Space Center in Dubai, in partnership with the Laboratory for Atmospheric and Space Physics at the University of Colorado Boulder, Arizona State University and the University of California, Berkeley.

The spacecraft is scheduled to launch aboard a Mitsubishi Heavy Industries' H-IIA rocket from Japan's Tanegashima Space Center and arrive at Mars in February 2021, coinciding with the 50th anniversary of the UAE's formation.

Also heading to the launchpad is an ambitious mission by China to explore the red planet with an orbiter, lander and rover. Tianwen-1 is slated to launch aboard a Long March 5 rocket from Wenchang, China, on July 23.

The mission will be China's second attempt to reach Mars. It partnered with Russia on the 2011 Phobos-Grunt mission, which included an attached secondary spacecraft, Yinghuo-1, which was to become China's first Mars orbiter.

Yinghuo-1, along with the rest of the payload, failed to leave Earth orbit due to a spacecraft main propulsion engine problem. The stack reentered the atmosphere in January 2012.

Efforts to get all three countries' Mars probes ready for the 2020 launch window have been complicated by workplace shutdowns and travel restrictions stemming from the COVID-19 pandemic.

Perseverance's ride aboard a United Launch Alliance Atlas V also has faced a trio of delays due to ground processing issues, postponing liftoff from July 17 to no earlier than July 30.

If the rover cannot be launched by mid-August, delaying the flight until the next Mars launch opportunity in August-October 2022 will cost NASA about $500,000, says Administrator Jim Bridenstine.

Originally, the 2020 armada was to include the joint European-Russian Mars Express (ExoMars) rover, but efforts to resolve parachute problems were stymied due to pandemic shutdowns, and the mission was delayed to 2022.

ExoMars will be the first mission to search for signs of present-day life on Mars, drilling up to 6.5 ft. below the surface, where biological signatures of life may be uniquely well preserved. Japan and India also plan to launch missions to Mars in 2022.

The current Mars fleet includes NASA's Curiosity rover, InSight lander and Mars Odyssey, Mars Reconnaissance and Maven orbiters; Europe's Mars Express and ExoMars Trace Gas Orbiter; and India's Mars Orbiter Mission.

MOHAMMED BIN RASHID SPACE CENTER

The UAE's Mars Hope mission has been prepared to launch on a Japanese HII-A rocket.

First All-Chinese Mars Mission To Deploy Rover

> IT HAS A FOUR-PHASE ENTRY, DESCENT AND LANDING PROCESS

> GROUND-PENETRATING RADAR TO OBSERVE SUBSURFACE

Bradley Perrett Beijing

Describing their upcoming mission to Mars, Chinese space program managers stress two points: China will be the first country to try orbiting, landing and roving on its first flight to the planet; and landing on it is difficult.

The mission is Tianwen 1, one of three international projects being sent to Mars in the launch window of July and August this year. Objectives include surveying the topography and geology of Mars as well as its physical fields, atmosphere, ionosphere, climate and the space environment.

Following flyby missions in the 1960s, the U.S. put a probe in Martian orbit in 1971, and the Soviet Union made a landing 18 days later. A U.S. rover followed in 1997. Now the first entirely Chinese shot at Mars aims at all three achievements.

Probably to prepare the public for the possibility of failure, the Chinese are using the description of a landing on Mars that NASA popularized before its Curiosity mission of 2012: "7 min. of terror." That is to say, something could easily go wrong.

The spacecraft may depart on July 23 or 24, says an industry source. It is due to arrive at Mars in February.

The assembly will separate into an orbiter and rover-carrying lander, the latter entering the thin atmosphere at 4,800 m/sec. (16,000 ft./sec.). Aerodynamic braking for 290 sec. will reduce this by more than 90%, to 460 m/sec., Bao Weimin, the director of the science committee of Casc, the main contractor for Chinese space programs, tells the *People's Daily* newspaper.

For a second phase, the lander will deploy a parachute, which in 90 sec. will pull the speed down to 95 m/sec. Then comes 80 sec. of propulsive braking, at the end of which the lander should be at an altitude of 100 m (330 ft.) and descending at 3.6 m/sec. (The total so far is 7.7 min.) The residual velocity can be dealt with during the hovering phase, in which the probe will spend 100 sec. surveying the terrain, autonomously moving away from locations with hollows or large rocks, then landing.

"This Mars exploration mission is not a simple repeat of what other countries have done," says Zhao Xiaojin, secretary of the party committee of Cast, which is China's main spacecraft-maker and has built the Tianwen 1 probe. In exploring Mars, "our starting point is high because of the level of our astronautical technology and the confidence of our astronautical engineers," he told *Science and Technology Daily* in May.

The orbiter will have seven payloads, reportedly: a radar, medium-resolution camera, high-resolution camera, mineral spectrometer, magnetometer, ions and neutral-particle analyzer and an energetic-particle analyzer. There will be six payloads on the rover: a topography camera, navigation camera, ground-penetrating radar, multispectral camera for observing surface composition, climate detector and magnetic field detector. To deal with the extreme Martian weather, the rover will autonomously sleep and wake. Its design life is 90 Martian days—or 92 terrestrial days.

"High autonomy is needed because of the communications delays," says Bao. "Illumination is weak—and it is diminished by the atmosphere—so providing power is harder, complicating the mission." The rover's mass will be 240 kg (530 lb.), says the *Guangming Daily* newspaper.

While conducting its own observations, the orbiter will act as a communications relay for the rover, Bao says. He emphasizes the challenge in achieving telemetry over the great distance of the flight to Mars.

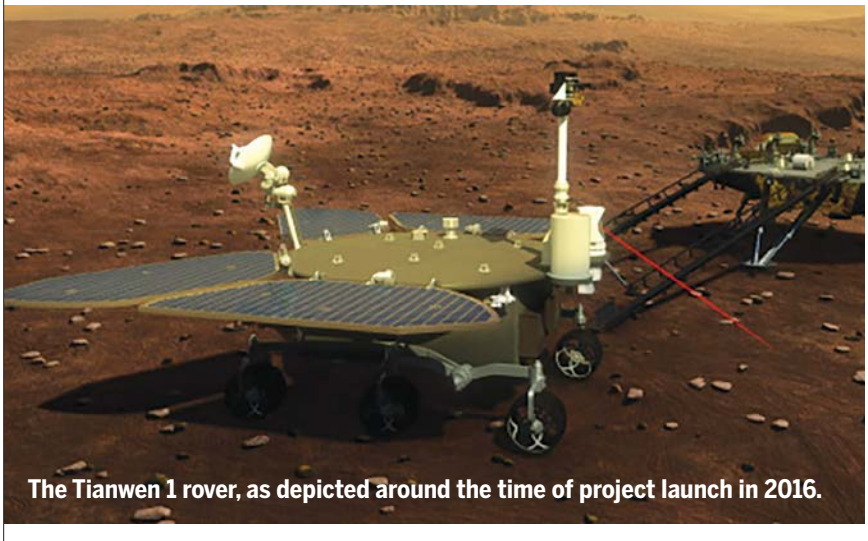
Tianwen 1 needs the launch capability of China's most powerful rocket type, the Long March 5 series, and specifically its initial version, simply called the Long March 5. That version failed on its second flight, in 2017, and returned to service in December 2019. The flop led to a reshuffling of missions, with Tianwen 1 moving higher in the sequence to ensure it could depart during the 2020 Mars-launch window.

The following Long March 5 mission will hurl the Chang'e 5 sample-return probe to the Moon this year.

A mission to bring a sample back from Mars and another mission to the Jupiter system will be conducted around 2030, Bao says. Work on critical technology for these is underway. A bigger launcher will presumably be required, since bringing back a sample requires sending more mass to a target celestial body than is needed for sending a one-way probe to it.

China attempted to send an orbital probe to Mars in 2011 as a piggyback load on the Russian Fobos-Grunt mission to the Martian moon Phobos. The Fobos-Grunt spacecraft did not leave Earth orbit, however.

The name "Tianwen" is unusually apt for a Chinese effort at space exploration. It is the name of an ancient poem and means "questions to heaven."



CHINESE GOVERNMENT

The Tianwen 1 rover, as depicted around the time of project launch in 2016.

OneWeb Buy Could Pave Way to UK Sovereign GNSS

- UK GOVERNMENT AND BHARTI GLOBAL WILL EACH HOLD 45% OF ONEWEB
- ONEWEB ENTERED CHAPTER 11 IN MARCH

Tony Osborne London

The British government's decision to invest in OneWeb looks set to put it in direct competition with Elon Musk's Starlink constellation, but London is eyeing other opportunities for the satellite system.

The UK along with India's Bharti Global cellular communications company made a successful joint $1 billion bid for the failed communications provider, giving UK taxpayers a 45% stake in the company. Bharti will also take a 45% share, while OneWeb's creditors will hold the remainder. The London-based satellite operator says the deal will give it a "robust foundation" to complete the launch of its planned 648-strong constellation. Just 74 of its satellites had been launched when the company entered Chapter 11 bankruptcy protection in March, following Japanese investor Softbank's withdrawal over coronavirus pandemic concerns.

The bid must be approved by a U.S. bankruptcy court on July 10, but the green light by judges would give the UK a global reach as it strengthens its space ambitions. The acquisition could be a relatively low-cost steppingstone to the creation of a sovereign global navigation satellite system (GNSS), filling a void left open by the loss of access to the European Union's Galileo Public Regulated Service following the country's Brexit decision.

ONEWEB SATELLITES

A OneWeb takeover by the British government and Bharti puts the future of the company's megaconstellation back in play.

Ministers had balked at the £5 billion-plus ($6.3 billion) price tag of a proposed independent system. The OneWeb purchase could, through upgrades and new payloads, "provide a highly accurate timing service," the UK's Satellite Catapult business incubator suggested in late June. OneWeb could augment and supplement positioning services provided by the U.S. Global Positioning System (GPS). Oneweb's Ku-band signals are more powerful than the L-band signals emitted by the GPS, making them more resilient to jamming and interference.

"OneWeb will offer something new into the Position Navigation and Timing (PNT) arena, and not simply another alternative system," Catapult suggested.

Officials have dismissed suggestions that the government had invested in the wrong type of satellite, with critics describing the purchase as "nonsensical" and claiming the satellites are too small and too close to the Earth for the PNT task. Industry officials point out that highly accurate clocks could be developed for fitment on smaller satellites.

Adding more capabilities to the satellites would see the UK likely lean on its own satellite manufacturing and engineering expertise, says UK Business Secretary Alok Sharma. But the UK is unlikely to call for manufacturing of the satellites—currently done by the OneWeb Satellites joint venture of OneWeb and Airbus in Florida—to move, as transferring such a specialist capability would come with additional unnecessary costs, industry officials tell Aviation Week. In May, OneWeb submitted proposals to increase the number of satellites in its constellation to 48,000, to meet expected connectivity demands. Whether the size of the constellation will ever meet this figure is unclear, but it would require additional manufacturing capability.

The purchase also allows the British government to potentially achieve another policy objective: the ability to beam broadband-speed internet into UK homes without the additional cost of ground infrastructure.

Sharma says the deal would allow the UK to "further develop our strong advanced manufacturing base." It was a message echoed by Richard Franklin, managing director of Airbus Defense and Space UK, who says the company looks forward to supporting the next phases of the project and growing the UK's contribution to the system.

"The UK Government's vision in backing this project will drive innovation and new ways of thinking about how space can contribute even more to the UK economy and the country's defense requirements, as well as playing a part in delivering broadband internet to communities across the country," says Franklin.

OneWeb CEO Adrian Steckel says the combination of Bharti Global and the British government would "bring immediate value," and "underscored confidence" in the business and the company's technology.

Sunil Bharti Mittal, chairman of Bharti Enterprises, says the deal could pave the way for deepened cooperation between the UK and India and suggested the Indian Space Research Organization (ISRO) could play a role in the OneWeb constellation.

Bharti was one of the initial investors in OneWeb and, clearly unperturbed by the bankruptcy, will provide the company with commercial and operational leadership, the UK government says. But it is unclear how this will evolve if more capabilities such as PNT are added to the wider constellation. Questions posed to the Department of Business, Energy and Industrial Strategy about the next steps have received no reply. Among the conditions set by London, however, is that the British government will have a final say over any future sale of the company and over future access to OneWeb technology by other countries, on national security grounds. Regulatory approvals and closing conditions are expected to be concluded by the end of the year.

ASK THE EDITORS

Can Boeing Overcome 737 MAX Issues and A320neo Growth To Regain Its Lead?


BOEING

Aviation Week's Executive Editor, Commercial, Jens Flottau responds: Boeing's market share in terms of deliveries is currently zero because of the 737 MAX grounding. That will increase once the aircraft has been recertified and deliveries resume. Nevertheless, Airbus appears to have a long-term market share advantage—as the A320neo order backlog stands at 7,445 compared with just 4,610 for the MAX.

But even when the MAX returns to service, Airbus' advantage could continue to increase, given that demand has been shifting to the larger variants of the narrowbody families, where Airbus has enjoyed strong market success (A321neo, A321LR and A321XLR). Conversely, Boeing hopes that as a result of the coronavirus pandemic, airlines will focus in the near term on smaller narrowbodies, where the 737-8 has fared well against the A320neo.

Some analysts have contended that Boeing needs to launch a new narrowbody sooner rather than later—yet they also agree that the company cannot really afford to do so in the middle of the COVID-19 downturn. There are also questions about how quickly advanced technologies, particularly engines, that Boeing would need to move the needle will be ready. And now Boeing has to take into account new European plans to develop a hydrogen-powered aircraft for short- and medium-haul routes in the early to mid-2030s, which may change the competitive landscape yet again.

Will the Airbus A220 and Embraer E2 Continue To Compete Post-Pandemic?

Jens Flottau answers: Competition between the A220 and E2 is limited. In terms of size, the -100 version of the A220 sits somewhere between the 190-E2 and the 195-E2, depending on the cabin layout. With a maximum takeoff weight of 63 tons, however, the A220-100 is heavier than the 190-E2 (56.4 tons) and 195-E2 (61 tons) and offers a lot more range: 3,400 nm vs. 2,800 nm for the 190-E2, and 2,600 nm for the 195-E2. So the A220 and E2 really address different market segments.


RAPHAEL JOLICOEUR/AIRBUS


EMBRAER

Most of the A220 orders are for the larger -300 version, which addresses long, thin routes. Airlines pay a cost penalty when they use it on shorter routes. Airbus is working on versions of the aircraft that would extend its range to around 4,000 nm, allowing airlines to fly it across the Atlantic Ocean or deep into Latin America from the U.S. The A220 could also be stretched further to enter the market space covered by the Boeing 737-7 and -8.

It is true that some airlines are operating the A220 even though they do not need its range. In some cases, Airbus bundles A220s with sales of other models such as the A320neo. That is why Embraer had hoped its recently scuttled tie-up with Boeing would have allowed the E2 to be offered as part of a broader portfolio.

A key element in future competition will be Embraer's approach to pricing. The company so far has stuck with premium pricing compared with the E1 family, but that approach has not worked well in winning orders. Another challenge is bringing down supplier costs so that the E2 can still make decent profit margins despite lower volumes. The A220 has the same challenge but holds one key advantage: It is backed by a huge owner that has more leverage to make the program profitable.

The Aviation Week Network invites readers to submit questions to our editors. Answers are published online at AviationWeek.com. To access our answer archive or post a new question, go to: **AviationWeek.com/asktheeditors**

CLASSIFIED ADVERTISING

To Place Your Classified Ad Contact Steve Copley
440-320-8871
stephen.copley@aviationweek.com

ADVANCED COMPOSITE TRAINING

ABARIS TRAINING
www.abaris.com
ADVANCED COMPOSITE TRAINING & SERVICES

EVENTS

Mass Properties Virtual Tech Fair
June 22 - July 10, 2020

- Technical Presentations
- Training
- Standards Workshops

visit
www.sawe.org

EQUIPMENT

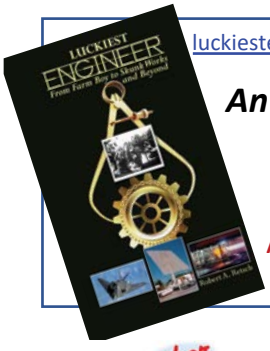
Matec Instrument Companies, Inc.

- Complete ultrasonic testing system integration
- Multi-axis gantries, immersion tanks, and specialty systems
- New construction and system modifications and upgrades
- C-scan and full waveform collection compatible
- Conventional and phased array ultrasonic inspection

Northborough, MA - Banning, CA
508-393-0155 | sales@matec.com | matec.com

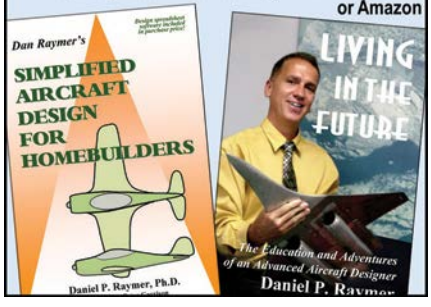
Set up a free account at our ad upload portal.
informa.sendmyad.com

BOOKS



luckiestengineerbook.com
An Aerospace Engineer's Memoir
Available in print and e-book

other
Dan Raymer's Books for Aircraft Designers
shop.btpubservices.com (800 247-6553)
or Amazon



WAYPOINT INTERIORS

UV LIGHTING SOLUTIONS
GERM FREE AIRLINE TRAVEL

- LONG TERM SOLUTION FOR COVID-19 AND FUTURE VIRAL THREATS!
- 99% + EFFECTIVE
- DISABLES VIRUS OR BACTERIA
- DISINFECTS SURFACES AND AIRBORNE GERMS
- NO HARSH CHEMICALS
- LATEST LED UV LIGHT TECHNOLOGY
- PERMENANTLY INSTALLED

ALWAYS WORKING, ALWAYS CLEANING!

SPECTRACLEAN™ Sanitation Solution

WAYPOINT INTERIORS

1-425 265-0070
www.waypointinteriors.com

Contact Us

President/Publisher: Gregory D. Hamilton;
+1 (212) 204-4368; hamilton@aviationweek.com

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:
Andrea Rossi Prudente (UK); +44 (207) 182 4524;
andrea.rossiprudente@aviationweek.co.uk

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

Ad Operations Specialist: Kara Walby;
(913) 967-7476; kara.walby@informa.com

Advertising/Marketing Services

Media Kits, Promotions or Custom Media:
www.aviationweek.com/mediakits or Elizabeth Sisk;
(860) 245-5632; elizabeth.sisk@aviationweek.com

Business and Finance Manager: Gabriel Balmes;
+44 (0) 7881-010660; gabriel.balmes@informa.com

Subscriber Service

U.S.: (800) 525-5003

Outside the U.S.: +1 (847) 763-9147

Manage Your Subscription (and Claim Digital Edition) at:
aviationweek.com/awstcustomers

Conferences/Exhibitions

www.aviationweek.com/events:

To Sponsor/Exhibit: Beth Eddy;
(561) 279-4646; betheddy@aviationexhibits.com

To Register: Virginia Gongora;
(212) 204-4202; virginia.gongora@aviationweek.com

AW&ST Mailing List Rental and Sales

Mary Ralicki: (212) 204-4284; mary.ralicki@informa.com

Reprints, Photocopies and Permissions

Custom Reprints: informa@wrightsmedia.com

Wright's Media, 2407 Timberloch Place, Suite B
The Woodlands, Texas 77380
Office: (281) 419-5725
Toll Free: (877) 652-5295
Cell: (713) 724-6987
Fax: (281) 419-5712
wrightsmedia.com/sites/aviation-week/contact.cfm

Social Media

Join the conversation. Follow us at:

linkedin.com/company/aviation-week
Twitter.com/AviationWeek
Facebook.com/AvWeek
YouTube.com/AviationWeek

Aviation Week & Space Technology is published biweekly, with one issue in August by Informa Markets, a trading division of Informa PLC, 22701 W 68TH TER STE 100 Shawnee KS 66226-3583. Member of Audit Bureau of Circulations and Magazine Publishers of America. Periodicals postage paid at Kansas City, MO and additional mailing offices. Canadian GST #R126431964. Title reg.® in U.S. Patent Office.

Postmaster: Send address changes to *Aviation Week & Space Technology*, Attention: Subscription Services, P.O. Box 1173, Skokie, IL 60076.

Aviation Week & Space Technology
JULY 13-26, 2020 VOL. 182, NO. 14
(ISSN 0005-2175)

Aerospace Calendar

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

July 15-Aug. 20—RTCA Plenary Sessions/Committee Meetings. Virtual or various locations (check website). See rtca.org/content/upcoming-committee-meetings

July 20-21—DoD Hypersonic Capabilities Symposium. Virtual event. See hypersonics.dsigroup.org

Aug. 1-6—Small Satellite Conference (SmallSat 2020): Space Mission Architectures. Virtual event. See smallsat.org

Aug. 4-5—vFuze (Next-Generation Fuzing for Next-Generation Weapons Systems). Virtual event. See ndia.org/events/2020/8/4/vfuze-2020

Aug. 4-6—Space and Missile Defense Symposium. Virtual event. See smdsymposium.org

Aug. 9-13—AAS/AIAA Astrodynamics Specialist Conference. Virtual event. See space-flight.org/docs/2020_summer/2020_summer.html

Aug. 12-13—Civil Avionics International Forum 2020. Chinese Society of Aeronautics and Astronautics. Shanghai. See galleon.eventbank.cn/event/9th-annual-civil-avionics-international-forum-2020-25450

Aug. 19-21—Space Warfighting Industry Forum (SWIF). U.S. Air Force Academy Arnold Hall. Colorado Springs. See ndia.org/events/2020/8/19/space-warfighting-industry-forum#

Aviation Week Network Events

+1 (800) 722-6344 or Events.AviationWeek.com

Aug. 5-6—CAPA Australia Pacific Aviation Summit 2020. Adelaide, Australia.

Aug. 11-13—Urban Air Mobility Virtual. Virtual event.

Aug. 25-26—Aerospace Manufacturing Conference. Charleston, South Carolina.

Sept. 1-3—MRO Americas. Dallas.

Sept. 2-3—Military Aviation Logistics & Maintenance Symposium (MALMS). Dallas.

Sept. 14-16—Commercial Aviation Industry Suppliers Conference-Europe. Toulouse.

Sept. 16-17—Aero-Engines Europe. Virtual event.

Sept. 22-24—MRO Asia-Pacific. Virtual event.

Sept. 23-24—Aero-Engines Asia-Pacific. Virtual event.

Oct. 8-10—Routes Asia 2020. Chiang Mai, Thailand.

Oct. 15-16—CAPA Americas Aviation & LCCs Summit. San Juan, Puerto Rico.

ADVERTISERS IN THIS ISSUE

VIEWPOINT

A Wake-Up Call on GPS

By **Daniel S. Goldin**

For the past nine months, I have worked with world-class experts to study a longstanding request from Ligado Networks to create a ground-based 5G network using L-band spectrum. We found that L-band paired with C-band will accelerate the deployment of U.S. 5G and help counter China's 5G ambitions without causing harmful interference to GPS. The testing record proves it and is further corroborated by the recent release of internal statements from Pentagon spectrum experts.

On April 20, the U.S. FCC announced approval of Ligado's application to use the L-band spectrum between 1 and 2 GHz for a terrestrial 5G network providing cellular and internet-of-things data services. But Pentagon GPS advocates have enlisted the help of the Senate and House Armed Services committees to include amendments to the fiscal 2021 defense authorization bills that would empower the Defense Department to undermine the FCC's unanimous, bipartisan decision on Ligado. If the respective Commerce committees do not assert jurisdiction over the FCC and blunt these amendments, this overt power move by the Pentagon could be complete.

While military bureaucracy claims it is committed to protecting GPS, it has neglected serious risks for decades. Excessive cost, timeline overruns and improperly filtered GPS receivers are tolerated, while the Pentagon maligns Ligado's harmless 9.8-watt signal (a power level set by the FAA with a huge 23 MHz guard band) as a grave risk. Ironically, the Pentagon's preoccupation with Ligado may be what finally brings proper attention to GPS mismanagement. The truth is the system has been vulnerable for a long time, endangering the troops who depend upon it. Congress has attempted to hold the Defense Department and the Position, Navigation, and Timing (PNT) community accountable, but GPS stakeholders have resisted. How bad is it? Consider:

■ In 1996, then-Vice President Al Gore announced a plan to modernize GPS. In 1997, the Defense Department began developing a jam-resistant military satellite signal called M-Code, with the support of Congress and the president. After 23 years, the program is still 15 years from completion.

■ President Donald Trump's fiscal 2020 budget directs the Pentagon to transition approximately one million military GPS receivers to M-Code military receivers, but this will not occur until 2035 at the earliest—the one million M-Code chips necessary have not been made yet.

■ There are now 24 M-Code-capable satellites on orbit but no compatible receivers. Further, eight of 24 M-Code satellites have been in orbit for 11-15 years, well beyond their 7.5-year design life. Some will fail or be retired before they are ever used for military operations.

Meanwhile, China started deployment of BeiDou-3 satellites in 2015 and has launched 30 satellites in five years, enabling worldwide operations in June. GPS embarked on its phase 3 program in 1997, launched three GPS III satellites and hopes to complete the program by 2034.

A 40-year span from problem identification to problem solution is unacceptable and requires an examination of the legacy power structures behind such mismanagement. The PNT Advisory Board is composed of seasoned members of the GPS community serving before and after the senior U.S. leaders they advise come and go. What is the purpose of an advisory board with such continuity if not to help decision-makers avoid the negligence described above?

Decision-makers deserve complete information. The Pentagon's top leaders put the country first without regard for bureaucratic agendas. However, their advisors on PNT/GPS have provided them with incomplete information, claiming Ligado is a problem and GPS is not, when the opposite is true. In my 58 years working on science, technology and U.S. national security, I have never seen an issue of such importance so beset by misinformation as the Ligado case—nor have I seen such complacency in a program as vitally important as GPS.

I HAVE NEVER SEEN AN ISSUE OF SUCH IMPORTANCE SO BESET BY MISINFORMATION AS THE LIGADO CASE.

Such challenges will define how we as a nation respond to the increasingly common technology and national security decisions ahead. Either we will grind to a near-halt debating facts to advance internal agendas, or we will make evidence-based policy decisions to counter formidable threats to our national security and economy. I have confidence that the leaders of the Defense Department and our Armed Services committees—when presented with whole information on critical issues like Ligado, 5G and GPS—will discern the best way forward to protect our nation.

Daniel S. Goldin is an engineer who served as NASA administrator under three U.S. presidents from 1992 to 2001. He has no financial affiliation with Ligado Networks.

Digital Extra *For more detail, read Goldin's in-depth analysis at:* **AviationWeek.com/GPSFix**

U.S. GOVERNMENT

第13届中国航展
AIRSHOW CHINA
2020.11.10-15 ZHUHAI·CHINA

第十三届
中國國際航空航天博覽會
The 13th China International Aviation & Aerospace Exhibition

引领亚洲巨大的航空市场
LEADING TO THE LARGEST AEROSPACE MARKET IN ASIA

珠海航展有限公司
ZHUHAI AIRSHOW CO., LTD.
WWW.AIRSHOW.COM.CN

EXHIBITION
Mr. Jimmy Sum
Tel:+86-756-337-6304
Email:jimmysum@airshow.com.cn

TRADE VISITOR & AIRCRAFT EXHIBITION
Mr. Aaron Huang
Tel:+86-756-337-6111
Email: aaron@airshow.com.cn

LOCKHEED MARTIN

The choice between solving today's problems or solving them for decades to come.

Lockheed Martin integrates game-changing X2 Technology™ with a state-of-the-art open mission system to give you the edge. Because we know you need enhanced capabilities to stay ahead of adversaries' evolving threats. Expand your reach, survivability and lethality...at the speed of relevancy. Your only choice that provides growth for the next 40-plus years.
lockheedmartin.com/fvl

Lockheed Martin. Your Mission is Ours.®