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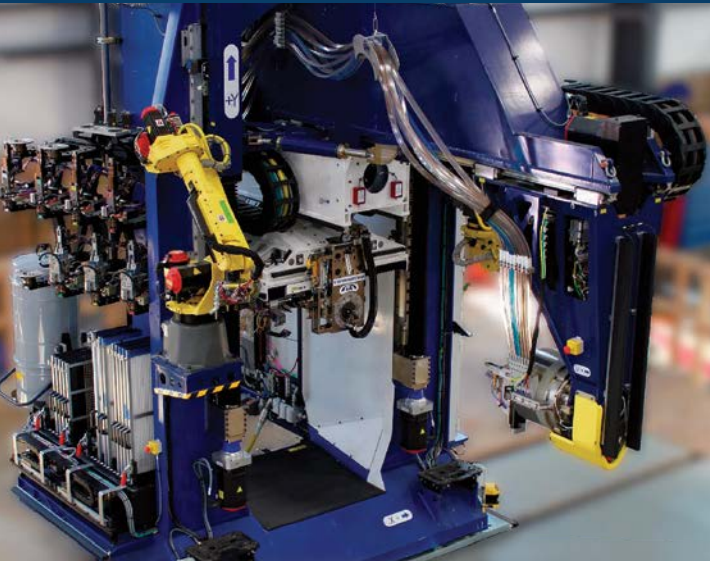
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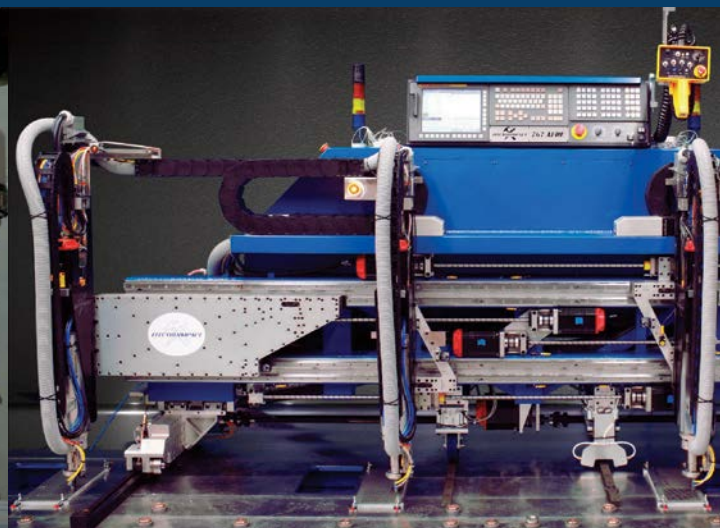
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ON THE COVER

Nine years after the last U.S. human orbital spaceflight, SpaceX is poised to launch NASA astronauts Robert Behnken, rear, and Douglas Hurley, front, to test its new Crew Dragon spacecraft. The astronauts suited up in March to participate in a full simulation of launch and docking with flight controllers in Houston and SpaceX headquarters in Hawthorne, California. SpaceX photo. Aviation Week publishes a digital edition every week. Read it at AviationWeek.com/AWST



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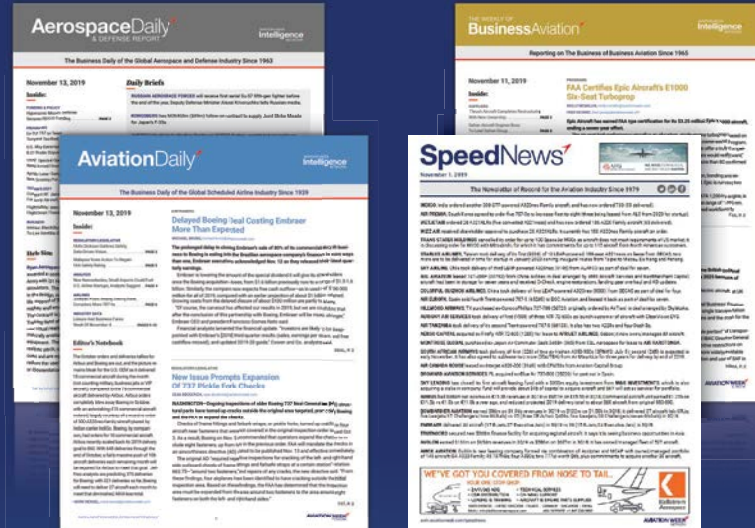
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'HAVE YOU SEEN MY MAGAZINE?'

My dad, James E. Hannigan, who passed away in January, was a long-time subscriber to *Aviation Week & Space Technology*. For decades, I can remember seeing copies of *AW&ST* in the house. He also had a long career in aviation and space technology: Starting out as a flight-test engineer for Boeing, Lockheed and the U.S. Air Force; moving to NASA, where he ran the Lunar Module Branch during Apollo; and retiring from various NASA contractors that worked on the space shuttle.

NASA



James Hannigan, at left in back row.

Although in later years he developed dementia, and slowly his interests and abilities dwindled to where he would only sit in his chair all day long, doing nothing (or napping), he never lost interest in his *AW&ST* magazine. He would thumb through the magazine until the very end. We don't know how much he understood, but he always asked, "Have you seen my *Aviation Week* magazine?" And it was always there for him.

Thomas Hannigan, Silver Spring, Maryland

FARA TOO COMPLEX

As I gaze at the Future Attack Reconnaissance Aircraft (FARA) contender renderings in "Boeing Reveals Long-Awaited FARA Design" (*March 9-22, p. 26*), I'm taken back to my first day on the job as an 18-year-old private in an Army Reserve Medevac unit, when I was handed a grease gun and ordered to lube a UH-1 Huey sitting nearby. I came to appreciate the phrase "a helicopter is 10,000 spare parts flying in close formation."

Of all the FARA proposals, only one has two moving rotors: the Bell Invictus. The AVX CCH? Four. The Sikorsky Raider and Boeing? Three. The Karem AR40's tailrotor has a rota-

tion mechanism to allow it to become a propulsor, so three as well. Bonus? Bell is testing an electric distributed tailrotor system—even fewer moving parts.

I predict the Bell will come in as the FARA price leader.

Jason Wooden, Mendon, Utah

REVISING ROCKETS

I read with much interest Irene Klotz's "Price of Reusability" (*April 7-20, p. MRO32*). I was corporate director of advanced concepts for McDonnell Douglas when we built and flew the Delta Clipper in 1993, the first rocket to take off and land vertically. After the DC-XA program was ended because of a landing gear problems I felt there was a way to improve on this approach by doing the following;

- Eliminate the need for the landing gear by hooking and latching on a padded recovery line sliding up the side of the rocket strung between two towers.
- Minimize fuel/oxidizer use especially for a second-stage rocket by using the rocket body as a low-density decelerator by bringing the rocket down rotating about a lateral axis and perpendicular to the direction of travel.
- Minimize heating by performing multiple rebound maneuvers off the atmosphere to cool in space before coming back in and rapidly turning down to thick air to decelerate.
- Keep the crew compartment attached to the rocket to reduce refurbishment and make it easier to use the rocket fuselage as a low-density decelerator.
- Allow a large center of gravity range using small control fins by rotating the rocket, preferably about a lateral axis.
- Enable the crew compartment to rapidly separate from the rocket.

It wouldn't take that much to modify either SpaceX or ULA rockets and spacecraft to use this approach.

Randy McDonnell, Las Vegas

'CHOOSE WISELY'

I have retired after 50+ years in advanced propulsion projects at GE and Aerojet. My professional tag line is "Better Is Always Different,

Different Is Not Always Better; Choose Wisely." The hyscram engine concept described in "Hyper Cycle" (*April 6-19, p. 44*) is proof that you must choose wisely.

I could write a book on the flaws and misconceptions in this concept, but I will just hit the two most egregious: **Turbomachinery operating up to Mach 8.** The stagnation inlet air temperature at Mach 8 is over 5,000F, which exceeds the rotating material limits even when not rotating. The magnetic bearings would fail at a far lower temperature. Cooling the superconducting rotating elements is not possible because no suitable low-temperature heat sink is available.

This is why cocooning was invented. When compressor stages are turned off, the air passing through will wind-mill the blades, absorbing power and reducing the airstream total pressure. In most propeller aircraft, the blades are feathered when the engine is turned off to reduce air drag of a wind-milling prop.

Magnetohydrodynamic (MHD)

augmenter. In this concept, the air passing through the superconducting power turbine has power extracted, which then powers the augmenter. The turbine is at most 70% efficient and the MHD accelerator much less. Even if both are 100% efficient, diverting energy from a low-energy stream to a high-energy stream will reduce thrust.

Mel Bulman, Fair Oaks, California

CORRECTIONS

"Sprawling Alaska Complex Becomes Newest Home for F-35" (*April 20-May 3, p. 46*), should have stated that Eielson AFB has one of the world's largest runways.

"COVID-19 Complicated T901 Milestone as FARA Awaits New Engine Design" (*April 20-May 3, p. 40*) should have stated that a critical design review milestone for the GE Aviation T901 turboshaft engine originally scheduled in the third quarter now could slip into the fourth quarter.

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.

The Universities Space Research Association has named **Margaret Meixner** director of mission operations for the Stratospheric Observatory For Infrared Astronomy (SOFIA), NASA's major airborne astronomical observatory. SOFIA staff also will team with the Deutsches SOFIA Institute to boost productivity and prepare for the James Webb Space Telescope's entry into service.



Acro Aircraft Seating has hired **Neil Cairns** as CEO. Cairns has experience in all seating classes and a track record of lean-process and performance improvement.



He had been Collins Aerospace vice president and general manager and previously ran the B/E Aerospace seating facility in Kilkeel, Northern Ireland.

Ann Ackerson has been hired as *BAE Systems'* chief procurement officer and named to the senior leadership team and to chair its global procurement council.

Ackerson had held executive positions at Freeman and Dresser-Rand. She succeeds Paul Smith.

Draken International has elected **Joseph Ford** as CEO and board member. Ford was president at DynAviation. He succeeds founder and CEO **Jared Isaacman**, who will become the nonexecutive board chairman.

Woodward Inc. has reappointed **Robert F. Weber, Jr.**, as vice chairman and added the role of chief financial officer, in response to ongoing economic uncertainties due to the COVID-19 pandemic. He succeeds Jonathan W. Thayer, who has left the role of chief financial officer.

Astroscale, an early startup in the satellite-debris-removal market, has hired **Dave Fischer** as U.S. vice president of business development and advanced systems and **David Hebert** as U.S. communications director. Fischer had led business development for RUAG Space USA and held several roles with Ball Aerospace. Hebert was The Aerospace Corp. senior communications strategist and government liaison.

Summit Aviation has hired U.S. Army Master Sgt. (ret.) **Frank Reuter** as director of maintenance. Reuter was AAR Lift maintenance and engineering vice president, lead rotary wing mechanic for Black Water Aviation, Melbourne, Florida, and Presidential Airways senior maintenance manager. He succeeds John Bonnell, who is retiring.



Duncan Aviation has promoted **Pete Marte** to manager of the White Plains, New York, and Oxford, Connecticut, satellite avionics shops and **Aaron Jensen** to manager of the Seattle satellite avionics shop, from supervisor. Duncan plans to launch an aircraft interior disinfecting capability soon.



Aeronautics Group has promoted **Matan Perry (Perez)** to vice president of marketing and business development from director. His military experience with a wide variety of UAV platform types has served clients building UAV squadrons within their own territory.

Richard Goglia has been named an independent director for *Triumph Group*. A former Raytheon treasurer, Goglia will join the audit and finance committees.

CDB Aviation, a wholly owned Irish subsidiary of China Development Bank Financial Leasing, has hired **Jorge Garcia** as senior vice president for commercial and **Alan Mangels** as vice president for commercial, both in the Americas. Garcia was AerCap leasing vice president. Mangels was Rolls-Royce vice president of business aviation sales and marketing.

Spaceflight launch services has hired **Dennis Wiessner** as general counsel. He was vice president/general counsel of Sea Launch when it was an international joint venture of Boeing. He also worked for the Lockheed Martin spinoff Astrolink, was vice president, general counsel and corporate secretary for Italy-based Leonardo Helicopter's Philadelphia subsidiary, and held a similar role at France-based Thales Group's California avionics business unit. ☼



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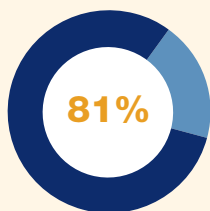
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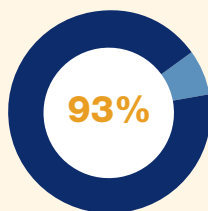
At SpeedNews' **21st Annual Commercial Aviation Industry Suppliers Conference - Europe**, aircraft and engine manufacturers will present status reports on their programs. Industry experts will offer delivery and retirement forecasts, and review the current economic status of the industry. Maintenance and subcontractor issues will also be addressed.

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FIRST TAKE

COMMERCIAL AVIATION

Boeing is to cut its workforce by 10%—15% in commercial aircraft and global services—and cut airliner production rates in response to the COVID-19 crisis. Airbus cut its production rates by a third in April and is focusing on preserving cash (page 20).

Embraer has launched arbitration against Boeing, accusing the U.S. giant of wrongfully terminating an agreement to form a commercial aircraft joint venture. Boeing canceled the deal on April 25, worth \$4.2 billion to Embraer, citing a failure to resolve critical conditions (page 20).

Airbus and Rolls-Royce have terminated the E-Fan X hybrid-electric propulsion demonstrator as they scale back research and development activities in response to the COVID-19 coronavirus pandemic.

The European Commission plans to finalize social distancing and sanitation guidelines for aviation by mid-May, paving the way for flights to resume in a unified way.

The UK government has approved trials using a fixed-wing unmanned aircraft to fly medical supplies from the mainland to the Isle of Wight.

Aerion has selected Melbourne, Florida,

as the location for a \$300 million development, production and support facility for the AS2 supersonic business jet.

China's EHang has partnered with the city of Hezhou in Guangxi province to build the first dedicated vertiport for its electric vertical-takeoff-and-landing air taxis.

Zipline drones are delivering COVID-19 test samples collected from rural clinics in Ghana to laboratories in the capital, Accra, and Kumasi, the country's second-largest city.

DEFENSE

A German order for Boeing Super Hornets could lead to "massive, lasting harm," to the country's defense industry, Airbus warns. Germany also proposes buying 93 Eurofighters (page 50).

The first of three Saab GlobalEye swing-role surveillance platforms was delivered to the United Arab Emirates air force at Al-Dhafra airbase near Abu Dhabi on April 29.

The U.S. Missile Defense Agency is seeking bids for an \$11 billion effort to develop a new generation of national missile defense interceptors. It plans to award two contracts.

Three companies have received the U.S. Air Force's second draft solicitation for a contract to supply 608 new turbo-

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Aviation Week Network Wins Three Neal Awards

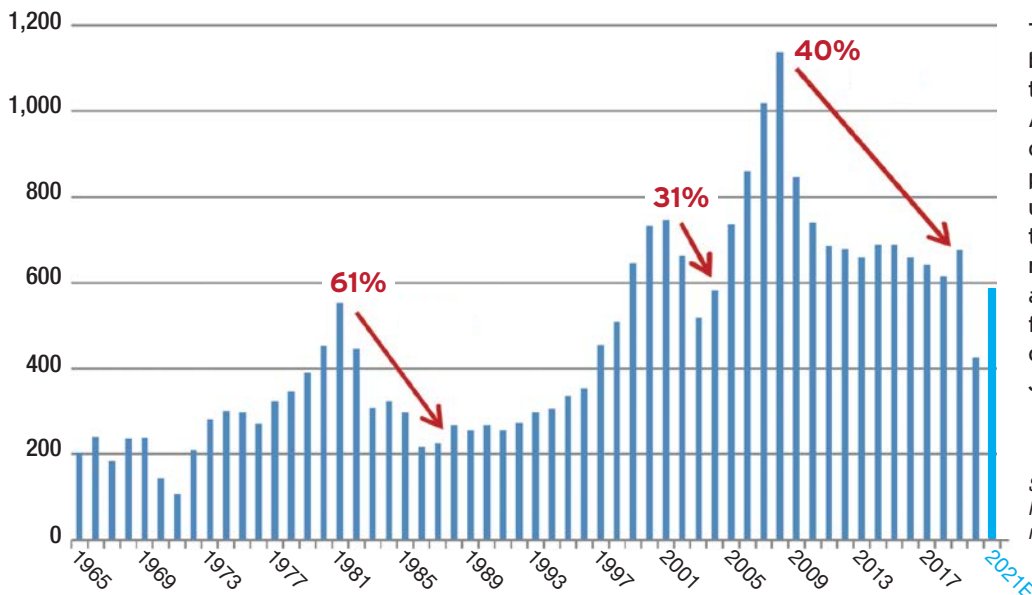
The Aviation Week Network has won three Jesse H. Neal Awards, the business-to-business equivalent of the Pulitzer Prize. The Neal judges awarded a Best News Coverage honor to Air Transport and Safety Editor Sean Broderick and his colleagues on the editorial and data teams for their coverage of the Boeing 737 MAX saga in *Aviation Week & Space Technology*, *Aviation Daily* and on the Check 6 podcast. And Neal Awards for Best Instructional Content and Best Technical Content went to *Business & Commercial Aviation* writers Fred George, James Albright, David Esler and Patrick Veillette. The winners were announced on April 17.

fan engines for the Boeing B-52H fleet.

Kazan Aviation Plant has handed over the first two midlife-upgrade Tu-160M bombers for state trials ahead of a scheduled entry into service in 2021.

The Russian government has commissioned the Mikoyan and Sukhoi design bureaus to study aerodynamics for a new lightweight fighter, says the RIA Novosti news agency.

Global Recession and the Risk to Business Aviation



The current downcycle for business jets continues to be the worst since the 1980s. And given the strong historical correlation between corporate profits and aircraft deliveries—underlined by the declines after the 1981 and 2001 economic recessions—COVID-19 presents a great risk in the foreseeable future, with expected profit decline and reduced wealth, say JP Morgan analysts.

Sources: Teal Group, The General Aviation Manufacturers Association, company reports and JP Morgan estimates

The U.S. Air Force has selected Raytheon Technologies for the \$4.5 billion Long-Range Standoff cruise missile program two years early, closing down Lockheed Martin's rival effort (page 46).

SPACE

It is unlikely the heavy-lift launch market can support more than two U.S. providers in the long term, concludes a long-awaited RAND report for the U.S. Air Force. Blue Origin, Northrop Grumman, SpaceX and United Launch Alliance are competing for two contracts for space launches in 2022-2027.

Iran's Qased three-stage launch vehicle placed the Nour 1 satellite into a 425-km (264-mi.) orbit on April 22, but U.S. Space Command assesses its intelligence-gathering capability as minimal.

Russia's S7 Group has shelved its Sea Launch space program until market conditions improve.

Premature shutdown of one of nine Merlin engines on a SpaceX Falcon 9 launch in March was caused by cleaning fluid trapped inside a sensor igniting (page 14).

The U.S. Defense Department has objected to a Federal Communications Commission decision to grant Ligado Networks a slice of spectrum adjacent to GPS (page 54).

A Falcon 9 lifted off from Kennedy Space Center on April 22 to deliver a sixth batch of SpaceX's Starlink communications satellites into low Earth orbit (page 14).

OBITUARIES

Former NASA Administrator **James M. Beggs** died April 23 in Bethesda, Maryland. He was 94. During his tenure as administrator in 1981-85, Beggs oversaw the early era of the space shuttle program. A former U.S. Navy submariner, Beggs served as NASA associate administrator in 1968-69, after which he moved to the Transportation Department where he was an advocate for supersonic air transportation in 1969-73. "Mr. Beggs led the agency during the earliest days of the space shuttle program and helped us open a whole new era of exploration," says NASA Administrator Jim Bridenstine.

VIEW FROM WASHINGTON

Two Is Company in Defense Launch

The heavy-lift launch market is unlikely to support more than two U.S. launch providers in the long term, according to a long-awaited RAND report commissioned by the U.S. Air Force.

Highlighting the short-term schedule risks of transitioning to new providers, the study supports the National Security Space Launch (NSSL) strategy of continuing to deliver tailored support to three launch operators through 2023 while transitioning to two providers for the long term.

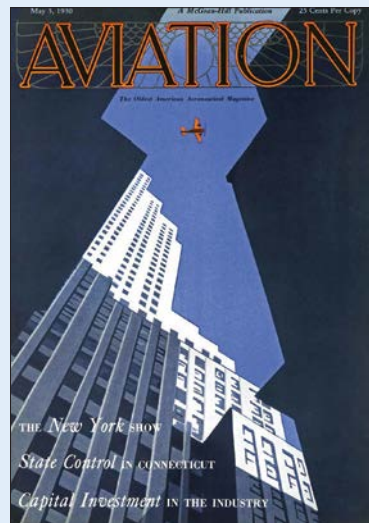
The U.S. Space Force plans to award a pair of contracts this year for the second phase of NSSL, with Blue Origin, Northrop Grumman, SpaceX and United Launch Alliance competing to provide launches in 2022-27.

RAND's assessment shows supporting more than two launch providers would decrease each vendor's launch tempo, lowering reliability and increasing costs. However, the Air Force is under pressure to support three launch providers.

The report recommends the Space Force prepare for only two U.S. providers of heavy-lift launch, one of which may have little support from the commercial market. The Space Force likely will support three providers through 2023, but that does not mean selecting three companies for NSSL Phase 2, cautions RAND.

90 YEARS AGO IN AVIATION WEEK

The aviation industry put on a brave face as the pain of the Great Depression deepened in 1930. Our May 3 issue previewed the upcoming New York Aircraft Salon, a showcase event for the world's largest city. The eight-day exhibition required a remodeling of Madison Square Garden to make room for 50 airplanes—some hung from the ceiling—and a wide array of engines and accessories. A star of the show was the "mammoth" four-engine Fokker F-32, which could carry 30 passengers. Other aircraft on display included the Consolidated Commodore flying boat, a Boeing fighter "fully equipped with guns" and the Lockheed Sirius that Col. Charles Lindbergh and his wife, Anne, had flown just two weeks earlier to set a new coast-to-coast speed record. But several of the ads in the magazine reflected the tough economic times. Fokker and partner General Motors announced



they were reducing aircraft prices between \$4,000 and \$13,000, respectively, while the Ford Motor Co. touted a nearly 10% cut for its 14-passenger, all-metal 5-AT transport, lowering the price tag to \$50,000.

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UP FRONT

RICHARD ABOULAFIA



THE NOT-SO-UNEXPECTED END

of the Boeing-Embraer jetliner joint venture undoes years of planning by both parties. It also raises many questions about the future of the 70-120-seat market. But before those questions are settled, there will clearly be winners and losers as a result of this development:

Losers: Embraer's jetliner business. With Airbus' acquisition of Bombardier's C Series, Embraer went from competing with a peer small airframer to competing with a giant one. It will be hard for Embraer to pressure its suppliers when the volume it offers is a tiny fraction of Airbus', a problem that the Boeing joint venture would have rectified. So E190/195E-2 costs will remain high relative to the A220, resulting in lost profit, market share or both.

Winner: Airbus. The 100-130-seat market segment is growing and likely to do well in the aftermath of the COVID-19 crisis as airlines look for jets that allow them to keep their networks intact with less total ca-

Winner/Loser: Boeing. The news here is mixed. Leaving Airbus with a market segment it cannot address (100-130 seats) is certainly not a welcome outcome. And Embraer would have been a fantastic source of engineers and flight-test resources for Boeing's next jetliner. Across the board, Embraer would be a natural partner for Boeing in adjacent markets and in future product development.

On the other hand, Boeing may not design a new clean-sheet jetliner for many years. A tie-up with Mitsubishi could be a nice consolation prize. If it does wind up requesting U.S. government financial assistance in the coming months, Boeing would not need to worry about explaining why it just spent \$4.2 billion acquiring a foreign business. Most of all, Boeing can walk away from the joint venture with more than \$4 billion in liquidity to add to its beleaguered balance sheet.

None of these manufacturer outcomes is certain. There are simply too many outstanding variables. How quickly can Embraer recover and reconfigure itself, since it had reorganized in preparation for the joint venture? Will it attract Brazilian government

EMBRAER



capacity. Airbus will have a much stronger position here for the same reasons that Embraer is now weaker: It no longer has to worry about a direct competitor with the same level of supply chain muscle and, therefore, cost control. The A220's market share will only grow.

Winner: Mitsubishi. The E175 remains the most popular regional jet on the market today, and with Boeing's help it would have increased its market share against the only other regional jet family with a modern engine, the SpaceJet (formerly the MRJ). Keeping Embraer as a relatively small airframer gives Mitsubishi a better shot at growing its market share. The SpaceJet is unlikely to grab the top position, but it is now in a much better place.

The end of Embraer/Boeing also may free Boeing to work with Mitsubishi on product support. Collaborating with Boeing on SpaceJet product support was Mitsubishi's original plan, but this was thrown into disarray by the announcement of Boeing's Embraer joint venture. In fact, Mitsubishi's backup SpaceJet support plan, acquisition of Bombardier's CRJ business for its service network, is not going to close until the second half of 2020. Conceivably, Mitsubishi could find a way out of that deal if it can reach an agreement with Boeing in time.

Industry Chaos

Winners and losers in the Embraer-Boeing breakup

support due to the COVID-19 aviation market collapse? Will it find the resources needed to pursue its new turboprop concept on its own? Will the KC-390 military transport joint venture between Embraer and Boeing survive? It is a completely separate joint venture that Boeing says it wants to continue, but it might be hit by fallout from the inevitable acrimony following the jetliner joint venture collapse.

There also are the questions of Mitsubishi's plans to acquire a SpaceJet product support apparatus and its parent company's tolerance for ongoing cost overruns and seemingly interminable program delays.

The biggest outstanding variable is the ultimate position of Embraer. The bitterness emerging with the joint venture's dissolution implies that a connection with Boeing is unlikely, but it still remains the most sensible outcome. No level of government support can change the fact that it is the only small jetliner prime in an industry filled with giants. Will China finally admit that the ARJ21 is a failure and move to acquire Embraer? Will it be allowed to do so? Are there any other partners or purchasers for Embraer's jetliner unit?

The end of this joint venture means that for smaller jetliners, market chaos will be accompanied by industry chaos. That is not a welcome development. ☹

Contributing columnist Richard Aboulafia is vice president of analysis at Teal Group. He is based in Washington.

GOING CONCERNS

MICHAEL BRUNO



COMPANIES HAVE GOOD QUARTERS

and bad quarters, but rarely does a whole industry sound like it just got sucker-punched. That's what the next few weeks will be like in the aerospace and defense sector, and for sure there will be headlines describing industrial carnage as the industry gasps for air and works to recover after COVID-19.

The truth is the aerospace and defense (A&D) supply chain suddenly is far too large for what is needed, maybe by a quarter or a third of excess capacity. As a result, quick or methodical cutbacks in manufacturing and services are expected throughout the syndicates that make airliners, business jets and other aircraft. As public companies report their latest quarterly financial results in late April and May, they will have to address the year ahead and offer insight into their response plans.

Unfortunately, business as usual prior to COVID-19 is not expected until 2022 or later, according to numerous analysts and advisors. And that is just too long to carry extra financial costs, which means all levels will feel pain.

"People who didn't plan for it were unreasonably naive," asserts Avitas consultant Adam Pilarski, a longtime expert who espoused a bearish view on commercial aviation long before the Boeing 737 MAX crisis started gumming up business models. "There is no magic potion here. You will have less production."

While Pilarski's comment may come across as harsh, it accurately describes the depth of the coming paradigm shift for commercial aviation. Yes, perhaps it was too much to have asked OEMs and suppliers to model for a 95% collapse in passenger air traffic and two-thirds of large commercial aircraft fleets getting parked—including brand-new deliveries. But practically no one seemed to imagine simultaneous cuts to new orders, standing backlogs

and aftermarket revenue streams. Indeed, Pilarski was one of the few who envisioned an environment with much less than the traditional 5% annual growth in air traffic.

That is now changing: Airbus has revealed narrow-body and widebody production rate cuts of about a third, and Boeing is expected to follow suit any day.

According to Credit Suisse analysts, such sudden rate changes will have a materially negative impact on the supply chain because the effect is exponential. "[The supply chain] will need to cut production by much more as Airbus consumes its inventories—for instance, potentially going to rate 20 on the A320 for some months and ramping up again to 40," the analysts say. Boeing's inventory—including roughly 800 MAXs that are backed up with its customers and supplier Spirit AeroSystems and are waiting to join its own fleets—is worse.

Here are three factors to watch for in earnings reports to discern how the supply chains will change.

First, how much U.S. government aid will compa-

A&D Revenue Exposure by Market

Company	Percent of 2019 Revenues by Market			
	Aerospace Original Equipment	Aerospace Aftermarket	Defense/Space	Other Government
AAR	2%	66%	33%	0%
Aerojet Rocketdyne	0	0	100	0
AeroVironment	0	0	79	0
Astronics	43	36	18	2
CPI Aero	20	5	75	0
Crane Co.	11	5	9	0
Cubic Corp.	0	0	43	57
DLH Corp.	0	0	45	55
Ducommun	42	6	45	0
HEICO	4	49	34	0
Hexcel	68	0	20	0
Kratos Defense & Security	0	0	100	0
Mercury Systems	0	0	100	0
RADA Electronic Industries	0	0	100	0
Spirit AeroSystems	88	5	7	0
The Boeing Co.	52	11	37	0
TransDigm Group	26	32	37	0
Triumph Group	60	18	20	0

Notes: Aerospace original equipment and aerospace aftermarket include all commercial transport and business jet exposure. Defense and space includes both original equipment and aftermarket sales.

Sources: Company Reports, Canaccord Genuity estimates

nies receive? This is a significant variable, and as of mid-April, we still did not know how much even sector leader Boeing will receive (presuming it does).

The Future With COVID-19

Three watchpoints for change in A&D supply chains

growth, record mergers and acquisitions, and record private equity involvement have dramatically consolidated industry (for better or worse). Yes, it meant elimination of countless companies, and some smaller survivors remain stressed by technology investments and meager working capital accounts. But top-tier companies have been working to eliminate chokepoints and shore up weak links in their supply chains for the last few years, ironically as they sought to raise rates.

Finally, many companies became less susceptible one way or another, especially through revenue diversification (see table). Will this lead to resilience? Some say yes. "In many ways, the supply chain is now more mature, diversified and well-positioned to handle this economic downturn versus in 2001 and 2008," says Alex Krutz, managing director at Patriot Industrial Partners, an advisory firm focused on operations and supply chain. "A large number of suppliers over this last decade have taken significant steps to ensure their long-term success." 📌

INSIDE BUSINESS AVIATION

WILLIAM GARVEY



HERE'S A GAME EVERYBODY PLAYS but no one knows the ending for, oh, 25 years or more: "Guess What They'll Become and Do."

As a father, friend and neighbor, I've played that game for decades. I well remember the day I was introduced as the new assistant coach of my young son's Little League team. I studied all those tykes' eager faces looking up at me expectantly and thought, "Where will life take each of you?" The season that followed was unremarkable—a fair reflection of my baseball coaching contributions—but now, decades later, I have some answers to my question. They became a banker, songwriter, investigator, choir director and soldier, among other diverse careers. Each one a surprise. And the game continues.

Over the years, I got to see one of those kids' faces quite a lot because Matt Lambton became my son's best friend. They were inseparable and essentially lived in each other's houses. As a result, our families grew quite friendly and familiar. It turned out that Matt had a brother, Michael, a really good kid. But he was a couple of years Matt's junior, which among grade schoolers counted as a full generation behind. As such, he never became a regular visitor to our place. But thanks to our family ties, we were aware of his doings as he advanced through childhood and adolescence. However, once our kids were grown and gone, we moved to another state and lost touch.

Fast forward to the 2017 National Business Aviation Association (NBAA) Regional Forum at Westchester County Airport. Matt Greene, then head of marketing (now president) at nearby Safe Flight Instrument Corp., is walking past me with several young men in tow. He sees me, stops and says he'd like to reconnect me with one of his new charges. I turn, curious, and there stands Michael, smiling. I learned that he was graduating from Rensselaer Polytechnic Institute with a mechanical engineering degree and that, thanks to another former neighbor, he was interning at Safe Flight. He started working at the company full-time a few months later. So, to my quiet satisfaction, the former kid from up the street became an aviation colleague.

During the 2018 NBAA convention, I encountered Michael again at Safe Flight's exhibit. He was there to demonstrate a synthetic clutch servo—think digital autothrottle with tactile stops—that he had helped invent. His name was on a patent, I learned, for the sec-

ond time since joining the company. And just recently, his work came to my attention again.

To help ease the urgent shortage of personal protective equipment, Safe Flight started making face shields for emergency room personnel on the front lines of the battle with COVID-19. But Chairman/CEO Randy Greene asked his managers if there was something more they could do. When Michael's manager posed him that same question, he called his brother, Dr. Matthew Lambton, the former Little Leaguer turned emergency room physician at a Rhode Island hospital, who was very much in the thick of it. Michael's question: Is there something more we can provide? "Ohhh, yeah!" was Matt's instant response. More ventilators.

And so the young aircraft systems engineer began researching medical technology and came to learn that, in extreme situations, ventilators could be divided or "split" for air/oxygen delivery to multiple patients. At his brother's request, Matt overnighted ventilator parts for sizing and Michael came up with a splitter design that would enable a single ventilator to service one, two,

three or four patients simultaneously. A team formed quickly to devise a production process using Safe Flight's 3D printer and to ensure quality fabrication and material traceability. Once fast-track-approved by the feds, the company planned to begin shipping devices immediately and hoped licensees would do the same in quantity.

It is said that crisis speeds ingenuity. The elapsed time from Greene's request for "something more" to product selection and the Quad/Vent Splitter's final design was roughly 1.5 days.

And here's the thing, Safe Flight is just one of many business aviation companies stepping into the breach. Piper, Textron Aviation, FlightSafety, Cirrus, Dassault, Gulfstream, NetJets, CAE, Avfuel, Duncan, Tecnam, VistaJet, PlaneSense and Universal Avionics are among the many within the community investing their time, talent, equipment and capital to help fight the pandemic even as the crisis wreaks havoc to bottom lines and shreds payrolls. We salute and thank them all.

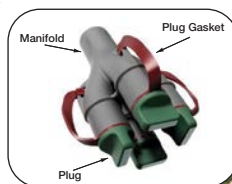
So I've got answers to the "Guess what . . . ?" question as applied to the Lambton brothers and those like them.

What will they become? Heroes. What will they do? Use their skills, intelligence and focus to save the world, one person at a time. ☛

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

Brothers in the Fight

Lifesaving four-way split



Michael (left) and Matthew Lambton.

LESLEY LAMBTON, INSERT: SAFE FLIGHT

AIRLINE INTEL

JENS FLOTTAU



CHRISTIAN SCHERER, AIRBUS CHIEF commercial officer, spoke with Aviation Week recently about the role of lessors.

He was full of praise: “It is a real quid pro quo for manufacturers in a crisis. In bad times, lessors can pay back. They are a financial shock absorber for OEMs.” In past crises, lessors absorbed the shocks to the industry by continuing to take delivery of aircraft on order when airlines had long been canceling their commitments. That was particularly the case in the aftermath of the 9/11 attacks, which happens to be the one crisis that is generally referred to as having the most similarities to the novel coronavirus pandemic the industry is experiencing right now.

Of course, Scherer’s comments predate the full-scale impact that COVID-19 has had on aviation. And a few weeks into the timeline it is becoming clear that for lessors, 9/11 and COVID-19 are actually not similar at all. In other words, lessors are not the “shock absorber” they once were.

There is a relatively simple reason for this: The business model of leasing aircraft to airlines is based on the assumption that not all airlines will suffer at the same time. If one airline in a specific region is going through a rough period, aircraft can go to an operator in another region. That is what has made the aviation industry so attractive for investors. Unlike real estate, aircraft can be moved from one place to another and are generally in high demand—unless they have four engines.

That model is not viable in the situation the industry is currently experiencing, one where all customers suffer simultaneously. Suddenly aircraft can no longer be moved around. As a result of the pandemic, lessors are now behaving in the same way that airlines did nearly 20 years ago, deferring or canceling orders wherever they feel they must and have the opportunity to do so.

Due to the fact that not all deals and new agreements in the industry are in the public domain yet, any judgment about trends has to be made with caution. Nonetheless, it is striking that the Boeing 737 MAX appears to be particularly vulnerable: Avolon canceled commitments for 75 aircraft; GECAS removed 69 from its orderbook, even though that also means fewer CFM International engines will be built; CDB Aviation scrapped 29 orders; and Alafco is in the process of terminating a commitment for 40. These four customers alone represent around 20% of the precrisis direct lessor orders

for the MAX. And industry sources say there is more to come—in terms of cancellations and deferrals and possibly in terms of consolidation within the leasing sector itself, as some players are mulling their exit strategies, according to industry sources.

So, beyond the obvious reasons, why the MAX? “Customers smell weakness, and Boeing are the natural guys to go after,” says one senior industry source. “You have strong arguments against them because they did things wrong,” he adds, referring to the MAX grounding. The

subsequent long delivery delays allow customers to cancel some orders more easily.

But the story is a little more nuanced. Boeing sales chief Ihssane Mounir told Aviation Week in February: “As an industry, we have probably sold too many aircraft to lessors. Collectively, we have to rebalance the content. And we have been working very aggressively on this strategy over the past 12 months.” Besides, Boeing is not

No More Shock Absorber

Lessors cannot help OEMs in this crisis



AERCAP

going to produce nearly as many MAXs as previously planned anytime soon. Airlines simply cannot take them, either from Boeing directly or through lessors as intermediaries. The company had planned to increase production to 57 aircraft per month, but analysts expect only a little more than half that output for the near-to-medium term.

Like Airbus, Boeing cannot afford to lose marquee names among its customers in the leasing industry. It will therefore always have an incentive to agree to some concessions.

Fortunately for the OEMs, lessors also do not really have an interest in many outright cancellations. Deferrals, even for longer periods, are the much preferable option, as they ensure lessors will remain players in what will hopefully become a sizable market in due course. The fact that near-term slots are canceled merely shows how deep the crisis is.

Long-term deferrals carry their own risk, however. Demand patterns can change over time, as can the competitive landscape. Suppose a large part of a lessor’s portfolio for A320neos were to be deferred by several years. That fleet could lose residual value in the long term if Boeing ultimately finds the money to develop a new narrowbody—a development almost everyone in the industry agrees should happen sooner rather than later. But these are luxury issues, given the extraordinary crisis the sector is going through now. 🌐

CREW DRAGON DEBUTS

> DURATION OF DEMO-2 UP IN THE AIR

> BOEING REPEATING UNCREWED FLIGHT

Irene Klotz Cape Canaveral



NASA HAS FACED MANY FORMIDABLE challenges in a decade-long quest to restore U.S. human orbital spaceflight, so it may have been better prepared than other agencies to face widespread travel bans, workplace shut-downs, health issues and other quagmires posed by the ongoing coronavirus COVID-19 pandemic.

But confident in its ability to complete outstanding work, NASA announced a target launch date of May 27 for a flight test to the International Space Station (ISS) by two U.S. astronauts aboard a SpaceX Crew Dragon capsule flying from Florida.

The launch, scheduled for 4:32 p.m. from Kennedy Space Center Launch Complex 39A, will be the first human orbital space launch from the U.S. since the space shuttle Atlantis touched down at the Florida spaceport on July 21, 2011, closing out the 135th and final space shuttle mission.

The return of Atlantis marked the start of U.S. dependence on Russia to ferry crews to the ISS, a 15-nation orbital laboratory that has been continuously staffed by rotating teams of astronauts and cosmonauts since Nov. 2, 2000.

As the station prepares to mark 20 years of human presence in orbit, NASA is in the homestretch of launching astronauts from U.S. soil—while testing a new business model for human space exploration that it intends to expand for travel to the Moon as well. “We are at the cusp of making our Commercial Crew dreams a reality,” says Douglas Loverro, NASA associate administrator for human exploration and operations.

NASA kicked off its Commercial Crew partnership program in 2010 with the goal of financially and technically supporting private enterprise initiatives to develop human space transportation systems. The idea was that NASA would become one customer among many, buying flight services, similar to how it contracts with SpaceX, Northrop Grumman and Sierra Nevada Corp. for ISS cargo supply runs.



SPACEX

In September 2014, NASA narrowed the field of Commercial Crew contenders to Boeing and SpaceX, awarding the companies \$4.2 billion and \$2.6 billion, respectively, for flight tests and up to six operational crew-rotation missions. The goal was to have one or both of the companies transport crew to the ISS in 2017, but funding shortfalls and technical issues delayed both programs.

Despite contrasting cultures and a 38% difference in NASA funding, Boeing and SpaceX have been neck and neck in a low-profile race to be the first to launch NASA astronauts.

SpaceX successfully flew an uncrewed Dragon 2 mission to the ISS in March 2019, then lost the capsule during preparations for a static test fire of the launch abort system a month later.

Software problems precluded Boeing's uncrewed CST-100 Starliner from docking with the ISS during its orbital debut last December, a test that is scheduled to be repeated this fall. Both Boeing and SpaceX have been bedeviled by parachute development and testing.

SpaceX is providing Dragon's ride to orbit, so Falcon 9 issues have migrated onto NASA's radar screen as well. For example, NASA announced a launch date for SpaceX's Demo-2 mission, which will carry astronauts Robert Behnken and Douglas Hurley, only after it was satisfied with SpaceX's explanation for a March 18 Falcon 9 premature engine shutdown.

Residual cleaning fluid trapped inside a sensor ignited, prompting a cutoff of the Merlin 1D engine toward the end of the first-stage burn, SpaceX disclosed on April 22. The booster's eight other engines were able to successfully deliver



NASA astronauts Robert Behnken (left) and Douglas Hurley are poised to break the nine-year hiatus in U.S. human orbital flight.

the payload—a sixth batch of 60 SpaceX Starlink satellites—into its intended orbit.

Boeing's ride to orbit for the Starliner capsule—United Launch Alliance's Atlas V—has received similar scrutiny, though it has had a longer and smoother ride during its 83-flight history than SpaceX's Falcon 9. The Falcon 9, which first flew on June 4, 2010, made its 84th flight on April 22, surpassing the Atlas V for the most flights of any operational U.S. booster.

The Falcon 9 flight record includes two premature main engine shutdowns, neither of which affected the primary mission, one failed cargo run to the ISS, and one preflight launchpad accident that destroyed another rocket and its payload, an Israeli commercial communications satellite.

The Atlas V, which began flying in 2002, had one issue with a Centaur upper stage in 2007, but the satellites were able to maneuver to their intended orbits. The rest of its missions have been completely successful. Though Boeing will repeat the Starliner's uncrewed orbital flight test, the December 2019 launch certified the Atlas V for human spaceflight.

WORK AMID PANDEMIC

NASA and SpaceX have a full plate of work ahead of a targeted May 22 Demo-2 Flight Readiness Review (FRR), which will take place in part virtually and partially at Kennedy due to COVID-19 travel restrictions and workplace shutdowns.

The final test of SpaceX's Mk. 3 parachutes is scheduled

for early May. Testing was delayed by a March 24 accident that resulted in the loss of a Crew Dragon test article, which became unstable as it was hoisted into the air by a helicopter.

SpaceX on April 24 completed a successful static test fire of the Falcon 9 rocket that will launch Behnken and Hurley on the Demo-2 mission.

Outstanding Crew Dragon certification products include verification closure notices, variances and hazard reports, NASA said, adding that specific items are proprietary.

Ahead of the FRR, NASA and SpaceX will hold Operations, Stage Operations, Launch and Flight Test readiness reviews. Multiple NASA executives sign the Certification of Flight Readiness after the FRR, with senior approval coming from Loverro, a seasoned national security and space policy guru recruited to NASA six months ago. Oversight of Demo-2 will be his first human spaceflight.

NASA has yet to decide how long the Demo-2 mission will last. While operational Crew Dragon capsules will have 270-day orbital lifetimes, the spacecraft being used for SpaceX's final Commercial Crew flight test can stay docked at the ISS for up to about 120 days.

Behnken and Hurley will transfer to the ongoing Expedition 63 crew as flight engineers, but the assignment is temporary. Staying longer would ease the ISS staffing shortfall—Expedition 63 is composed of just three crewmembers, half the usual number. But bringing Behnken and Hurley home to complete the Demo-2 mission means NASA can move on with the certification process needed for SpaceX to begin operational missions.

The agency is counting on the Expedition 64 crew to include astronauts launching on SpaceX's Crew-1 flight later this year. NASA remains in negotiations for an additional seat for a U.S. astronaut aboard a Russian Soyuz capsule. Expedition 63 Commander Chris Cassidy, who arrived at the ISS on April 9 along with cosmonauts Ivan Vagner and Anatoly Ivanishin, took NASA's last paid ride on a Soyuz.

Cassidy's backup, astronaut Stephen Bowen, has returned to the U.S., and the agency currently has no astronauts in training in Russia, says NASA spokeswoman Brandi Dean.

"Several Commercial Crew astronauts are in training for long-duration station missions," she wrote in an email to Aviation Week. "No other official assignments have been made."

NASA on March 31 added astronaut Shannon Walker and Japan Aerospace Exploration Agency astronaut Soichi Noguchi to the SpaceX Crew-1 mission. NASA astronauts Michael Hopkins and Victor Glover have been training for the flight, which includes a long-duration stay on the ISS, since August 2018.

Meanwhile, Boeing's operational Starliner missions will not begin until 2021 at the earliest. The Starliner flight-test crew, now back in line behind another uncrewed mission, includes Boeing astronaut Chris Ferguson, formerly with NASA.

During his last spaceflight, Ferguson and his STS-135 crewmates left behind a U.S. flag on the station to be returned by the first crew launching to the station from U.S. soil. That milestone is now within SpaceX's reach.

But NASA later added a second flag to emphasize the importance of having two independent U.S. crew transportation systems to orbit. It is a strategy that so far is the clear winner. 🚀

Digital Extra See a timeline of Commercial Crew program milestones from 2010 to April 2020:

[AviationWeek.com/CCTimeline](https://www.aviationweek.com/CCTimeline)

Panel Sounds Alarm Over ISS National Lab

- > NASA CHIEF ECONOMIST NAMED CASIS PROGRAM EXEC
- > AGENCY REORGANIZES ITS COMMERCIAL PORTFOLIO

Mark Carreau Houston and
Irene Klotz Cape Canaveral

After a damning report by an independent review team, NASA is revamping its oversight of the Florida-based nonprofit organization that runs the U.S. National Laboratory programs of the International Space Station (ISS).

The ISS National Laboratory is “not a national laboratory in any sense other than its legislative designation,” the report notes.

The 68-page independent review team assessment, titled “A Strategy for the Future of the International Space Station National Laboratory and Commercial Low-Earth Orbit Development,” was initiated by NASA Administrator Jim Bridenstine last August and released on April 6.

The report calls for significant changes in NASA’s oversight of the National Laboratory research and technology development operations and its partner in the program, the Center for the Advancement of Science in Space (CASIS.)

“While the aspirations for future space commerce expressed by NASA, CASIS and private sector participants reflect a boldness, the technical, regulatory and economic components of the equation are uncertain,” the report says. “And the trajectories for those based in physical and life science pursuits appear mutually exclusive.”

The panel, headed by the University of Arizona’s Elizabeth Cantwell, senior vice president for research and innovation, also notes that although private sector innovations portend greater reductions in launch and op-

erational costs, NASA likely will remain the primary source of revenue for ISS launch and resupply for the next 5-10 years, whether the ISS National Laboratory remains hosted on the ISS or, as NASA envisions, aboard one or more successor commercial orbital platforms.

A complete transformation to becoming a commercial landlord is likely 10-20 years away, the panel says.

“Use of the ISS as a unique resource through its end of life cannot be considered in isolation from other NASA objectives, including research and development for long-duration human spaceflight systems,

including capabilities for interplanetary travel and permanent space habitation,” the report says.

The ISS National Laboratory was created at a specific time for a specific purpose to address potential shortfalls in ISS utilization, the panel notes. “However, the underlying set of expectations and predicted futures

have evolved dramatically in the intervening 15 years. There are now entities using the ISS beyond the scope originally envisioned for the ISS National Laboratory, as well as competition between NASA and the ISS National Laboratory for crew time, critical on-orbit facilities and ‘credit’ for breakthroughs,” it adds.

The ISS—a \$100 billion NASA investment that costs an estimated \$3 billion annually to operate—also is no longer confronted by underutilization, the panel says.

The report identified four overarching issues with the NASA/CASIS approach as the ISS National Laboratory evolved: CASIS’ unusual structure and function for a nonprofit, lack of user community integration by CASIS, poorly managed oversight of CASIS by NASA, and poorly defined procedures for project and program sponsors entering and exiting use of the ISS National Laboratory.

“NASA has used CASIS and its results mainly for public relations and has played an insufficient role in driving what CASIS does,” the panel states in one especially critical conclusion. “CASIS has been left to define and redefine success based on a

A SpaceX Dragon resupply ship is attached to the Earth-facing port of the space station’s Harmony module.



**NASA Chief Economist
Alexander MacDonald**

AUBREY GEMIGNANI/NASA



NASA

changes in the composition and roles of the nonprofit's board of directors and executive leadership, including selecting a new chief executive. The agencies also are organizing a Users Advisory Committee comprising members from organizations that have formal agreements with NASA, CASIS and other government agencies sponsoring ISS research.

Projects considered for the ISS National Laboratory will be evaluated with greater transparency and by multiple external experts, NASA and CASIS say.

The station's U.S. segment was designated a U.S. National Laboratory by Congress under a 2005 NASA authorization measure seeking to increase utilization by other federal agencies and the private sector. NASA managed the lab until 2011 when, under congressional orders, it entered into a cooperative agreement with a nonprofit to manage the effort.

NASA signed an initial \$136 million, 10-year agreement with CASIS that was extended in 2017 to cover operations through 2024, at a total cost of \$196 million. ☒

'many voices' approach from NASA that has driven inflexible, and potentially damaging, board and operational behaviors," the report says.

NASA says it is addressing the issues flagged by the review, including a reorganization of its commercial programs portfolio.

"You'll see us create an organization where we focus all of our commercial work under one dedicated set of leaders," Douglas Loverro, associate administrator for human exploration and operations said during an April 20 webinar hosted by the American Institute of Aeronautics and Astronautics.

"Within my office, CASIS was managed separately from our Commercial Crew program, which was managed separately from our Commercial Cargo program, which was managed separately, in many cases, from our commercial vehicle development program," Loverro says. "We're putting those all together so we can make sure that they are synergistic."

NASA also appointed its chief economist, Alexander MacDonald, to serve as program executive for CASIS.

NASA and CASIS agreed to make

Osiris-Rex Clears One Test and Prepares for June Trial

➤ THE SPACECRAFT COMPLETED A SUCCESSFUL TEST ON APRIL 14

➤ ASTEROID LANDING IS PLANNED FOR AUG. 26

Mark Carreau Houston

Osis-Rex, NASA's first-ever asteroid sample-return mission, is poised to execute its second dress rehearsal June 23 in preparation for a touchdown in August.

Preliminary data shows that Osiris, a \$1 billion component of NASA's New Frontiers effort to explore the Solar System, successfully carried out a 4-hr. series of spacecraft maneuvers and deployments on April 14. The run-through was executed to practice the critical early stages of operations planned for late August, when Osiris-Rex is to land briefly on the asteroid Bennu to gather up to 4.4 lb. of surface material. Bennu is a carbon-rich, boulder-strewn primitive Solar System body 140 million mi. from Earth.

Responding to preprogrammed commands, Osiris-Rex autonomously departed its 0.6-mi.-high orbit around the 500-m-wide (1,640-ft.) asteroid, descending to its closest point near the surface since arriving at Bennu on Dec. 3, 2018. Confirmation that the "Checkpoint" exercise was a success concluded with the spacecraft ascending back to its orbital perch.

The mission was launched on Sept. 8, 2016, with Osiris-Rex outfitted to attempt up to three brief sample-collection attempts before departing for Earth in March 2021.

It is designed for the spacecraft to drop off its sample-return container as Osiris-Rex passes close to Earth. That container is set to reenter

Earth's atmosphere for recovery on Sept. 24, 2023, in a parachute-assisted descent onto the U.S. Army's Utah Test and Training Range. The science team, led by University of Arizona Principal Investigator Dante Lauretta, is hopeful that laboratory analysis of the pristine asteroid material will help to further explain the Solar System's 4.6 billion-year-old planet-forming era—including the role that asteroids played in the distribution of water ice and organics, the building blocks of life.

Also designated a near-Earth object, Bennu is of interest because of a one-in-800 chance it could collide with the Earth in 2182, possibly causing damage on a regional scale.

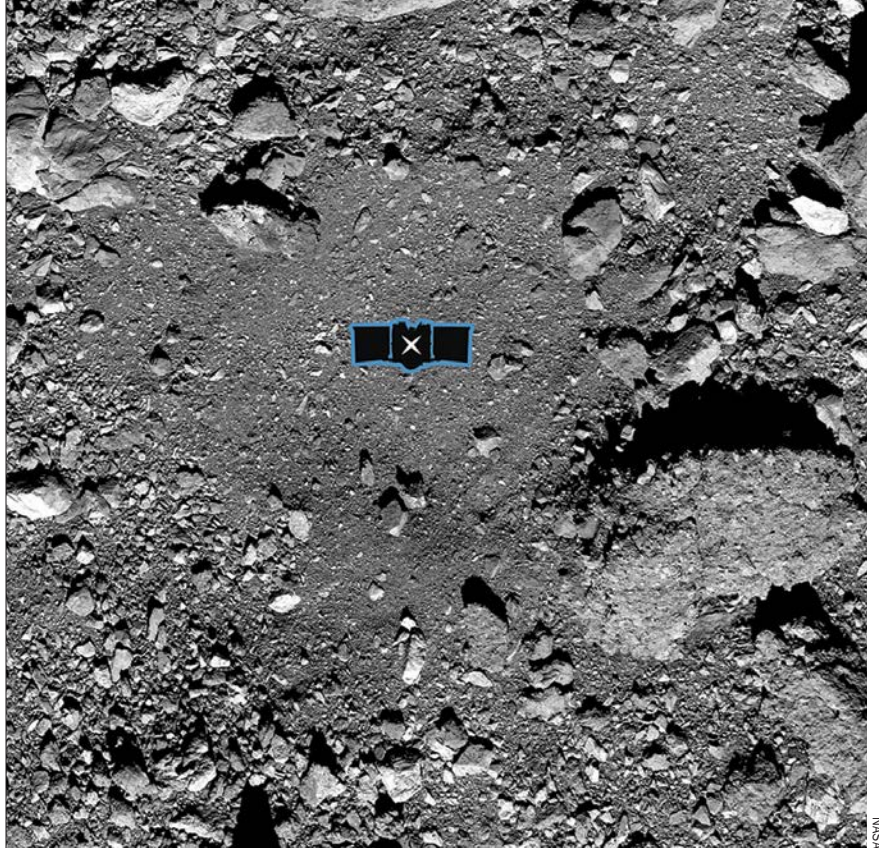
The April 14 Checkpoint exercise was the first of two planned rehearsals prior to the actual touchdown, now scheduled for Aug. 26 at a pre-designated landing zone around Nightingale, a 66-ft.-wide impact crater near Bennu's north pole.

Osiris-Rex departed its "safe home" orbit around Bennu with an attitude control system maneuver. It took 13 min. for data confirming the start of the drill to reach Earth, adding to the suspense.

"This is a bit of a nail-biter," Lauretta wrote on Twitter. His comment was made during a temporary loss of signal lock between Osiris-Rex and NASA's Deep Space Network (DSN), as Osiris-Rex began its slow descent. NASA's DSN is the global network of ground stations used by NASA for two-way communications with planetary science mission spacecraft.

Next, the probe extended its 11-ft.-long robotic arm, the Touch-and-Go Sample Acquisition Mechanism (TagSAM). The device is to release a blast of nitrogen at the landing site in late August to kick up pieces of Bennu into a sample-collection container.

The spacecraft then slewed into position to begin gathering images of the surface for autonomous navigation. The probe's natural feature tracking technology draws on software guidance systems and compares the real-time descent imagery with images stored in an onboard catalog of previously imaged landmarks. During its descent to the 410-ft.-altitude checkpoint maneuver level, the probe's solar arrays were positioned into a "Y-wing" configuration intended to prevent their contact with Bennu's surface during the actual landing. The



NASA

reconfiguration also extended the Tagsam along the spacecraft's center of gravity so that it could make only brief direct contact with the surface.

After the 3-sec. checkpoint thruster maneuver, Osiris-Rex continued its descent toward Bennu's surface for another 9 min., reaching an altitude of about 243 ft., the closest the spacecraft has come to the asteroid yet.

That was followed by a back-away maneuver to begin the ascent toward the probe's initial orbital position, including reconfiguration of the solar arrays to their original orientation and the issuance of commands for the Tagsam to reassume its stowed position.

Throughout much of the trial, spacecraft sensors also gathered thermal and mineral composition data from Bennu's surface.

A second rehearsal is planned for June 23. It will take Osiris-Rex through the same checkpoint deployments and maneuvers to a third critical descent milestone, the "Matchpoint" maneuver. Matchpoint is to occur at about 164 ft. over Bennu's terrain, synchronizing the spacecraft's descent with the rotation of the asteroid so it can navigate accurately to its constrained landing zone at Nightingale.

After a lengthy global reconnaissance of Bennu's surprisingly rocky surface, the Osiris-Rex mission team

This image of the asteroid Bennu is overlaid with a graphic of the Osiris-Rex spacecraft to show the scale of the sample-collection site on the asteroid.

announced the selection of Nightingale as the primary sample-collection site on Dec. 12, 2019.

At the same time as the NASA announcement, the Japan Aerospace Exploration Agency's (JAXA) Hayabusa2 sample-return mission (launched on Dec. 3, 2014) to the larger asteroid Ryugu was starting to make its way back to Earth after gathering surface and subsurface samples in 2019. The Japanese spacecraft is to drop off a sample container as it passes by Earth in December 2020 during a parachute-assisted descent into remote Australia for recovery.

Scientists involved in Osiris-Rex and Hayabusa2 plan to exchange sample materials for scientific analysis.

Much of the checkpoint rehearsal was carried out in telework fashion due to the coronavirus pandemic. The work was led by personnel from NASA's Goddard Space Flight Center, Lockheed Martin Space Systems' control center in Denver and the University of Arizona. Only a limited number of essential personnel—all taking safety precautions due to COVID-19—were at each of the sites during the drill. 🚀



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**AVIATION
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Bad to Worse

- > AIRBUS AND BOEING ANNOUNCE DEEP PRODUCTION CUTS
- > BOEING TERMINATES EMBRAER TIE-UP BUT REMAINS OPEN TO MITSUBISHI PARTNERSHIP
- > RECOVERY TO PRE-COVID-19 LEVELS IS EXPECTED TO TAKE SEVERAL YEARS



Jens Flottau Frankfurt, **Guy Norris** Los Angeles and **Sean Broderick** and **Michael Bruno** Washington

Almost exactly 15 years ago, tens of thousands of spectators positioned themselves around the fences of Toulouse's Blagnac Airport. On April 27, 2005, the Airbus A380 took off for its very first flight, heralding what many believed was going to be a new era of flight. Fast forward to April 2020: Almost the entire fleet of A380s is grounded, as are tens of thousands of smaller aircraft. And Airbus CEO Guillaume Faury wrote in an internal memo that "the survival of Airbus is in question."

That such a message would come from Airbus, arguably the soundest commercial aircraft manufacturer in terms of finances and strategic positioning, was unthinkable just two months ago. But similar memos could have been issued by any of his colleagues or competitors as the novel

coronavirus wreaks havoc on commercial aviation. Many airlines are on the brink of collapse, as are many suppliers. And the financial pressures on the OEMs and large suppliers are so intense that they have no choice but to focus on their own survival rather than considering customer financing or supplier support at any scale.

The COVID-19 pandemic is reshaping aerospace and, about two months into the sector's worst crisis ever, its future shape is becoming clearer. The industry is becoming much smaller than it was just a short while ago. Bankruptcies are almost guaranteed and will not be limited to smaller, weaker firms. State bailouts and the rising influence of governments will soon be commonplace. Research and development has slowed or is on hold. And transactions are collapsing, most

prominently the planned commercial aircraft joint venture between Boeing and Embraer, Boeing Brasil-Commercial. There will continue to be two major players. A third, Embraer, is trying to compete in its own niche against the giants while new rivals such as Mitsubishi slowly appear on the horizon.

The only bit of good news is that while air transport is about to reach rock bottom in some of the hardest-hit markets, it is on a slow upward slope in others, particularly in Asia where some airlines have cautiously begun to add flights. Unfortunately for the aerospace side of the business, the full effect of the declines is only beginning to filter through and will dominate industry activity for the foreseeable future, with analysts generally not expecting traffic to recover to precrisis levels before 2023.

Airbus had already announced a 30% across-the-board production cut



Commercial aviation faces much pain and turbulence in the years ahead as it tries to deal with the fallout from the COVID-19 pandemic.

NEXT143/GETTY IMAGES

on April 8. Now Boeing, too, is scaling back big-time in various ways: cutting into production rates and curtailing the pace of development programs and future projects.

The combined production rate for the Boeing 777-300ER/F and 777X is set to reduce to three per month in 2021, while the Boeing 787 rate will be cut to 10 per month later this year and shrink to seven per month by 2022.

The 777 slowdown cuts the official production rate in half, to around 2.5 later this year from the current five per month, although the actual rate cut is cushioned because Boeing already accounts for around 1.5 “blank” positions per month in anticipation of the production switch to the 777X. The gradual introduction of the initial 777X model—the 777-9—will also be slowed under the new rate plans and will bring the combined 777/777X production tally to three per month in 2021.

“We will take a measured approach to the 777X rate ramp, as we will look to minimize the amount of change incorporation work by managing the number of aircraft produced prior to entry into service,” says Boeing CEO Dave Calhoun. The reduced rate underlines the drastic change in fortunes for Boeing, which only three years ago provisionally planned to produce seven 777s per month in 2020, almost half of which were to be 777Xs.

The production reduction for the 787 is more precipitous, at least in the midterm, with the rate dropping to 10 per month later this year from 14. The previous plan would have seen a shallower cut, from 12 later this year to 10 in early 2021.

Production of the 737 MAX is to restart this quarter and increase gradually to 31 aircraft per month sometime in 2021, with further increases based on demand. Boeing was producing 52 MAXs monthly and preparing to ramp up to 57 when all MAXs were grounded in March 2019 following two fatal accidents in less than five months. It cut production to 42 in April 2019. In January 2020, it paused production, following months of missed projections about when the FAA would approve changes ordered after the accident probes and related reviews.

The pandemic has also slowed planning for Boeing’s next new aircraft project. In January, the OEM was already transitioning away from the long-running two-family new mid-market airplane (NMA) initiative to a revised 757-size concept. Although

on a new airplane now because of all the market and product ramifications associated with this [market] change,” he says. “It is going to take us a while to sort that out.”

Calhoun also indicates the potential shift to smaller-capacity aircraft in a market recovering from the pandemic may have removed some of the urgency to develop a new product family, as well as breathed new life into the 737 MAX sector. “In some ways, if airplane loads want to get smaller as a result of a smaller set of passengers flying on them in the next several years, it might actually play to us,” he says. “We have a robust [737] backlog with it.”

“Robust” could not be used to describe Boeing’s finances, but the picture is beginning to look much less bleak then it did only weeks ago. The OEM was negotiating with the Trump administration about receiving U.S. bailout funds, but company leaders believe they can maintain investor-grade ratings, and they see a sustainable financial path where its commercial aircraft business returns to growth in 3-5 years.

Getting there, however, will require billions of dollars more in debt financing—although no longer from the U.S. government, Boeing said April 30—as well as cutting its workforce at least 10%, or 16,000 employees.

“We are doing everything in the next six months on the liquidity front that we believe is necessary to keep us operating and keep us safe,” Calhoun says. Private-sector financing has opened again, thanks to the new

Airbus Key Metrics

	First Quarter 2020	First Quarter 2019 Restated*	Change
ORDER INTAKE (NET)	290	(58)	N/A
BACKLOG (UNITS)	7,650	7,357	4.0%
DELIVERIES (UNITS)	122	162	-24.7%
REVENUES**	€7,569	€9,697	-21.9%
EBIT**	€57	€319	-82.1%

*2019 financial figures restated to reflect the adoption of a new segment reporting structure for “Transversal” activities

**In € million (€1 = \$1.08)

Source: Airbus

Calhoun emphasizes that the company is “not out of the product development business,” he cautions that “it’ll be a little while before we announce a big new airframe.” The advanced engineering and manufacturing lessons learned from the NMA program will be used in whatever program follows. “[But] we will not try to drop a point design

CARES Act in response to COVID-19, as well as the Fed’s separate-but-related corporate-backstop program. Boeing is examining all options and a mix of sources of financing—including Treasury Department funding via CARES that could entail giving the government a stake in the company.

“I think things have changed a bit

for the better since maybe a month ago,” Calhoun adds. “But at the same time, we have not yet made choices, and I don’t want to predict outcomes on that front.”

Boeing stunned Wall Street and the aerospace world in March when it openly asked for at least \$60 billion in federal aid for itself and its suppliers. Following the latest revelations, though, Boeing’s stock price closed up almost 6%, with analysts and observers noting with relief both that the quarterly results were not worse and that Boeing sees a sustainable path forward. The OEM burned through \$4.7 billion in the recent quarter, better than analysts

ton state and South Carolina, where Boeing Commercial Aircraft work is centralized, as well as in Dallas-Fort Worth and other Boeing Global Services sites. Cuts should be shallower at Boeing Defense and Space, which is likely to become the dominant division for years to come while commercial and maintenance, repair and overhaul businesses contract, the CEO notes.

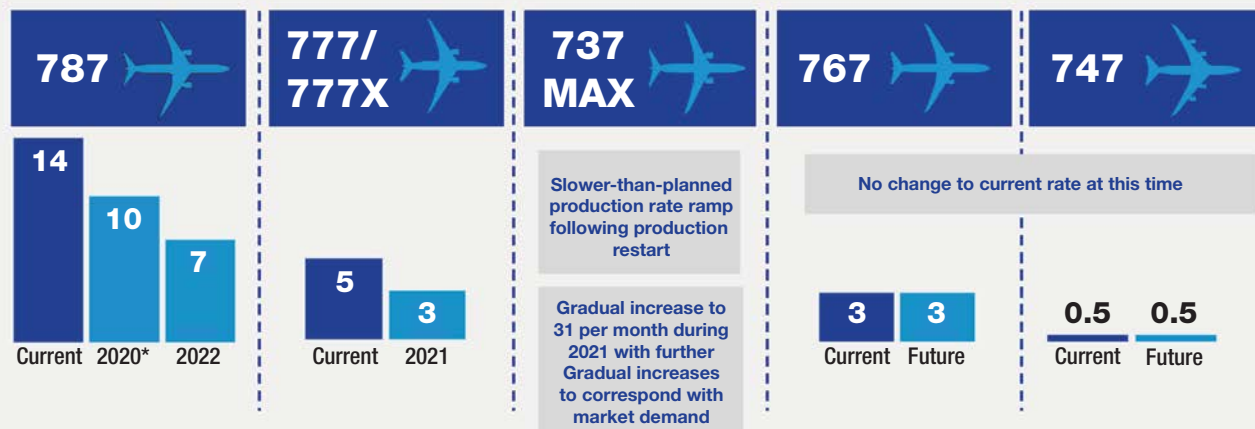
Boeing reported first-quarter revenue of \$16.9 billion, down 26% from the same quarter of last year. Loss per share was \$1.11 on regular accounting rules, compared with a \$3.75 gain the first quarter of 2019, and a so-called core business loss per share of \$1.70

if they want to—and if they believe they’ve got some innovative capabilities—[could] move into more of our kind of world,” Calhoun says.

Potential partnerships with companies such as Mitsubishi would help with the “effect it has on globalizing our company,” Calhoun adds. “Each and every deal has to be struck at the right economic levels and it has to be struck in a fair way,” he says. “And in each of those cases, there’ll be conditions, and both parties will have to meet those conditions.”

One might interpret that as a hint about why Boeing thinks it had the right to terminate the planned Boeing

Boeing Commercial Airplane Production Rates Per Month



Total Backlog of ~5,000 Commercial Airplanes

*Previously announced a 787 production rate transition from 14 month to 12 month in late 2020 and to 10 month in early 2021.

Source: Boeing

expected, and had \$15.5 billion of cash or equivalents available as of March 31.

“Boeing’s . . . first-quarter cash-burn seems to be a relief, and it appears increasingly possible that the company might avoid raising capital from the government, or at least the Treasury,” JP Morgan analysts said. “Nevertheless, the path forward for Boeing remains quite challenging, and while the production rate outlook in today’s release is not a big surprise, it suggests substantially lower activity for some time.”

In turn, Boeing likely will have to rely on layoffs—i.e., involuntary separations—to achieve its 10% workforce cuts, Calhoun says. The company will target white-collar jobs over touch labor and make deeper cuts in Washing-

versus \$3.16 gain. Those came from a GAAP (generally accepted accounting principles) loss of \$641 million against \$2.15 billion in earnings the same period last year.

Total debt was \$38.9 billion as of the end of March, up from \$27.3 billion at the beginning of the year, primarily due to the drawdown of a new \$13.8 billion term loan facility during the quarter.

While Boeing appears to have determined that it can no longer afford the deal to acquire Embraer’s commercial aircraft division, it is already talking about new partnerships. This time it is with Embraer’s (future) rival Mitsubishi. “I’m open to any kind of major partnership. They [Mitsubishi] are in fact incredibly competent, important players in the industry who,

Brasil-Commercial joint venture with Embraer, which began a public fight between the companies.

“[Embraer] believes strongly that Boeing has wrongfully terminated the Master Transaction Agreement (MTA),” the Brazilian company says. “[And] that it has manufactured false claims as a pretext to seek to avoid its commitments to close the transaction and pay Embraer the \$4.2 billion purchase price. . . . Boeing has engaged in a systematic pattern of delay and repeated violations of the MTA because of its unwillingness to complete the transaction in light of its own financial condition and 737 MAX and other business and reputational problems.”

Boeing, of course, has a different view. “[Boeing] has worked diligently

over more than two years to finalize its transaction with Embraer,” says Marc Allen, Boeing’s president of Embraer partnership and group operations. “Over the past several months, we had productive but ultimately unsuccessful negotiations about unsatisfied MTA conditions. We all aimed to resolve those by the initial termination date, but it didn’t happen.”

The collapse is a blow for Boeing that may have long-term consequences on its ability to compete against Airbus and reestablish itself as an equally competitive force in the narrowbody and midsize aircraft market. It also means a U-turn for Embraer, which will now have to compete as an independent manufacturer, putting it in an economically much weaker position. Airbus is emerging as the big winner from the breakup.

Regulatory approval for the deal from the European Commission was still pending, which was a key condition for the transaction to be completed. But industry observers say the real reason behind Boeing’s decision is that the current financial pressures are so enormous it did not believe it could afford the transaction. Also, it would have been extremely difficult politically to ask for financial assistance from the U.S. government, cut thousands of jobs and at the same time spend more than \$4 billion for an acquisition abroad, as strategically important as it may have been.

Embraer’s value for Boeing was twofold: One, after Airbus had acquired the C Series program from Bombardier and converted it into the A220, Boeing felt pressed to react at the bottom end of the narrowbody market with an aircraft offering the same economics as the A220. Boeing was keen to acquire Embraer’s engineering capabilities, too, which are highly regarded in the industry and would have been welcome in new aircraft programs such as the NMA.

The lack of a viable product at the bottom end of the narrowbody market that can compete at least in part of the A220 spectrum is now raising even more questions about the timing and design of Boeing’s next new aircraft. The manufacturer not only faces the task of designing an aircraft that eclipses Airbus’ highly successful A321neo/LR/XLR at the top end of the narrowbody market but also faces that gap at the bottom.

Millennium’s Missed Opportunity?

Tony Osborne London

AIRBUS WILL NOT BE THE ONLY VICTOR RESULTING FROM THE TERMINATION of the tie-up between Boeing and Embraer. In fact, Lockheed Martin may be breathing a small sigh of relief too.

The proposed C-390 joint venture (JV), 51% owned by Embraer and 49% owned by Boeing, could have resulted in a serious competitor to the Lockheed Martin C-130J Hercules being assembled in the U.S.—if the innovative twin-jet airlifter had found sales traction with the Defense Department. Boeing’s marketing clout would have certainly helped the aircraft in the U.S., and a Defense Department contract would have resulted in additional overseas orders, too.

“The world fleet of medium-sized freighters, with nearly 3,000 aircraft in service and average age of 30 years, will likely undergo a renewal process in the coming years,” Embraer stated in its 2019 investor prospectus detailing the C-390 JV. The company added that the JV partnership “opens up prospects of new and relevant markets for the KC-390, such as the North American and European markets, which together account for more than half of the global fleet of aircraft in service.

“New market prospects will open up, which may significantly amplify the production and delivery scale of the C-390,” the prospectus said.

Without the JV, the C-390 program should, according to Boeing, fall back on a teaming agreement signed in 2012 to jointly market the aircraft. Embraer says it has not yet discussed this with Boeing. It is unclear whether this teaming deal will remain in place if the now public dispute about Boeing’s decision to terminate the Master Transaction Agreement reaches the courts.

“The Boeing cooperation agreement represented upside potential, rather than necessity,” says consultant Richard Aboulafia of the Teal Group. “It was always far from clear how the C-390 could get into the [Defense Department] budget, but with Boeing it had a chance . . . and the -390’s cost, price and support network would have benefited from Boeing involvement.”

Though the JV failure is a setback for the C-390 program, it is far from a body blow. Embraer has already demonstrated it can sell and support its military platforms internationally: The Super Tucano continues to sell as a counterinsurgency platform, and the OEM has secured the first export order for the C-390. Portugal plans to purchase five C-390s, with the first delivery in 2023. Hungary is showing interest in the platform as well. Brazil has now taken delivery of two of its planned 28 KC-390s, using them in Brasilia’s battle against the COVID-19 pandemic. ☛

Embraer is on its own for now and needs to decide whether it will look for another strong partner, which would likely have to be outside of aerospace, or continue as a broad but small aerospace firm. It also has to decide whether to reintegrate Yavora Industria Aeronautica, the carved-out former commercial aircraft unit, into the group or run it as a separate entity for the time being.

Across the Atlantic, Airbus’ Faury is also preparing his team for tough times. “The aviation industry will emerge into this new world very much weaker and more vulnerable than we went into it,” Faury wrote in his memo.

While he did not go into potential staff reductions in detail, insiders say Airbus is preparing a major cost-savings program that may be similar to the 2008 “Power 8” project, under which it cut 10,000 jobs. “We may now need to plan for more far-reaching measures,” Faury wrote. “That is because of the sheer magnitude of this crisis and its likely duration. . . . We are living through one of the largest economic shocks in history so must consider all options.”

Airbus plans to build 40 narrowbodies per month, down from more than 60, along with two A330/A330neos and six A350s per month. Analysts

have suggested that Airbus will have to make further cuts of a similar size as customers continue to defer deliveries. However, the OEM will not decide on such changes to its production rates before June. And if they come, they will be “on a smaller scale” than previous cuts, according to Faury.

The airframer plans to spend the next few weeks on an analytical deep dive into the plans and financial performance of its customers, both lessors and airlines, to be able to better assess what their short-term behavior and long-term strategies will look like. The analysis will be “very granular.” Airbus is also trying to assess what the recovery in traffic will look like and is adapting its financial planning accordingly.

Notably, Chief Financial Officer Dominik Asam says, “If we are able to do what we plan, [government aid] should not be necessary, given that at the beginning of April we had about €30 billion [\$33 billion] in liquidity resources, which should be ample funding under the circumstances.”

Faury says deliveries will be “very low” in the second quarter, after the manufacturer was able to hand over 122 aircraft in the first quarter, which was only partially affected by the novel coronavirus crisis. Nonetheless, Airbus was unable to deliver 60 completed aircraft in the quarter. “After the summer, we will start delivering aircraft at a better pace,” he expects. Faury says the number of undelivered completed aircraft will peak in the third quarter.

While the short-term focus is on cash conservation and cutting rates, Faury also wants to position Airbus in a way that enables it to resume growth quickly. “The race will start again; we want to be fast and agile,” he says. “There is a threat of being stuck in the crisis and not being able to compete again.” He anticipates that the single-aisle market will recover faster than the widebody one, but he notes the pace of the recovery and the timing “are very difficult to predict.” He indicated that there could be “a very aggressive ramp-up in single-aisle production” after the COVID-19 crisis. The A321XLR devel-

opment program will continue “at good speed,” he says.

In his discussions with airlines, Faury observes a preference for smaller aircraft compared to pre-COVID-19 planning and asserts that Airbus is well-positioned with its smallest narrowbody, the A220, as well as the A321XLR taking on some former widebody missions and the A350.

Faury expects widebody demand to recover in 2023-25, while the outlook for narrowbodies is “not that gloomy.”

Airbus reported a €481 million net loss for the first quarter on sales of €10.6 billion. That compares to a €40 million net profit on €12.5 billion in sales the same period a year earlier. The adjusted operating profit was down 49% at €281 million for the quarter. Free cash flow was a negative €8 billion in the quarter, almost twice the amount in the first quarter of 2019. 📢

Check 6 Teal Group's Richard Aboulafia joins *Aviation Week* editors to discuss fallout from the Boeing-Embraer breakup: [AviationWeek.com/podcast](https://aviationweek.com/podcast)

Throttling Back

- ALMOST 38,000 COMMERCIAL JET ENGINES ARE ON STORED AND PARKED AIRCRAFT
- ENGINE AFTERMARKET AND NEW PRODUCTION FACE SIMULTANEOUS CUTS

Guy Norris Los Angeles and **Michael Bruno** Washington

Any listing of the currently parked and stored commercial airliner fleet makes for grim reading in these COVID-19 pandemic times, but multiply each of those by two—and sometimes four—and the scale of the crisis facing the engine industry really begins to hit home.

Having long since focused the core of their business models on the aftermarket, engine-makers fear the lines of silent aircraft are not only a bellwether for drastic cutbacks in production but also for a potentially calamitous drop-off in demand for engine maintenance, repair and overhaul (MRO) services. The impact, coming so suddenly, is an unprecedented double whammy for an industry that has spent most of the past decade accelerating production to keep pace with bounding airliner delivery rates.

The engine companies face a bleak situation because the coronavirus-triggered crisis affects three key areas; production of new engines, support of engines in service and future development. The first of these problems is already upon engine-makers as they grapple with the challenge of shrinking production by up to 50% to match the lower airframe

production rates forecast for at least the next two years.

Second, they must adjust to much lower MRO revenues as work is deferred or, in the worst cases, vanishes altogether as fleets of older aircraft are prematurely retired by airlines desperately consolidating to survive. How long and how deep this problem will become is up for debate. Assuming commercial air traffic drops 60-70% in 2020, there will be a major destocking effect, which could take a few months out of demand, according to consultant Richard Aboulafia of the Teal Group.

New-build demand could decline 40-50%, but the aftermarket could plummet 65-85% for a few months before leveling off at a 60-70% decline as the market recovers, says Aboulafia. Total care and integrated aftermarket packages from the OEMs will likely have to be flexible, and shops will have to work with customers in terms of price and margin, he told a Jefferies teleconference April 23. Flexibility could lead to share gains,



With more than two-thirds of the world's commercial jet fleet grounded, almost 38,000 engines are parked or in storage.

but if such offerings do not evolve, there could be competitive openings for smaller niche players.

With virtually all their resources reprioritized toward survival, engine-makers are meanwhile expected to significantly slow research and development of new engines and propulsion technology—at least in the near term. All the manufacturers inevitably face painful decisions in the weeks and months ahead as they trim research and development work in the short term, knowing that long-term environmental pressures to further improve performance will return.

Funding for committed programs will therefore continue, albeit potentially stretched over longer timescales. Rolls-Royce, for example, is continuing to invest in test and development of the UltraFan next-generation turbofan but, along with codeveloper Airbus, announced on April 24 that it had canceled plans to flight-test the E-Fan X hybrid-electric propulsion demonstrator. Ground development of elements of the system, meanwhile, will continue.

From a production volume perspective, GE Aviation-Safran's CFM joint venture is expected to see the greatest change. After delivering 1,736 Leap 1s and 391 CFM56-5/7s in 2019, output from the combined French and U.S. operations will decline significantly in 2020 in lockstep with urgent reductions in production at Airbus and Boeing. CFM, which was previously on track to achieve a planned annual production rate of more than 2,000 Leap 1s by the end of 2020, is likely to slash this target by around half.

GE Aviation, which was already expecting a leaner 2020 before the pandemic because of delays to the GE9X-powered Boeing 777-9 and slowdowns to the GE90-115/GENx-1-powered 777-200LR/300ER and 787 programs, is eyeing the even more troubling impact of the crisis on its aftermarket business. Although about a quarter of GE Aviation's revenues come from its military and other businesses, just 30% comes

Commercial Jet Transport Engines Stored/Parked by Aircraft Class*				
Engine Manufacturer	Regional Jet	Narrowbody	Widebody	Totals
CFM International		17,166	272	17,438
Engine Alliance			480	480
General Electric	3,524		3,802	7,326
International Aero Engines		4,430		4,430
Pratt & Whitney	108	1,713	925	2,746
Rolls-Royce	1,132	674	3,488	5,294
Honeywell	284			284
Totals	5,048	23,983	8,967	37,998

*As of April 18, 2020. Includes 6,077 engines in reduced-activity "parked/reserve" status that flew 1-2 of previous 7 days.

Source: Aviation Week Intelligence Network Fleet Discovery

from commercial engine sales. A much larger portion of its revenue—approximately 45%—comes from MRO services.

Amid the uncertainty, Wall Street investment advisors the UBS Group has modeled several potential outcomes. In an April 23 report on GE, two scenarios were based on a roughly 40% hit to airliner utilization this year, compared with analysts' precoronavirus assumptions and a predicted return to prepandemic business levels by 2024. The worst case sees a 50% drop this year and much less commercial flying for the foreseeable future. Regardless, the result would be a 60-70% hit to free cash flow, or revenue minus expenses, generated from GE Aviation in 2020-21 compared to UBS' prior model.

While some programs, such as the CFM56 for the Boeing P-8A maritime patrol aircraft as well as military fighter engine efforts, will continue much as before, the company has already taken drastic action to stem losses by furloughing half of its engine manufacturing workers for four weeks. This move, taken in early April, followed an announcement in late March that it was reducing its workforce by 10% (around 2,500 employees), in direct response to the collapse of its MRO workload, which the company estimates will be down by around 50% through midyear at least.

According to the Aviation Week Intelligence Network Fleet Discovery database, the ubiquitous CFM56 makes up the bulk of the engines currently on nonoperational aircraft as well as those not in regular everyday service in the Western-built jet transport fleet. Including aircraft that are parked, in long-term storage or in shorter-term parking or storage, there were more than 14,960 CFM56 engines idle as of April 18. The joint venture's Leap 1 engines, which power the grounded Boeing 737 MAX and compete with Pratt & Whitney's PW1100G for the Airbus A320neo family, make up a further 2,474.

In addition to CFM, GE Aviation has more than 7,320 engines on aircraft either parked or stored. Almost half of these, 3,520, are CF34s powering Bombardier CRJ regional jets while almost 1,400 are CF6s on a variety of Airbus and Boeing widebodies. Approximately the same number of GE90s are also currently idle, while a further 1,000 GENx-1/2s are also fallow on parked 787s and 747-8s.

For Rolls-Royce, the emerging MRO problem is particularly acute, as the UK engine-maker focused increasingly on the widebody market over the past decade, widening its exposure to reliance on the support revenue from aftermarket work on older fleets of 747 and 777s as well as A330s. With large-scale premature retirement possible for the relatively young Trent 900-powered A380 fleet as well as the rapid decline of the RB211-535 powered 757 and Trent 500-powered A340-600 fleets, the company can no longer bank on the expected



MARK WAGNER/AVIATION-IMAGES.COM

rebound in deferred maintenance coming out of the crisis.

The Aviation Week database indicates 3,330 Trent engines as well as 636 RB211s are currently grounded or in some form of storage. Overall, Rolls has more than 5,280 inactive engines, of which over 940 are AE3007s on stored Embraer 145-family regional jets.

Rolls has rushed to mitigate losses by enacting measures aimed at saving at least £750 million (\$600 million) in cash this year. These include a 10% salary cut for the global workforce and canceling dividend payments. Further moves are expected as the company adjusts to rate reductions announced by Airbus involving the Trent-powered A330neo and A350-900/1000, as well as by Boeing for the Trent 1000-powered 787.

Pratt & Whitney, now part of Raytheon Technologies, is similarly affected across the board, with production of the PW1000G geared turbofan reduced for the A220/A320neo families and commercial revenues hit by falling aftermarket revenues for the PW2000/PW4000 and V2500. Measures such as 10% pay cuts through year-end, as well as furloughs are being introduced, and research and development spending is being frozen. The early retirements of the PW4000, as well as some CF6-powered fleets, is also significantly affecting revenues for German engine-maker MTU.

Pratt, which will be forced to lean more heavily on production of military F135s for the Lockheed Martin F-35 and PW4000s for the Boeing KC-46A tanker, has more than

2,700 commercial engines on parked and stored aircraft. The PW4000 makes up the single largest tally, with more than 900 units, while the rapidly growing PW1100G fleet accounts for 810. Two big fleets that are unlikely to see a return to service in prepandemic numbers are the JT8D, with around 460 now in storage, and the 276-strong fleet of PW2000 engines. The 148 PW1500G engines on stored A220s also amount to a significant fleet.

Other large engine fleets that account for substantial MRO revenues for Pratt include the Engine Alliance GP7200 with GE and the former International Aero Engines V2500. According to the Aviation Week database there are 480 GP7200s on parked A380s and 4,430 V2500s on parked and stored A320s.

Pratt's commercial aftermarket revenue of \$11.1 billion accounted for 53% of total division revenue in 2019. But the Jefferies analysts expect this to decline 75% in the current quarter from the same period last year and drop 60% in the third quarter before finishing the year down 50%. At the same time, they also see a 29% decline in revenue from aircraft OEMs as narrowbody deliveries are pressured due to falling airline profitability, coupled with an "extreme" decline in widebody deliveries over the next three years.

Other analysts take a dimmer view. "We do not expect Pratt to recover to predownturn profitability for at least four years—in line with previous downturns," AllianceBernstein analysts say. ☹

European Carriers Try To Determine How Business Will Look After Crisis

- FRANCE PLEDGES €7 BILLION AND NETHERLANDS €2-4 BILLION TO AIR FRANCE-KLM
- NORWEGIAN HOPES BALANCE SHEET IMPROVEMENT PLAN WILL UNLOCK STATE AID

Helen Massy-Beresford Paris and **Jens Flottau** Frankfurt

European airlines are still reeling from the impact of the COVID-19 crisis, but the need to look ahead toward a post-coronavirus future to determine how the region's air transport industry will evolve in the longer term is clear.

Even airlines that were performing well before the coronavirus crisis are looking for external help. The goal is to ensure they survive long enough to take advantage of an anticipated increase in passenger demand when widespread travel restrictions are removed.

British Airways (BA) has set out plans for a major restructuring and redundancy program as a result of the COVID-19 pandemic, with up to 12,000 people leaving the airline. This comes on the heels of parent company International Airlines Group (IAG) report-

ing a first-quarter operating loss of €535 million (\$581 million), down from a profit of €135 million a year earlier.

In the April 28 earnings report statement, IAG said BA took the biggest hit, followed by Iberia and Aer Lingus. IAG said in the statement that it has reduced passenger capacity in April and May by 94% compared to last year, only operating flights for essential travel and repatriation. The group will determine passenger capacity for June and beyond according to "the timing of the easing of lockdowns and travel restrictions by governments around the world," its statement said. The group believes, like its European airline peers, that recovery to the passenger demand levels seen prior to the coronavirus crisis will take several years.

For Lufthansa Group, which is rack-

ing up losses of around €1 million per hour and only flying 1% of its usual passenger volume, the immediate financial situation remains unclear after the group rejected the proposed conditions on a €9 billion German government bailout package, according to industry sources. In exchange, the proposal would have called for the government to take control of a 25% stake and two supervisory board members, effectively preventing the company from taking painful restructuring measures.

Lufthansa has not commented on the proceedings but industry sources



say the group is now considering entering “protective umbrella” restructuring, a variant of Germany’s insolvency law aimed at fundamentally sound companies facing problems because of unexpected circumstances.

Senior executives at Lufthansa believe the airline can operate around 50% of a normal schedule in the upcoming winter timetable, at best. The forecast calls for that to rise to around 70-75% next summer and somewhat higher in the 2021-22 winter season. CEO Carsten Spohr has said he does not expect the airline to return to precrisis passenger volumes in the foreseeable future. The carrier has already set out plans for a smaller post-crisis fleet.

Bernstein analyst Daniel Roeska wrote in an April 29 research note that Lufthansa would need liquidity support in a matter of weeks. As a result, he believes the German government, the company and Lufthansa shareholders should work together to provide the necessary €8-10 billion to see the group through the crisis. “Governments will play a crucial role, and we expect support in the form of debt and equity,” Roeska wrote. “But shareholders should also contribute, and we suggest an equity raise to share the burden. Lastly, management should leverage some of its fleet and firmly commit to free cash flow targets to ensure a quick deleveraging of the balance sheet.”

Norwegian Air Shuttle, which was already under financial pressure following rapid expansion before the COVID-19 crisis grounded nearly all of its fleet, has warned that without more state help it will run out of cash by mid-May.

The low-cost carrier (LCC), which has temporarily laid off most of its workforce, has set out a debt-for-

equity conversion plan to improve its balance sheet. The action is a precondition for accessing 3 billion Norwegian kroner (\$290 million) of aid, 300 million Norwegian kroner of which has already been granted.

If Norwegian succeeds in putting the plan in place, the airline wants to use the cash generated to change its strategy, gradually emerging after the crisis with a fleet of around 110-120 aircraft, down from a precrisis plan of 168 aircraft.

The airline plans to focus on tried-and-tested routes—such as long-haul flights between London and New York or London and Los Angeles, or intra-Nordic services in the short-haul network. It will also look to put in place a cost-cutting initiative and drive an increase in ancillary revenues.

But industry observers have predicted the coronavirus crisis will lead to more consolidation. For now, Norwegian is waiting to see if the plan it has put forward will be approved—granting it the reprieve it needs to “hibernate” through the next year before returning to the skies starting in April 2021. Without state funding, Norwegian could become another coronavirus casualty.

The Air France-KLM group, which has grounded 90% of its fleet since the crisis began, is also looking to the future, with the help of a massive bailout from France and the Netherlands.

The French state, a 14.3% shareholder in Air France-KLM, is granting a total of €7 billion in loans. The Netherlands, which holds 14%, has pledged €2-4 billion in aid, likely to be made up of a guarantee and a loan. But the group knows the combined €9-11 billion of aid it is set to receive comes with strings attached.

After France made its announce-

ment, Air France-KLM CEO Ben Smith said the funding was “not a blank check.” The Dutch finance minister said the funding was provided with the understanding that Air France and KLM, “take measures, to be set out in a restructuring plan, to ensure they will be able to continue playing a significant role in what is a highly competitive international aviation market.”

On the Dutch side, the government is asking staff to take a pay cut. The highest earners are expected to make the biggest contribution, but KLM will also “make a contribution in terms of sustainability and nuisance reduction, for example by cutting back the number of night flights.”

Before the crisis hit, Air France-KLM, which also includes LCC subsidiary Transavia, was conscious of the need to restructure.

Smith took the helm of the group in September 2018 with the mission of improving its performance and narrowing the profitability gap with its peers. In November, he launched a restructuring plan aimed at doing just that by simplifying and modernizing the fleet, improving efficiency and reducing operating costs, refocusing on profitable segments and boosting its two hubs at Paris Charles de Gaulle Airport and Amsterdam Schiphol Airport.

The group has already made progress with that plan, including major aircraft orders for Airbus A350s and A220s as well as the decision to retire its A380s. But apparently the restructuring already underway is not enough.

“Faced with the upheaval the world is going through, we are going to have to rethink our model immediately,” Smith told staff in a video message after France pledged its aid.

Smith said the group’s transformation would now work toward the single priority of regaining economic and financial security as quickly as possible “in order to survive in this ferociously competitive marketplace in which we operate.”

He also promised to focus on environmental transformation, reflecting wider calls for state aid to airlines to be contingent on greater efforts to improve sustainability.

“We must dedicate our efforts to imagining and implementing a more environmentally friendly aviation model,” Smith said. “I believe this crisis could have a silver lining.” ☘

—With Alan Dron in London

Lufthansa is currently flying about 1% of its usual passenger volume.



MARIO HOMMES/DEFODI IMAGES/GETTY IMAGES

737 MAX Return Timeline Remains Uncertain

- BOEING CHANGING WIRING ON UNDELIVERED JETS
- PANDEMIC HOLDING UP KEY TRAINING REVIEW

Sean Broderick Washington

Boeing has begun modifying horizontal stabilizer control wiring on its stored Boeing 737 MAX fleet, but several key tasks required before the aircraft can return—including an important training program review by global regulators—remain in limbo, in part because of challenges introduced by the novel coronavirus.

the accidents. The most significant: reworking wiring to ensure MAXs comply with electrical wiring interconnect system (EWIS) regulations added in 2009 to prevent short circuits and other hazards from creating safety risks.

As part of Boeing's work following the model's grounding, the FAA asked the manufacturer to examine possible faults that could cause uncommanded horizontal stabilizer movements. Boeing identified about a dozen places within the wiring bundles where it could not guarantee required separation of stabilizer trim motor wiring. It also could not guarantee that a wiring fault would not cause an uncommanded stabilizer movement, though the scenario has never occurred on the 737 fleet.

The wiring bundles in question are the same on the 737 Next Generation (737NG) and the MAX. But the EWIS rules in question, Part 25.1707, were added after the 737NG's certification.

Boeing argued that the NG's fault-free service history meant the issue is not a safety problem. The FAA said the undelivered MAXs must comply with its rules so they can get airworthiness certificates needed for customer delivery.

"We've begun work on modifying wiring and will continue to ensure the 737 MAX meets all safety and regulatory requirements before it returns to service," Boeing says.

The work involves running new wire outside of an existing bundle to replicate functions performed by wire in the bundle. The FAA and Boeing are still determining how to address the 387 MAXs delivered before the grounding. The most likely scenario is an airworthiness directive based on a still-to-be-issued Boeing service bulletin. It is not clear whether the FAA will require wiring in already-delivered MAXs to be modified before they can fly again, or give operators a longer grace period to make the changes.

Meanwhile, the manufacturer continues to work with regulators on other outstanding issues that must be addressed to ensure the MAX meets requirements. Flight testing of the new software has continued, as have meetings between civil aviation authorities and Boeing representatives to review software and training changes. Work is being done remotely where possible because of travel and other restrictions linked to the pandemic.

The limitations are holding up at least one critical return-to-service task: evaluation and approval of proposed new MAX training. One of the steps is a multi-day evaluation by a Joint Operational Evaluation Board (JOEB), a group of pilots and other regulatory officials from several civil aviation agencies that will review the proposed MAX training using simulators. The JOEB's report will help shape the FAA's Flight Standardization Board document that will spell out the minimum recommended MAX training. The JOEB's work session has not been scheduled, Boeing confirms.

The FAA in early April completed another must-do to get the MAX back into airline service: updating the model's master minimum equipment list (MMEL). The new MMEL includes several changes linked to the flight control software modifications. The most notable addition, however,

Boeing must modify wiring in more than 400 MAXs before delivering them to customers.



DAVID RYDER/GETTY IMAGES

In January, before the spread of COVID-19 led to travel restrictions and wiped out nearly all passenger travel demand, Boeing CEO Dave Calhoun expressed optimism that the FAA would approve the 737 MAX's return around mid-year. Boeing now says several issues will keep the MAX grounded into the third quarter at least. Regulators ordered the fleet parked in March 2019 following two fatal accidents in 133 days. Calhoun's mid-year projection included extra time for a few unforeseen issues. Boeing maintained this was a prudent consideration since the MAX's grounding has been prolonged by numerous findings that regulators determined need addressing. Many of them focus on the MAX's flight control computer software, including the Maneuvering Characteristics Augmentation System (MCAS) flight control law.

The MCAS played a central role in both MAX accident sequences, commanding nose-down stabilizer inputs that were not needed because faulty angle-of-attack data told the flight control computer that the MAX's nose was too high. In both cases, Lion Air Flight 610 in October 2018 and Ethiopian Airlines Flight 302 in March 2019, the pilots did not understand what was happening and could not figure out how to override the MCAS.

Boeing also is tackling other issues that have no link to

is that MAXs will require at least one working autopilot.

The change, which was not included in draft versions, has nothing to do with the accidents and subsequent software changes. Rather, one of the MAX's non-normal checklists calls for pilots to engage the autopilot as part of troubleshooting.

The scenario is linked to the MAX's fly-by-wire spoiler system, one of the changes Boeing made from the 737NG design. When the MAX's elevator-jam landing assist system is active and spoilers are extended, pilots are told to use the "ASSIST ON" non-normal checklist. One of its steps is to engage one autopilot system to retract the spoilers, and then use autopilot "as needed."

The original MAX MMEL, approved in 2018, allowed dispatch without either autopilot functioning so long as the planned route times were not too long, routes and approaches avoided airspace that require an autopilot, and pilots, who face higher workloads when hand-flying, did not object. All other 737s, which are covered under a different MMEL, have similar conditions.

But the MAX's new spoiler system and associated checklist created a conflict—mandating use of an autopilot even though one was not always required to be functioning—that went unnoticed until operators began reviewing the proposed MMEL revision. MAX operator FlyDubai pointed out the change, according to an FAA document.

Requiring a functioning autopilot meant mandating several related functions that were previously not required for

dispatch. They include having a working autopilot-engage command switch, indicator light, aural disengage warning system, disengage light and control wheel disengage switch.

The MMEL/checklist conflict is a reminder of the challenges both Boeing and the FAA face to earn back industry confidence following a year-plus grounding of the manufacturer's key commercial product. The MCAS' suspect design, combined with inaccurate assumptions about how pilots would react if the system activated when it was not needed, led to the model's grounding. Besides changing the MCAS software, Boeing was tasked with a top-to-bottom review of the MAX's design, paying special attention to how pilots were trained to interact with the flight control system.

Because the MCAS was intended to function in the background, Boeing did not include a description of it in the original MAX pilot manuals. Investigators determined this was one of several missteps that helped set the stage for the accidents.

Despite the intense scrutiny during the grounding, the MMEL conflict—a fundamental incompatibility that should have been caught during design review—was discovered 18 months after the MAX entered service, by an operator.

"The whole world is watching both organizations, and it seems reasonable that they'd both be stepping through the system very, very carefully and in lockstep," says one former FAA certification official. "It's not the run-of-the-mill daily procedures we're talking about, so one would expect especially all the non-normals to be thoroughly wrung out." ❧

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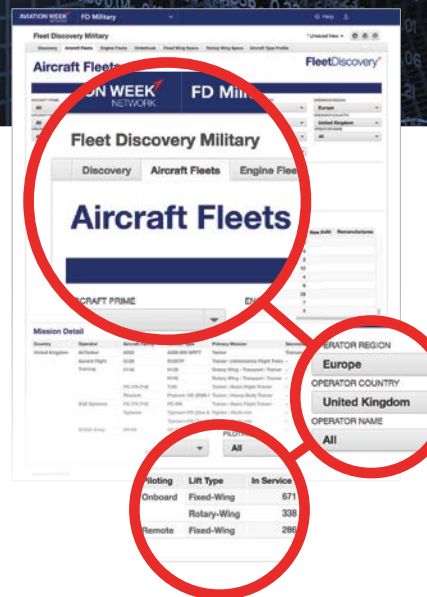
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AVIATION WEEK⁺
NETWORK

Air Traffic Plunge Reflects Advance of the Pandemic

- > MORE THAN HALF OF GLOBAL AIRCRAFT GROUNDED
- > DATA REVEALS COVID-19'S EFFECT ON REGIONS

Bill Carey Washington

There are various ways to measure the impact of the COVID-19 pandemic on commercial aviation—airline schedule reductions, canceled aircraft orders, government bailouts, layoffs—and all point to major upheaval. Among the starker indicators is the number of air traffic movements.

According to newly available satellite-tracking data, less than half the number of aircraft that were flying worldwide in January continued operating in mid-April because of travel restrictions imposed to fight the pandemic. The number of aircraft flown by major cargo carriers was only 4% less than the prepandemic level in November 2019, indicating that cargo largely continues to move.

The data comes from a collaboration between space-based surveillance provider Aireon and the Civil Air Navigation Services Organization (CANSO), which have partnered to measure the global impact of the pandemic on the flow of goods and services and to help signal where and when a recovery appears to take hold.

Aireon operates a global surveillance network based on automatic dependent surveillance-broadcast (ADS-B) receivers carried by Iridium Next low-Earth-orbit satellites. The receivers capture signals from ADS-B-equipped aircraft and route the data to air navigation service providers (ANSP) that subscribe to Aireon's service. CANSO, based in the Netherlands, represents world ANSPs.

The continuously broadcast signals contain data including an aircraft's horizontal position, altitude, velocity, identification and call sign, which an ANSP can combine with ground-based surveillance and flight plan information for air traffic management applications.

Parsing the impact of the COVID-19 pandemic is yet another unplanned use of the system, which became fully operational in late March 2019 upon the completion of the Iridium Next satellite constellation. That month, data that Aireon shared on the position and trajectory of Ethiopian Airlines Flight 302 before it crashed minutes after takeoff prompted the FAA to ground the Boeing 737 MAX.

Announcing the collaboration with CANSO, Aireon CEO

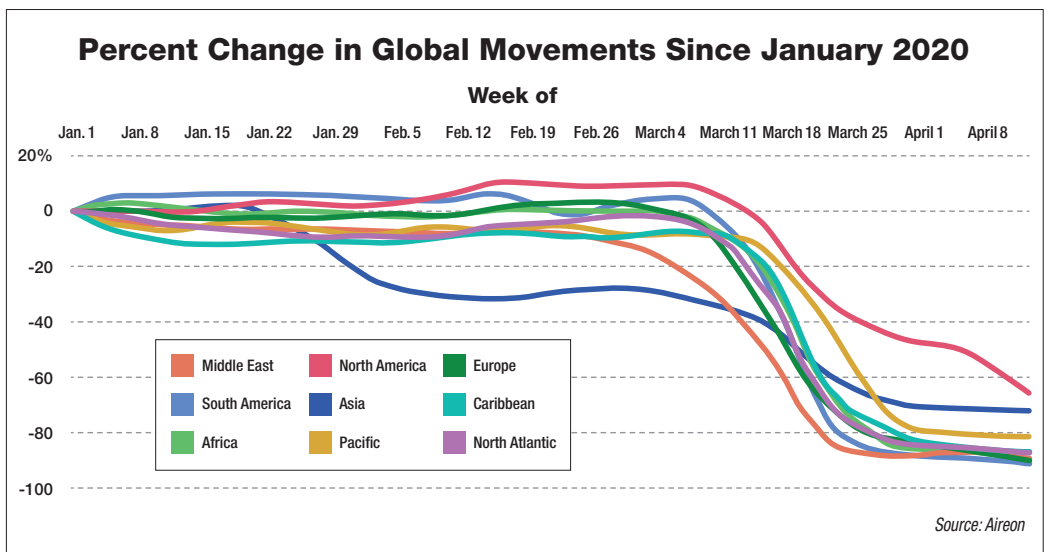
Don Thoma noted: "Good data has been fundamental to tracking the spread of COVID-19, and it is clear that jurisdictions making decisions based on strong data have been the best prepared. Aireon is proud to partner with CANSO to deliver data-driven insights in the hopes our efforts will provide answers in the face of growing questions."

Data reveals that on April 13, Aireon's space-based ADS-B system tracked 16,780 transponder-equipped aircraft—down 56%, or about 21,000 aircraft, from the 37,780 average unique aircraft tracked during the first week of January.

"Broadly, we saw just about half the world's unique aircraft on the ground, parked, within four weeks" of the U.S. and European nations imposing widespread travel bans in mid-March, said CANSO Director General Simon Hocquard, during an April 16 webinar.

In addition to fewer aircraft flying, the data also reveals a 74% decline in average global aircraft movements and a 72% drop in global flight hours compared with the first week of January.

"On average, in the first week of January, each aircraft flew approximately 6 hr. daily, whereas on the 13th of April, each aircraft was only flying about 3.8 hr., and there are less aircraft flying," Hocquard said.



On a regional basis, there were 91% fewer flights in South America in mid-April compared with early January, 89% less in Europe, 88% less in Africa, 87% less in the Middle East and 64% less in North America.

Asia, the region in which the novel coronavirus that causes COVID-19 originated, appeared to be bottoming out at 72% fewer flights than in January. But Hocquard tamped down any expectation of a speedy return to normal global operations.

"Everyone is still looking to Asia for signs of recovery. But the opening up of domestic travel in China, and some international [travel], has been offset by declines in other parts of the Asia-Pacific region. So while we see a leveling, we're not seeing signs of a regional traffic increase just yet," he said.

"Interestingly, though, Air China has filed a domestic schedule for the weeklong May holidays coming up that offers similar capacity to 2019 levels," Hocquard added. "That, I think, is a remarkable sign of planned domestic aviation recovery." 🌐

MAY 2020

InsideMROTM

Component MRO Market Eyes Recovery

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With most of the fleet idled or parked due to the pandemic, assessing the MRO market has become problematic

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MAINTENANCE CHECK

Pace of Rebound

While accurately predicting what the MRO market will look like, even at the end of this year, is tricky due to the COVID-19 pandemic, these recent figures and facts could hint at what it will be.

Big mergers during these cash-crunch days are not happening: Boeing and Embraer, as well as Hexcel and Woodward, both called off their planned deals. However, the one-stop-shop concept isn't going away, so MRO consolidation will continue.

The number of parked aircraft is probably at or near its peak. Aviation Week Network's Fleet Discovery data shows nearly 16,000 aircraft are parked and about 3,500 are in parked/reserve status (flying 1-2 days during a 7-day period). Airbus A320s and Boeing 737s comprise 9,300 of that total, meaning that more CFM56s are parked than any other engine type by far.

A decrease in aircraft belly freight due to fewer flights is leading to new opportunities for cabin modifications as airlines temporarily carry freight in their cabins. Companies such as HAECO Cabin Solutions are designing products to place freight on or between seats, or removing seats to make room for a "palletized" unit on the floor.

Airline travel will most likely recover at a slow, gradual rate, rather than a V-shaped spike. That means not all of the aircraft and engines will return. As airlines and lessors determine whether their aircraft and engine assets are worth more remaining whole or as pieces, teardowns will increase. This will lead to more used serviceable material.



"A hint of what it will be."

Until travel restrictions ease, however, the industry faces all sorts of logistics problems—from people to parts.

For instance, lessors' scheduled returns are being held up because of travel restrictions and quarantines. They need to find local resources to perform maintenance, inspect the aircraft and sign the required documents. "This delay creates the risk that a long-stop date in the next lease with a follow-on operator is passed, and the follow-on lease is terminated," says Bill Gibson, a partner at Vedder Price.

On the bright side, one thing that is helping airlines and aftermarket companies through this crisis is remote collaboration tools. During an Aviation Week webinar April 22 on MRO compliance, 67% of participants said they had looked into remote collaboration tools before the COVID-19 crisis and 19% said they had done so since.

These tools and others—such as what AAR is piloting (see MRO page 15)—will make the MRO industry more efficient.

Companies are understandably trying to preserve their cash, but in these times it is important to focus on your business fundamentals so your company will meet customer needs and expectations and be positioned for the future post-COVID-19—because the market will recover. It will look different and it might take a few years, but it will rebound. ☺

—Lee Ann Shay

Aviation and COVID-19

The aviation industry has faced its share of disruptive challenges, and each time it has emerged stronger. With that in mind, Aviation Week is expanding our COVID-19 coverage with content that not only helps in the short term with news and situational awareness but also skews to predictive and best-practices content that will help our industry make good decisions now—and for the better times ahead.

Updates Access coronavirus coverage from across the Aviation Week Network—including current news, a new weekly webinar series and expert forecasts and analysis of what's next for our global industry: [Aviationweek.com/coronavirus](https://www.aviationweek.com/coronavirus)

Highlights

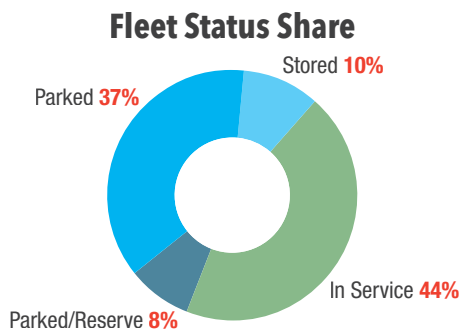
LHT Offers Cargo Conversions

Lufthansa Technik has launched a new service in response to the surge in demand for cargo services since the COVID-19 crisis has grounded the vast majority of passenger aircraft and with them, their belly capacity. It obtained Engineering Order Specific Tailsign approvals from the German Federal Aviation Authority to convert four of Lufthansa's 236-seat Airbus A330-300s. The A330s are now fitted to transport medical supplies to meet the growing demand for airfreight during the coronavirus crisis.

As demand for transporting commercial goods by air is growing rapidly, LHT is working to obtain supplemental type certificates for all common aircraft types so that airlines can quickly convert their passenger aircraft into auxiliary freighters.

Thousands of Aircraft in Reserve Status

Aviation Week's Fleet Discovery data shows nearly 16,000 aircraft in parked status and an additional 3,600 in parked/reserve status, meaning aircraft are flying once or twice during a seven-day period. Airlines often do this to maximize fleet flexibility, keep aircraft out of short-term maintenance and maintain crew flexibility. As of April 24, the top three operators using this tactic were Delta Air Lines, United Airlines and Ryanair.



Source: Aviation Week Fleet Discovery

Boeing Makes Leadership, Structural Changes

Boeing has tapped Mark Jenks to lead a new Airplane Programs organization that the company expects to ensure both consistency and efficiency throughout its core commercial aircraft production efforts—one of several changes aimed at aligning similar businesses.

This step will combine management of its external and internal supply chains under Elizabeth Lund, currently Boeing Commercial Aircraft's vice president for the supply chain. Lund will oversee not only Boeing's 3,000 external suppliers but also internal parts, subassembly and kit procurement coming out of Boeing's sites around the world and feeding into its production facilities.

Boeing also is combining management of its Seal Beach, California-based Customer Support organization under Mike Fleming, who is head of the company's recently created Global Aviation Safety System as well as the 737 MAX return to service effort. The change will streamline commercial customer support, including the need to deliver 420 stored MAXs to customers and another 385 stored MAXs in operators' hands back into service, under a single leader.

EASA Releases Cabin Air Circulation, Cleaning Guidance

The European Union Aviation Safety Agency (EASA) has released a safety information bulletin (SIB) series aimed at limiting the spread of the COVID-19 virus. The SIB urged operators to crack down on pilots and cabin crew members who may be using their own cleaning products on aircraft. Using unapproved cleaning agents could damage surfaces or mix with other cleaning agents to create fumes that could endanger passengers and crew members, the agency says.

EASA's operational guidance also addressed the issue of minimizing the virus's presence in cabins. Aircraft with high-efficiency particulate air (HEPA) filters in their cabin air system are well-equipped to minimize the spread of the novel coronavirus, but those without such systems should consider minimizing cabin air recirculation, the agency concludes. EASA's latest information on containing the virus and the COVID-19 illness it triggers—updated April 7—revises previous guidance that recommended using air conditioning, which draws in fresh air, as much as possible. 🌐

Contracts

Aeronautical Engineers was selected by **KF Aerospace** of Canada to convert three 737-400s to freighters; the first (24769; ex-Flair Airlines) is scheduled to commence modification in May 2020 at KF Aerospace's Kelowna, British Columbia, facility.

De Havilland booked its first order from **Jazz Air** for SB/kits to convert 13 Dash 8-400s to package freighters. The reconfiguration includes 17 cargo nets to provide a total payload of up to 17,960 lb. and a total cargo volume of up to 1,150 ft.³ per aircraft.

S7 Technics of Novosibirsk, Russia, was selected by **Air Astana** to perform C checks on two Boeing 757-200s prior to their return to lessors.

ST Engineering secured S\$838 million (\$591.5) in aerospace contracts in first-quarter 2020 versus S\$1.3 billion in first-quarter 2019. The new deals include MRO contracts from Chinese airlines for A320s and CFM56-7Bs and from a Southeast Asian airline for 737 and Bombardier Q400 component support.

Wideroe reached an agreement with **Luftambulansetjenesten** to convert some de Havilland Dash 8s into Bodo-based air ambulances.

Contract Source: SpeedNews

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Pandemic's Ramifications Help Advance Remote Technology

It is tempting to think that aviation will derive nothing positive from the novel coronavirus pandemic. While parked aircraft, smaller operators, and a generally downsized industry are clear negatives, some changes forced by the spread of COVID-19 will benefit the industry long after the viral menace is gone.

In the regulatory compliance area, expansion of remote technology may end up being the most positive development. Using technology such as cameras was never prohibited, but its use was not readily embraced by certificate holders. In March 2020, the U.S. FAA's Aircraft Certification Service, backed by several years of industry input, fast-tracked guidance on technology such as cameras and video conferencing for a range of required tasks, including conformity inspections as well as engineering and ground tests. On April 20, the FAA's Flight Standards unit followed up with its own inspector guidance, providing a framework—but, importantly, not prescriptive limitations—that expands technology's use deeper into the MRO world.

The guidance provides general considerations of which inspectors should be mindful when video and communication technology (VCT) is proposed to help accomplish tasks. Among them: Video quality must be sufficient for the task and must provide some method of validating that whatever is being recorded or broadcast is happening where and when it is supposed to—think time stamps, for example.

The order does not exclude any specific technologies or products from eligibility, saying only that the tools must be able to “accomplish the task.” The only exception is a general one: FAA personnel must use government-issued devices for any tasks they perform. An example: Watching a video shot by a certificate holder on a government-issued laptop or smart phone.

VCT may “enhance processes and procedures” or may serve as an “alternative” to a given task, the FAA



MRO shops are confident that remote technology can be used on everything from article inspections to facility audits.

guidance says. The technology also can be used live. For example, picture an inspector watching a video feed of an inspection and directing the camera holder on what should be shown.

Industry stakeholders are confident that the new guidance, combined with the realities of the pandemic-related social distancing, will prompt rapid adoption of VCT. Certificate holders can use devices as simple as a smart phone to record evidence of accomplishing tasks that the agency can then validate.

Airframe services specialist MRO Holdings is among the aftermarket providers embracing the new technology. The company was in the midst of a major facility expansion when the pandemic hit. A required FAA facility inspection was due, but getting an inspector out during the pandemic was a nonstarter. Instead, the inspector was brought in virtually, using a video-conferencing service.

In addition to serving as the FAA inspector's “eyes and ears,” the link allowed for digital photos to be taken and electronic documents to be deliv-

ered, says Gregg Brown, MRO Holdings vice president of compliance and technical solutions. The inspection took 3 hr., and the facility was approved for use right away.

The company has loftier aspirations for VCT. It uses remote links to connect a newly centralized planning, engineering and supply chain operations center with its multiple airframe facilities. The setup means the company can put a team of experts in each MRO shop without their having to physically be there, Brown says. A similar approach could eventually be used to help customers keep tabs on aircraft in MRO Holdings' facilities with fewer airline technical representatives on-site.

“I think [we will be] in a rapidly evolving landscape for the foreseeable future,” Brown says. “This crisis is going to spur some really innovative thinking, and I'm really excited as a technology geek to watch this happen.”

—Sean Broderick in Washington
and Lindsay Bjerregaard in Chicago

ARSA UPDATE

Remote Possibility

IN 2018, I USED MY SPACE IN THE September edition of *Inside MRO* to call out the aviation industry's inside-the-box mentality. Having seen the general excitement stirred up by well-hyped technological advancement, I could not believe the hidebound habits preventing new (ubiquitous) tools to streamline aviation safety.

The subject of my incredulity at the time focused on FAA guidance for "video-witnessing" testing or inspections in design activities. "Are you kidding me—videotaping?" I thought.

For months, the agency and industry explored how both regulators and certificate holders could use broadly available remote connectivity tools and technologies to enhance the "capability to ensure original design or production elements are met and to supervise design, production, operation and maintenance activities or to perform inspections."

As a result of the engagement, 16 aviation trade associations delivered a draft advisory circular to the FAA outlining basic standards for the use of remote technologies. Within a few months, the FAA concurred with the industry's interests and promised explanatory guidance in relatively short order. We were still waiting for that guidance as recently as a couple of months ago—it was still stuck inside the box—until COVID-19 became a global pandemic.

Then things started to move quickly.

On March 15, the White House issued a memorandum directing government agencies to realign operations to slow the spread of the novel coronavirus. Agency leaders were instructed to "utilize the full extent of their legal authority and discretion to execute this realignment" and to "maximize telework . . . while maintaining mission-critical workforce needs."

ARSA seized on that direction to remind the industry and agency about

the work both had done on remote connectivity. On March 31, the FAA's Aircraft Certification Service issued its policy (as promised, albeit a year late), and Flight Standards followed on April 22 with a memorandum to its employees about "Video and Communication Technology."

You can find and review both policies—along with the industry's work to shape them—at [arsa.org/remote-connectivity](https://www.arsa.org/remote-connectivity). The bottom line is that the agency is openly acknowledging the use of any technology that achieves the purpose of the regulation and will show compliance.

Here's the frustrating thing: The industry was already down that road. When ARSA's Brett Levanto participated in an Aviation Week webinar on April 22, an audience poll indicated that more than two-thirds of the participants were exploring and using such tools before the pandemic.

"In terms of remote connectivity, using tools to engage over distances is not a new emergence—it's not something that the switches were flipped on just because suddenly inspectors, customers or other parts of the supply chain had to stay home," Levanto said during the webinar. He noted ARSA members had made headway implementing use of remote tools based on one of the association's key principles of compliance: "What's not prohibited is allowed."

We're not completely out of the box yet, but the industry, particularly those who are just undertaking the use of these connection tools, now have more than a remote possibility of making reasonable connections. 🌐

Sarah MacLeod is managing member of Obadal, Filler, MacLeod & Klein and a founder and executive director of the Aeronautical Repair Station Association.



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Croatia Airlines

Davor Bujan, technical director of Croatia Airlines, discusses with James Pozzi how the airline has adjusted its maintenance activities in the wake of the COVID-19 pandemic.

How has the COVID-19 outbreak affected Croatia Airlines' maintenance operations?

Croatia Airlines Technical Services is maintaining our own fleet and performing line and base maintenance work for our customers. As for the Croatia Airlines fleet regarding the COVID-19 situation, we are adapting to the changes in the flight schedule, following all recommendations from our health authorities by using protective equipment, and working in 14-day schedules with staff operating from home whenever possible. We are continuing to work in hangars with a reduced capacity but are still performing base maintenance work on our aircraft at our base in Zagreb.

What about maintenance work for your third-party customers?

Regarding customer aircraft, we had some slot cancellations in our hangars due to travel restrictions for customers' crews and technical personnel. Line maintenance has basically stopped for third parties since most airports are closed and most companies have ceased operations. There is some limited line maintenance work still taking place at Zagreb Airport to support our daily flight to Frankfurt and some activity at Brussels, but there has been a complete shutdown at the rest of our line stations. The impact of COVID-19 has been immediate, has been hard and will continue to be so.

Will Croatia Airlines' maintenance teams undertake any work on the carrier's grounded aircraft?

We are still performing heavy maintenance on one of our de Havilland Dash 8-400s, but of course with limited capacity. From a manpower perspective, this is taking place with a differ-

ent shift schedule—that is, minimizing the number of personnel in shifts. We have also faced difficulties in areas such as parts ordering and logistics. We are using this opportunity to perform some engine changes and minor work on the rest of the fleet. Parking and storage procedures will also require some maintenance capabilities during this period.

From a workforce perspective, what measures has Croatia Airlines taken to ensure staff safety?

As already mentioned, we adapted to the COVID-19 situation to completely follow recommendations from our health authorities and company crisis management staff. In every department where working from home is possible, we organized ourselves in a way that allowed work to continue without stopping and that assured the continuing airworthiness of our fleet. Special measures were issued, reducing risks to acceptable limits. For the personnel that need to be at work sites, we organize working times and shift schedules to minimize the number of personnel present during working hours. We also introduced 14-day rotations to allow isolation of staff if necessary.

Will the airline look to do more maintenance in-house?

Our long-term strategy is to perform the majority of work in-house with our own personnel. We invest a lot of resources to maintain a stable but flexible system in our technical department, relying on highly skilled personnel. We are fully capable of performing heavy maintenance on our fleet including six-year and 12-year checks, nondestructive testing, shop work and engineering. However, despite this extreme new situation of closed borders and limited travel, even within cities and within our country,



CROATIA AIRLINES

Croatia Airlines Fact Box

FOUNDED: 1989

FLEET: 14 aircraft, comprising five Airbus A319-100s, two A320-200s and seven de Havilland Dash 8-400s.

REACTION TO COVID-19: The airline expects to resume domestic operations on May 11, following their suspension in mid-March. While most airports in Croatia remained open during the novel coronavirus pandemic, Croatia Airlines was only operating a once-daily flight from Zagreb to Frankfurt.

MAINTENANCE CAPABILITIES: Croatia Airlines Technical Services, the airline's MRO affiliate, carries out A-D checks on A320, de Havilland Dash 8-400 and ATR 42/72 aircraft on both the airline's fleet and for third-party customers. For line maintenance, it operates several stations across Croatia, as well as one each in Sarajevo, Bosnia and Herzegovina, and Skopje, North Macedonia. The carrier also offers European Union Aviation Safety Agency (EASA) Part 147 approved type training courses and EASA Part 145 approved training courses.

we will continue work on our fleet, to be completely ready when the time comes for our aircraft to fly again.

Are you looking at reevaluating existing maintenance contracts?

Yes, of course. We are in continuous talks with our partners and maintenance providers to find mutually acceptable solutions on how to overcome this difficult and unexpected situation.

It is unprecedented that basically a complete industry has ground to a halt in such a short period of a time.

How do you think the MRO industry will change as a result of the coronavirus?

In the first period of recovery, perhaps during the next few months after COVID-19, there will obviously be reduced demand for MRO services due to a decrease in utilization of the worldwide fleet. If the crisis lasts through the whole of 2020, it will probably result in more fleet retirements, which will impact the MRO industry as well. Analysis and predictions regarding MRO capacities and demand that we had previously made need to be re-drawn and adjusted to this new and completely different situation.

In the last few years, we have been facing great demand for MRO services—for instance, extremely high demand for engine shop visits. Many new facilities were opening and many pre-



CROATIA AIRLINES

dictions were made about how much skilled labor the industry would need in the future. Now we see many of the big airlines retiring older aircraft, canceling new orders and reducing their fleets. In our opinion, MRO providers that based their future on steady and continuous growth by developing internal capabilities and—most important—investing in their own personnel will have the knowledge and experi-

Some heavy maintenance work has continued, albeit in reduced volumes, at the airline's Zagreb facility.

ence to adapt to the new ball game. Investing in quality, fostering a fair and open relationship with customers and investing in your own people will pay off in the long run. Good planning and teamwork will ensure that we will fly again. ✈

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A photograph of a warehouse interior. A worker wearing a blue shirt, grey pants, and a safety harness is standing on a wooden pallet. He is operating a black and silver Raymond forklift. The warehouse is filled with tall yellow metal shelving units stacked with numerous cardboard boxes. The lighting is bright, and the perspective is looking down the aisle between the shelves.

A DISRUPTIVE INFLUENCE

Component MROs focus on the post-pandemic market

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

With global air travel severely disrupted by the COVID-19 pandemic, the component MRO market is expected to take a hit, at least in the short term. Yet suppliers of engine and aerostructure components maintain that demand is generally holding steady despite projected decreases in MRO spending and some pricing pressure.

Prior to the pandemic, the component MRO market for 2020 was estimated at \$17.5 billion. However, now a decrease of \$5.4-8.3 billion is projected in component MRO spending over three years, according to Aviation Week Commercial Fleet and MRO Forecast data.

"The effects of the COVID-19 pandemic are likely to be felt for at least 18-24 months; perhaps even longer as the dramatic knock-on effects resonate through economies, airlines and MROs," says Brian Kough, Aviation Week's senior director of forecasts and aerospace insights.

The International Air Transport Association (IATA) recently projected an overall air traffic decline of 38% in 2020, which would "likely be the floor" for any corresponding decline in component MRO. "Since many components are maintained 'on condition,' their maintenance demand is directly proportional to fleet utilization," says Adam Guthorn, a director of the Alton Aviation consultancy in New York.

Guthorn says that with a significant portion of the fleet parked, and airlines throughout the world focused on cash conservation, increased aircraft retirements and material availability, along with cannibalization and borrowing of components from stored aircraft are expected to reduce demand for MRO services in the near term.

Component MRO will face competition from surplus parts and inventory "burn-down," notes Richard Brown, managing director of the NAVEO consultancy in London. At the same time, midlife aircraft—those 12-17 years old—will become yet another competitive source of supply in a component MRO market that he predicts could be down 25-30% this year.

"While the drop in air travel demand will encourage airlines to retire aircraft in their sunset or end-of-life phase, we



GE

will start seeing the premature retirement of midlife aircraft that are most likely to require engine shop visits, as well as airframe and component maintenance,” Brown says. “That will likely mean more availability of used serviceable material (USM) as retirements increase and more aircraft are parked.” He notes that airline capacity could be down 70-80% in April 2020.

“While more USM will benefit the airlines, it could also challenge the USM traders who might see an excess supply of some part types and pricing pressure on inventory previously thought to be valued higher,” Brown cautions.

PRICING DYNAMICS

USM can be characterized as a spot market that will fluctuate with demand, says Horacio Repetto, general manager of GE Aviation Materials (GEAM), a major USM supplier. “As many MROs are currently slowing down and furloughing employees, the USM market dynamic is that demand will follow that trend,” he says.

Those factors, Repetto explains, will result in sellers seeking to align supply with demand, rather than sell when demand is low in lieu of preserving value. “Cash pressure dynamics could shift that behavior, and it will be important to monitor the market leaders,” he remarks.

Repetto predicts the USM market should continue to align

The market for used serviceable material, pictured in inventory at the GE Aviation Material warehouse, has not undergone substantial change, although some brokers are being cautious about buying material that may have to be held longer.

with global demand for shop visits and the resulting actions on MRO capacity. “There has been no substantial change to the USM market, although we have seen some brokers being cautious with buying inventory that may require being held longer in order to find demand,” he says.

Although it is difficult to say when traffic will recover, Repetto cites a report from IATA that predicts a return to 2019 traffic levels by the end of 2020. That, he says, will mean stored aircraft will be required to meet demand. “For the USM market, it will be important to monitor closely the actions that aircraft and engine operators, as well as owners, take with respect to utilization and future shop visits,” Repetto notes.

Component traders and leasing companies are taking the long view, confident that the downturn in MRO will not be long-lasting.

“For the commercial aircraft engine and airframe component market, all the expected trends have shifted with the focus on COVID-19,” says Anca Mihalache, vice president of engine trading for APOC Aviation, a Netherlands-based component leasing, trading and aircraft part-out company. “Over the last three years, there had been a steady increase in narrowbody aircraft engine sale prices and lease rates, which were expected to continue or remain at the same level. Now we can see prices slightly decreasing.”

Mihalache points out specifically lease rates for engines powering the Boeing 737NG and the Airbus A320neo, predicting that they might not return to what they were only a few months ago. Even so, she expects those engines will still have a high value after the pandemic passes.

The CFM56 could, in fact, be a bright spot. Mihalache cites the protracted Boeing 737 MAX grounding as the reason behind ongoing demand for CFM56 components, with those for the CFM56-7B generating the highest pricing increase. This has also led to higher prices on CFM56-3C1 material, but on a lower scale, she says. Those engines, respectively, power the 737NG and 737-400, many of which Mihalache says have been converted from passenger to cargo aircraft.

“The cargo operators are now the ones generating high demand. That’s why I think the narrowbodies—the Boeing Classic/NG and Airbus A320, will always do well,” Mihalache states.

As for the availability of USM, Mihalache believes that material shortages will continue. “Even if some airlines do not survive, their aircraft will be redirected to other operators,” she says. “Not many will be retired, so I expect the material shortage on the CFM56 and V2500 engine types to remain.”

Jasper van den Boogaard, APOC Aviation’s vice president of airframe acquisition and trading, predicts demand for airframe components will remain steady. Even if aircraft are grounded, he asserts, they will still require calendar-driven maintenance checks and gear overhauls. “At APOC, we focus on two main asset types—the A320 family and the 737NG series, which make up over half the world’s fleet,”

says van den Boogaard, who is also an International Society of Transport Aircraft Traders (ISTAT) certified appraiser. “Historically, these have always recovered first after any [adverse] market influence.”

Karolis Jurkevicius, APOC Aviation’s vice president of landing gear trading and leasing, reports that depending on landing gear type, there has been a 5-10% decrease in landing gear lease rates, with the likelihood of a higher percentage drop due to an increase in assets available now—given the COVID-19 situation. He cautions that while demand should recover soon, prices will stay at a lower level for a longer period. “I’m sure that prices for some types of landing gear will come back to normal levels, as demand will still be high. However, others will remain low and never recover,” Jurkevicius says.

As the COVID-19 crisis abates, there will be “a massive upsurge in demand” for components, predicts Martin Ward, director of material management and supply chain for Vallair, a Luxembourg-headquartered aircraft leasing, trading, MRO and teardown company.

In fact, Ward reports that “progressive companies” already are buying up packages of spares from their providers for leading commercial airliner types, at bargain prices, as airlines look for ways to resume flying as fast as they can. “Aircraft in storage will have been subjected to daily/weekly checks to ensure everything is still operational so engineers and maintenance teams will know exactly what their needs will be,” he stresses, adding that packages of spares continue to be offered to Vallair. “If those packages come with the right traceability and paperwork, and they suit our own fleet of leased aircraft, then we’re interested.”

Technicians reassemble nacelle components at Vallair’s maintenance facility in Montpellier, France.

Vallair has observed ongoing interest in CFM56-5A engine parts, which “seems to go against perceived wisdom,” Ward says. “It appears that brokers want to fill up their stock.”

CHALLENGES

One of the major challenges in the narrowbody aircraft engine and airframe component market is a scarcity of life limited parts (LLP), says Justin Blockley, commercial director of Bii.aero, located near London.

“LLPs for narrowbodies have steadily increased in demand and pricing since the problems with the 737 MAX,” says Blockley, whose company is a components and services provider specializing in the 737NG, 747, 757, 767 and Bombardier regional jet families. “This is the same for CFM56-5A material, as airlines are looking to utilize the existing fleet longer. Simply, demand has outstripped supply caused by capacity constraints of new aircraft deliveries.”

He also notes that aircraft retirements will continue to have a bearing on component MRO, but given current conditions, decisions are fluid, with “retirement plans being rewritten almost monthly,” he notes.

“The coronavirus is hitting the pause button on both new aircraft production as well as demand,” Blockley says. “Those airlines with weak balance sheets are likely to move more and more to leasing options in order to protect cash and move large assets to a variable cost model.”

Asked if the new generation of Airbus products, and the eventual return of the 737 MAX are likely to push many more aging aircraft into retirement and affect the component repair market, Blockley says it may be too soon to tell. “But I think that aircraft which have already been through a heavy check will definitely complete their life cycle,” he says.

He also states that with fuel prices “the lowest in living



VALLAIR

memory,” the economics of the new low-fuel-burn fleets, compared to their large capital acquisition costs, throw the investment algorithm into serious question. “This, coupled with the huge backlog in engine MRO, means it is likely that the retirement age will take several years to return to the levels once seen—about 15 years—especially on narrowbody aircraft. It could, in fact, go as high as 18,” he predicts.

One example of engine MRO demand Blockley cites is the CFM56-5, which he says is “still in massive demand” for both overhaul and teardown as operators look to replace LLPs with partly run components in an effort to match engine life with postponed airframe retirements.

He predicts that OEMs will have a great presence in the MRO market after the pandemic, but he thinks this will be countered by an increase in parts manufacturing approval (PMA) and designated engineering representative (DER) options, “as operators refuse to be bullied into accepting the OEM pricing structure,” says Blockley.

OEM GROWTH

Alton Aviation Consultancy’s Adam Guthorn says 60-70% of the component repair market is held by airlines and independent MROs, with the component and system OEMs holding the remainder. “I would expect that the OEMs could gain another 5% of that over the next decade, through new contract wins on the newest-generation aircraft types,” he says. “That is where the OEMs hold a ne-

gotiating advantage at point of sale; the independent repair market is less developed, and surplus material is not yet a major factor.”

According to Rick Stine, president of StandardAero’s components, helicopters and accessories division, OEMs will be taking a greater position in component MRO but largely through affiliated networks.

“In the past, the legacy engines tended to have a more open structure around what repairs a third-party shop could perform relative to MRO,” Stine explains. “Today’s newer-generation engines require an MRO provider to be part of the authorized OEM network. Only then can it get access to repairs and technical data.”

He stresses that even with such authorization the availability of data is still limited and at times requires a third-party MRO to pay additional fees or royalties to qualify repair capabilities. “This new reality will be a major game changer as OEMs continue to take more control of the MRO market,” he says.

Coupled with that, Stine predicts there will be a disinclination among the OEMs to continue doing touch labor. “I see the OEMs not wanting to turn wrenches in the future,” he says. “I think this plays into how they are approaching engine component repair, which is to develop networks they can use to support their fleet. The MRO facility’s ability to match its skills and expertise to the OEM’s needs will be critical to supporting them.”



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Filling the Gap

Maintenance providers shift to aircraft storage and minor repairs during fleet groundings

James Pozzi **London**

The novel coronavirus pandemic has done much to stunt the growth of commercial aftermarket activity so far in 2020, with MRO facilities reducing operations given the mass grounding of aircraft fleets worldwide.

Fleet inactivity has meant a slowdown in maintenance work and a wave of work order cancellations by airlines looking to preserve liquidity. In early April, consultancy Oliver Wyman painted a bleak picture of the market for this year, cutting its previous annual market projection by \$17-35 billion.

services, along with aircraft parking and requests for virtual table inspection—a function that allows customers to inspect parts from a remote location.

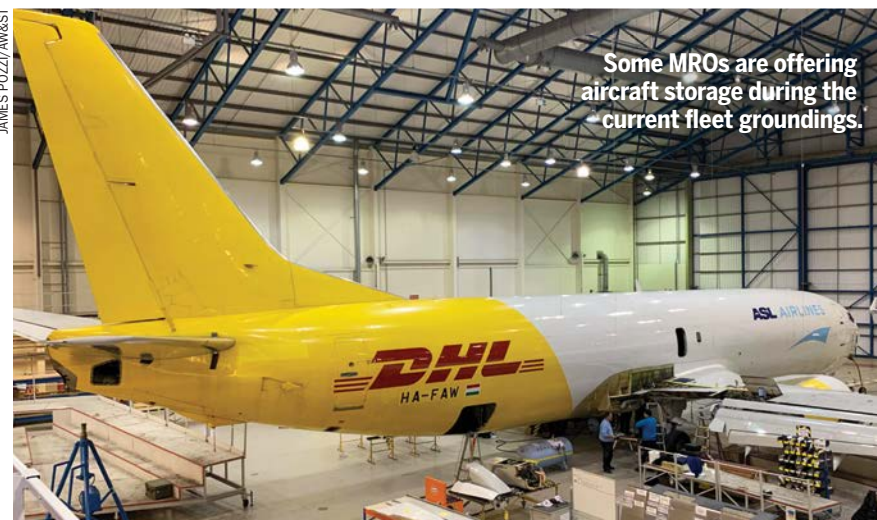
In its line maintenance business, which numbers 12 stations in Switzerland, Europe and Spain, SR Technics' customers are flying less, but the MRO has a solid backlog of requests to keep aircraft airworthy. "Currently, short-term aircraft storage maintenance, out-of-storage checks and return-to-service maintenance is high in demand, and we are prepared in case our customers require long-

ing a "quote and hold" program allowing customers to continue sending units to AJW Technique for technical evaluation without incurring any interim costs. It is also benefiting from carriers trying to maintain their fleets in airworthy condition during the groundings, with some even choosing to perform heavy maintenance inspections while their fleet is grounded.

In Italy, Naples-based MRO Atitech was approaching peak season in March for base maintenance, with customer airlines parked up in slots at full capacity about to undergo heavy checks. "We had a few slot cancellations from customers planned for the end of April and in May so far," says Pietro Pascale, Atitech accountable manager and managing director. Like many shops in Europe, Atitech temporarily reduced its workforce during the peak novel coronavirus period in mid-March but plans to start ramping up services again from May 4. Now it is focusing on storage services. "We are talking with customers in order to support them with parking and storage programs, and looking at how to reschedule new slots," he adds.

UK-based MRO Caerday, which has capacity to house up to 20 aircraft at its site at a former RAF airbase in St. Athan, Wales, is working with airlines looking to park their aircraft. Ben Lee, the company's commercial director, tells Aviation Week that "there has definitely been an increase. A lot of airlines and lessors are exploring options with their handbacks. Airports were very quick in offering support, but they don't have the capacity for everyone."

On the positive side, some analysts are predicting the MRO segment may bounce back within a two-year timeframe. In the near term, while existing maintenance orders aren't being fulfilled, some predict a surge in work post-novel-coronavirus. "The real crunch will be when this crisis is over, and airlines want to get their aircraft back in the skies," Caerday's Lee says. "There is going to be a real bubble of MRO work to prepare aircraft to return to service. Demand for MRO slots is going to rocket. While many airlines have their own facilities, there will undoubtedly be a significant overspill into the independents to keep up with capacity," he predicts. ☼



Longer-term, it predicts the aftermarket may not return to its pre-COVID-19 size until well into 2022.

In this new reality, MRO shops are losing scheduled maintenance work, and airlines are seeking to defer payments or renegotiate existing MRO contract terms. This has especially affected smaller shops lacking the resources to weather the storm, but larger players are also feeling the impact on operations.

Swiss maintenance provider SR Technics has seen workloads fall off since the downturn, and airline customers are already requesting payment deferrals. At the same time, more leasing companies are requesting repossession

term storage care and maintenance," an SR Technics representative says.

AJW Technique, the Montreal-based parts repair shop of the AJW Group, told Aviation Week in mid-April that it had 2-3 weeks of workload. "But we are slowly seeing a drop-off in demand and adjusting to match customer requirements," says Sajedah Rustom, CEO of AJW Technique.

Like SR Technics and other MRO providers, Rustom says the parts specialist is experiencing an increase in demand in certain areas. "We are mostly noticing customer requests for holding of components until they are required," she says, a factor that played a part in the company launch-

Drones & Digital

AAR is using augmented reality, drones and digital development to increase efficiency

Lee Ann Shay **Miami**

What it takes for MROs to become more digital, as a holistic operation, can be seen by the transformation process underway at AAR. While drone inspections and augmented reality are the attention grabbers, there are many behind the scenes digital transformation projects there as well.

AAR recently shifted its digital strategy to focus on external and internal customers, as opposed to just being customer-centric. Taking this more holistic approach of “how we make ourselves more efficient, more intelligent and make better decisions, allows us to be a better provider of services to our customers,” says Rahul Ghai, AAR’s chief digital officer. This all leads “to a more productive workforce that gets us closer to our vision of being a digital company,” he adds.

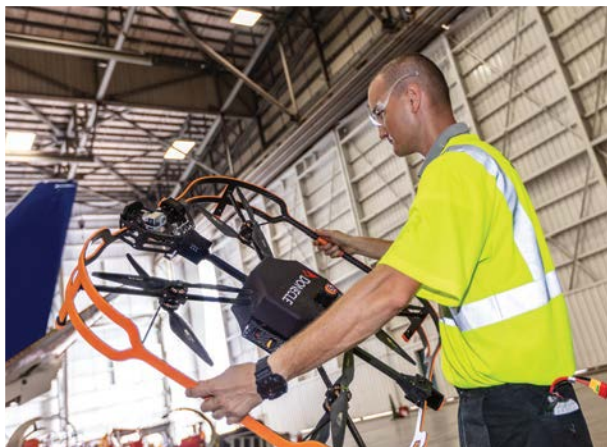
Ghai, who joined AAR in July 2019 after nearly 12 years with United Airlines, most recently as managing director of digital technology, says the aftermarket service company started building a 2-3 year road map for digital services that spans the company’s portfolio.

“One of the biggest challenges has been where to start, because there is so much opportunity,” says Ghai. “We have to be strategic about where we place our bets.”

Think of those bets as building blocks.

For MRO, the digital blocks include going paperless, making inventory smarter and making MRO more efficient—including the use of drones and augmented reality (AR).

AAR hopes to be a paperless operation in 18-24 months, resulting in a 15% efficiency gain for technicians,



AAR PHOTOS



AAR technicians ensure the aircraft configuration for the drone inspection. If it is set up for a Boeing 737-700 instead of an -800, for example, the drone will not fly because it is relying on a digital twin.

says Ghai. Today, tasks cards and documentation are still mostly paper; so technicians walk back and forth between the aircraft to get their next assignment and task cards. “We’re reimagining their processes, where they all have a mobile device and everything they need is on that device,” he says. “The idea is to tie images, documents and historical log page data together so that we start to run the learning algorithms against it,” says Ghai.

The goal to become paperless is to

include everything from integrated planning and execution to dynamic workforce management and mixed-reality collaboration.

AAR’s Miami facility is trying out AR for hands-free workflow and communication. It is using RealWear HMT-1 headsets and Librestream’s augmented reality platform.

With AR, a junior technician can show a master technician what he or she is doing and get instructions overlaid onto the tasks. AR will save master technicians’ time spent walking around the hangars answering questions, similar to how AAR’s engineers field frequent questions from their desks.

AAR also is using AR to grant permissions before technicians cut and drill sheet metal. A technician can use

the hands-free video, voice and photo capabilities to collaborate with a remote expert before making the cut.

So far, technicians and quality assurance managers report positive engagement with the tools.

DRONES

AAR’s Miami facility also is piloting drone aircraft inspections. The process could take 1-2 years, from bringing in off-the-shelf technology to conducting live pilots, getting it certified and scaling it.

AAR is using a Donecle drone for Boeing 737 general visual inspections (GVI) and has seen at least a 50% reduction in time compared to its traditional manual procedure. The drone flies itself on a preplanned flight and takes 1,500-1,900 pictures per narrowbody aircraft. “The quality and the data is what gets us really excited,” says Ghai.

AAR plans to conduct 150 inspections during the pilot phase.

As AAR pursues FAA certification, an inspector is reviewing the photos and identifying follow-ups and lightning strikes, in parallel. The drone system identifies more abnormalities, about 10-20% of which are false positives, but AAR says there is still an advantage over people and equipment moving around the aircraft.

To get the GVI-by-drone process certified, there are two options. Either Boeing approves it and adds it to its aircraft maintenance manuals, or AAR can work with a consortium to gain approval. AAR is pursuing both, including working with a group that includes the FAA, Boeing, Airbus, United Airlines, American Airlines and some component OEMs, says Matt Kammerait, AAR's director of digital and emerging technology. Industry sources say the FAA liked the consortium idea pursued by Airbus and airlines for A320 approval. “We think a rising tide raises all boats,” says Kammerait. “It's good for everybody if everyone has visibility into what's possible.

He thinks it will take another 9-18 months to obtain FAA certification for drone inspections inside the hangar. For the long term, the MRO would like to be able to use drones to inspect aircraft for lightning strike damage at airport gates, but that requires different authorizations.

While the maintenance staff have found it easy to learn how to use the drone, they asked for extra rechargeable batteries to be included as part of the process, because the battery needs to recharge after each flight.

DIGITAL DETAILS

As part of its digital journey, AAR also has developed in-house a closed-loop process for quality and safety management. The tool, called Aprise, includes

An AAR technician used augmented reality to obtain approval before he cut and drilled an aircraft structure.



everything from investigations to audit findings, customer feedback, injury reporting and import/export compliance. The tools within it—including self-audits, decision trees and investigation checklists—allow managers to immediately review and fix problems.

“Every employee has access to the dashboards because we think it's good to be open and see what's happening in the building,” says Shachar Hacohen, director of corporate environment, health and safety.

This system also includes Safety Management System dashboards, which AAR built in-house. AAR reports that since this program went

digital and became part of Aprise, it is seeing more proactive reports.

To solve a problem in Miami—lots of aircraft movements—AAR also developed HangarNotes. It provides a sky view of the hangar floor, with each aircraft rendered to scale and color-coded to reflect its status. It is a way to see where aircraft are, by tail number, work overview and customer.

Although AAR created HangarNotes to solve a problem, it is considering commercializing it.

The combination of digital projects makes “AAR an easier company to work with,” both inside and out, says Ghai. 🛩️

Beyond Borders

Australian MRO providers look to boost competitiveness but face regulatory costs

Adrian Schofield **Brisbane, Australia**

Australia's MRO industry has contracted in recent years, in stark contrast to the rapid growth of the sector in Asia. However, Australian MRO operators see opportunities to expand their role in the global market by focusing on areas of work where they still hold competitive advantages.

Like the rest of the aviation world, the immediate priority of Australian MRO providers will be surviving the downturn caused by the COVID-19 crisis and adjusting to the new industry landscape. In the longer term, the prospects for the local MRO sector could depend on boosting efficiency and participating more effectively in the Asia-Pacific market. But there is broad consensus that achieving these goals will require greater government support and regulatory reform.

Australia had "quite an extensive MRO industry" about 20 years ago, notes Andrew Sanderson, CEO of

Ipswich, Queensland-based TAE Aerospace. At that time, the industry included multiple sites around the country performing airframe and engine heavy maintenance for airlines, Sanderson said during the Aviation Week MRO Australasia conference on March 12.

However, business has declined in Australia since the 1990s, with more heavy maintenance sent overseas and many facilities closed. Now about half of the more than 400 commercial aircraft in Australia have heavy checks performed overseas, and almost no turbofan heavy maintenance is done in-country, Sanderson says. Australia is ranked in the top 20 for GDP, but there are no Australian companies in the top 100 largest global aerospace companies.

There were multiple reasons for the slide, Sanderson says. These include reduced labor-cost competitiveness, the growth of the Asian MRO industry, and scale disadvantages. The rise of

Australian LCCs was also a factor, as they generally outsourced their heavy maintenance overseas. And the emergence of new avionics technology and aircraft types required costly upgrades to legacy maintenance capabilities that not all providers could afford.

One way to strengthen the Australian MRO sector would be to focus on types of work where labor comprises a smaller proportion of total cost, Sanderson says: Engine heavy maintenance is one such area. While airframe maintenance costs are weighted in favor of labor rather than parts, the ratio for engine work is essentially reversed. Landing gear heavy maintenance also has a higher ratio of parts cost versus labor.

By boosting this type of work, Australia could better leverage its skilled workforce, Sanderson believes. It would also make labor costs relative to other countries less of an issue. However, he warns that expanding in these areas of work would require substantial capital investment.

When growth eventually returns to the Asian airline sector following the current crisis, MRO providers in the region may struggle to meet demand. More work could be brought to Australia if it has the infrastructure to support it, Sanderson says.



TAE engineers perform heavy maintenance checks on a Honeywell TPE331 turboprop engine.

TAE

Companies and state governments need to become better at collaborating, says Sanderson. The states are competing against each other to gain a larger share of the MRO industry, but there should be a more national approach in many cases, he argues.

Increasing the amount of defense-related MRO business can be a good strategy, and has been successful for TAE. Australia generally prefers to keep defense maintenance in the country, Sanderson notes. Picking up more defense work allows MRO companies to diversify and help protect their business when there is a downturn in the commercial sector.

Qantas has the largest MRO operation in Australia, which is primarily focused on its own fleet. However, the carrier can offer significant advantages for third-party work despite the dominance of Asian MRO providers, says Paul Crawford, head of base maintenance for Qantas.

Crawford admits that many Southeast Asian countries and MRO operators have a labor cost edge over Australian businesses. Qantas' unit costs "are not going to be comparable to MROs in the Asian region—that's a given," he says.

But Qantas has greater efficiency in many cases and can offer reduced turn time for heavy maintenance jobs, Crawford says. Cutting days or even a week off maintenance visits can result in a "revenue gain that far outweighs the unit cost difference."

This is a valuable benefit to airlines, if they consider the business case as a whole rather than focusing just on labor costs, says Crawford. Airlines need to "factor in what efficiencies [MRO providers] can bring to the customer."

The airline has traditionally not handled much third-party maintenance, says Crawford. However, in the past 3-4 years it has "started to branch out into third-party opportunities."

Crawford stresses that the Qantas fleet remains the top priority, and other customers would only be accommodated if there are vacant slots. But when the carrier sees opportunities, it will look to fill unused capacity.

There was growing interest from other airlines in having work done by Qantas before COVID-19, Crawford says. The carrier was getting "more and more inquiries" from airlines that

had not approached Qantas before, including some major players.

This was partly due to increased foreign airline service to Brisbane, where Qantas has its main heavy maintenance base. It also shows that some airlines are looking beyond the traditional centers for third-party MRO in other countries, says Crawford.

Qantas so far has only one significant third-party heavy maintenance customer. It performs heavy structural checks on Hawaiian Airlines A330s.

Scale advantages can be harder to achieve for Australian MRO providers dealing with small operators. However, this can be overcome by fostering greater cooperation among customers, says Matt Dennington, general manager of Brisbane-based StandardAero Australia.

StandardAero mainly performs Pratt & Whitney engine maintenance for a range of customer types including general aviation. The company is proud to support smaller operators, but dealing with them all individually can be "very time-consuming and . . . cumbersome" from an efficiency perspective, Dennington says.

For this reason, StandardAero encourages smaller customers to collaborate and group their fleets together in dealings with the maintenance provider. This is "a true win-win," Dennington says, as it gives the customers greater pricing leverage than they could obtain individually, and for StandardAero it allows operational efficiencies and reduces time spent managing separate accounts.

MRO executives generally agree that the government needs to be part of the solution to long-term growth for the Australian MRO industry, in terms of reducing regulatory costs and cross-border restrictions.

Regulatory requirements have progressively become more stringent and more expensive, says Dennington. For what used to be a "common sense decision," operators now "have to jump through red tape to make it happen," which diminishes efficiency.

Globalization of the MRO business is supposed to work in the industry's favor, but in reality any gains from cross-border transactions are "stifled" by taxes and duties, Dennington says.

For engine MRO work in the Asia-

Pacific region, StandardAero has to have "15 certificates on the wall from various countries," notes Dennington. Many of these national regulators need to visit to confirm the company complies with their standards, even though it has completed audits by the world's major authorities.

In general, MRO providers in Australia "are not making the margins they were 20 years ago," Dennington says. Margins in the low single-digits are becoming common. This makes it harder for maintenance organizations to absorb higher regulatory costs and remain viable, and it is "even harder for new entrants to join the market."

In Australia, "the regulatory authority and rules are really out of step" with today's aviation industry, says Ken Cannane, executive director of the Aviation MRO Business Association (Amroba).

As well as its safety and oversight roles, the Civil Aviation Safety Authority (CASA) needs to be more active in removing barriers to Australian aerospace companies doing business overseas, Cannane says. The Australian regulator should be looking for ways to harmonize approvals so Australian certifications can be more readily accepted in other countries.

"The Australian [supplemental type certificate] document doesn't mean much worldwide, and that's something we've got to get reversed," Cannane says. He adds that "we need CASA to be actively chasing [overseas] markets," particularly in the Asia-Pacific region.

Amroba has sent submissions on these topics to a senate inquiry established to examine the state of the general aviation industry and CASA's effectiveness. Among Amroba's recommendations is that CASA establish an international office to pursue agreements with other countries that would help open markets for Australian companies. The inquiry was launched in December, and findings are due in November 2021.

Cannane notes that while previous government inquiries have examined the performance of CASA, this one will also look at whether the regulations themselves are appropriate. "We need a completely new approach from the government, and I believe that will come about through this senate inquiry," he says. ☛

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Know. Predict. Connect.

Predicting Progress

Why airlines are not using predictive maintenance as much as expected

Henry Canada **Washington**

Big data, the Internet of Things, digital twinning and machine learning have become buzzwords in aviation and many other industries. But for aircraft MRO, the buzz must translate into new and beneficial forms of predictive maintenance to have practical value.

Of course, maintenance has already been at least partially predictive for a while. Engine health monitoring has long been a staple of engine support, cutting costs and keeping powerplants on wing longer. For nonengine components, solid reliability analyses can estimate probable failure rates after certain levels of hours or cycles have been reached, and planners can set inspection or removal rates based on these probabilities.

What is new is that the predictive process for nonengine components is moving closer to the engine model: that is, using multiple sensors and other data streams to make more accurate predictions for each aircraft part or system.

RATE OF ADOPTION

However, these new techniques are still very much a work in progress. For example, Boeing is seeing continued growth in demand for its predictive tools, which include the work of data scientists as well as artificial intelligence and machine learning. But Tonya DelMaestro, chief marketing officer of Boeing Global Services, agrees with others that so far the serious users of these tools comprise only a small percentage of all airlines.

About 10% of Airbus's A320 family is now on the OEM's predictive maintenance program, according to the manufacturer.

Philippe Bordel, digital commercial manager of AFI KLM E&M, estimates that less than 5% of the world's top 400 or so airlines have made any real progress with their predictive maintenance programs. Among airlines that have publicly stated that they are working on predictive maintenance, "most are co-developing their systems with a third party," Bordel adds.

Frank Martens, head of customer development for digital products at Lufthansa Technik (LHT), says the number of airlines using predictive maintenance on nonengine components with the latest big data technologies is limited but growing fast. "We may be talking about 50 airlines worldwide," he suggests. He distinguishes between mere prediction and predictive links to actual MRO actions, which he says LHT's Aviator platform provides.

Predictive maintenance needs to be more than mere prediction to be effective—it needs to link to specific MRO actions.

Jean-Philippe Beaujard, general director of Revima's Flightwatching unit, does not see most European airlines taking predictive maintenance to a high level. For his company, the carriers most active in using the new tools are in Asia and the Middle East.

"Asia is a very dynamic market, open to innovation in predictive maintenance and other forms of digitalization," Beaujard says. Greater interest in predictive techniques in the Middle East stems from a harsh environment that presents more maintenance challenges. "OEM monitoring does not work well in the region, they get failures before other carriers," he explains. Extreme heat and sandstorms are usually the culprits.

The number of carriers doing predictive maintenance is still "very limited," says Yann Cambier, a senior consultant at ICF and a former AAR executive. He adds, "Most airlines are not sophisticated enough to implement the new processes required to exploit predictive maintenance technologies."

Yet the rewards are real and benefits substantial. Cambier points to Delta Air Lines, which claims a dramatic reduction in maintenance-related cancellations using Airbus's Skywise predictions for its A320s and A330s. Significantly, Delta's error rate, or no faults found, was only 5%.

Airbus and Delta are now forming a digital alliance to develop new predictive solutions, with more data, to offer to other airlines. Airbus representative Martin Fendt says Airbus predictive maintenance reduces unscheduled events by 10-50%, depending on the components. The biggest improvements are for air conditioning and pressurization systems, electrical power, landing gear and brakes and pneumatics.

Boeing estimates that each removal of a component that is near failure saves several hundreds of thousands of dollars. Most of these savings are derived from avoiding revenue losses from schedule interruptions. Boeing Global Services Analytics Director Stefan Karisch says there are also savings from making a repair early, before a component fails.

The airframe OEM and its airline partners generally choose to work on components that are causing the most interruptions, rather than just the easy, "low-hanging fruit," DelMaestro says.

Cathay Pacific Airways has adopted Honeywell's Forge predictive solution for its A330 auxiliary power units. Honey-

well estimates Forge can prevent about 35% of APU failures.

Forge also covers 10 other ATA chapters. For example, it can reduce delays and cancellations related to pneumatic components by 30%, with a no-fault-found rate of only 2%, says product director Josh Melin. For hydraulics, the results are even stronger, eliminating 80% of delay events and 40% of minimum equipment list events. False positives are less than 5%, Honeywell reports.

Digital manager Jacques Guichard estimates that AFI KLM E&M's Prognos tool can prevent one flight cancellation per year for each ATA chapter of components it is applied to, not including delays avoided.

Martens says potential gains depend on the operational environment and MRO services used by airlines. For some components, reductions in unscheduled removals can reach 80%, while for some other components reductions are 30-40% and for others just 10%.

Beaujard says customers do not tell him how many unscheduled removals are being eliminated, but they are apparently very satisfied with the service. "Today in the Middle East, 100% of our recommendations are followed, so they have a high degree of confidence in them," he observes.

Predictive results also vary with an aircraft's age. For example, the Boeing 777 can generate four times as many alerts as the 737NG, and the 777X provides four times as many as the 777. But Karisch says Boeing is also working on predictions for older aircraft and notes: "There is a lot of operating data you can leverage from a 737. Adding sensors is not always the answer in the first place."

Fendt explains that best-practice predictive maintenance processes are similar for previous and next-generation aircraft, because value comes from monitoring the life cycle of components, not of the aircraft itself. Airbus can retrofit older jets with FOMAX, an onboard data-capture and transmission module that boosts the parameters that can be captured on an A320 from 400 to 24,000.

"On the latest-generation aircraft, we can increase the number of sensors being monitored, which means more data is being fed back to our systems, thereby enabling us to define more efficient predictive maintenance algorithms," Guichard observes. But Martens argues that it also makes sense to retrofit sensors on older aircraft. He stresses that nonsensor data is important as well, for example repair data from MRO shops.

"Older aircraft can be very interesting," Beaujard says. For older Airbus A300s and Boeing 747s, Flightwatching must usually go onboard to get data. But with a flight-data acquisition unit installed, the company can use ACARS to query and receive data remotely. And sensors retrofit on bleed systems of older 737s can also improve predictions for these components.

But with all these benefits, why has progress toward predictive maintenance been so slow? Cambier asserts that the biggest hurdle to predictive maintenance is lack of engineering expertise: "Only a few players in the industry have the expertise to effectively implement predictive maintenance, decades of MRO expertise with large owned fleets or third-party contracts." Other elements that must mature are data sharing, better and cheaper connectivity and a willingness to remove serviceable units.

DATA CONTROL

Martens agrees that data control is essential: "More and more OEMs restrict access to operational data for airlines, MROs and other players . . . this is not acceptable."

Karisch says Boeing predictive maintenance always starts with a partnership discussion with the airline, which owns the operating data. "We decide what we want to accomplish, then work back to analytic issues and how much data is required," he says. "It's a partnership."

Martens says lack of data interfaces within an airline also can hamper predictions, a problem Aviatar was designed to address. Pilot unions and work councils may restrict the use of data, while some governments also hamper data sharing.

Guichard acknowledges predictive maintenance drastically changes the way airlines work with OEMs and MROs. "Aviation regulations will also need to evolve, with regulators having to find a way to adapt to this new way of maintaining aircraft."

Beaujard says another hurdle is that airlines often want quick results, but "it takes three to four months to solve a new problem."



AFI KLM E&M

AFI KLM E&M estimates that its Prognos tool can prevent one flight cancellation per year for each ATA chapter of components to which it is applied.

Airlines must be willing to share operations data with a provider because they trust that the data will be used to benefit the airline, says DelMaestro. Then airlines must trust predictions enough to change maintenance practices or proactively schedule component maintenance events in advance. Securing that trust requires holding no-fault-found, or false positive, rates to a minimum.

DelMaestro agrees that connectivity also can be a problem. Moving data off of aircraft can be tough if a carrier has a tight schedule. "Data is not always their highest priority," she notes.

Fendt says airlines need to understand the technology, invest in it and modify processes and tools. "Data scientists should be integrated into the standard airline environment and data competencies added to the maintenance operations. Further, the value chain needs to transform its test-bench and no-fault-found policies to the predictive approach, to avoid in-service degradation of components."

Many elements have to fall into place to make predictive maintenance work. But as experience with the process is gained, obstacles become easier to overcome. Despite data-sharing conflicts and other issues, progress is being made. ☛

737NG MRO Market

With most of the fleet idled or parked due to the COVID-19 pandemic, assessing the MRO market has become problematic

Frank Jackman **Washington**

It's complicated. That is really the only way to describe the outlook for the Boeing 737NG aftermarket.

If the 737 MAX had not been grounded 13 months ago and the novel coronavirus had not morphed into a global public health crisis and then a pandemic, the outlook for the NG would have been much easier to

a compound annual rate of 2.7% between now and the end of 2029. But that projected overall decline masked a flat to modestly increasing value in the shorter term. MRO demand for 737-700s, -800s and -900s was pegged at roughly \$14.0 billion for 2020, with engine maintenance accounting for about 40%, or \$5.6 billion, of that total.

just under 3,100 flight hours, but the COVID-19 pandemic has gutted airline schedules around the world, and an increasing number of airliners are being parked. The aircraft that are still flying are being utilized far less than normal. Put another way, much of the NG fleet is not accruing maintenance activity or is doing so at a much slower rate. "Fleet-wide, there are simply a lot of NGs sitting on the ground," Marcontell says. "They're not flying at all."

In a recent report on the impact of COVID-19 on commercial MRO, the Oliver Wyman consultancy said that depending on when recovery from the coronavirus begins, global MRO demand could decline 19-39% this year from original forecasts. But the firm

also said: "Predicting with any certainty fleet decisions and the effect on maintenance, repair and overhaul activity in response to COVID-19 is nearly impossible at this time, given the disease's evolving nature." The report also stated that while many of the aircraft that are parked will eventually return to service, "experience from previous deep shocks suggests that many aircraft will stay parked and then move straight into retirement."

Marcontell, one of the authors of that report, said data analyzed over the past two weeks paints a grim picture. "We're already parked at the bottom," he says,

adding that the question now is how long the industry stays at the bottom. "Is the bottom four weeks or is the bottom 12 weeks?" And then once the passenger market does start to pick up again, how long is the recovery? The current prevailing thought at Oliver Wyman is that traffic levels will not return to what they were in January of this year until 2022.

The ongoing grounding of the 737 MAX has had a more straightforward impact on the 737NG market. With the MAX grounded, airlines that had planned to phase out their NGs in fa-

With many 737NG aircraft parked, much of fleet is accruing maintenance more slowly—or not at all.

determine. "Previously, you would have seen a steady decline in MRO work for the NG as the MAX replaced it," says David Marcontell, senior vice president at Oliver Wyman and general manager of CAVOK, its technical consulting and service division.

That is essentially what Aviation Week Fleet & MRO Forecast data show. The value of the 737NG MRO market was projected to decline by

Over the next two years, 737NG MRO demand was forecast to increase to approximately \$14.6 billion before beginning a gradual decline to just under \$10.9 billion in 2029. During that period, the size of the in-service 737NG fleet was expected to drop from 6,352 this year to 4,576 in 2029, a decline of roughly 28%.

The total value of the MRO market over the decade had been estimated at \$137.5 billion, but now it is hard to pinpoint the value 10 years out.

The MRO forecast also assumed average annual aircraft utilization of



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vor of the newer model are keeping the NGs, which can be seen in the passenger-to-freighter conversion market. Even before COVID-19, feedstock for 737-800 conversions had dried up, and some expect it could be more than a year after the MAX returns to service before a significant number of -800s are available for conversion. In the interim, cargo operators are looking at other options. In March, Aeronautical Engineers Inc. said it was seeing renewed interest in 737 Classic conversions from customers looking for cargo lift alternatives until the -800 feedstock frees up.

The MAX is expected to be recertified this year, but Marcontell says the “damage has been done” to the program in terms of its potential. Oliver Wyman is predicting a significant decline in the number of MAX deliveries expected over the next 10 years, with Boeing losing market share to the Airbus A320, A321 and A321XLR.

From an MRO perspective, the outlook for the 737NG is far from bleak,

however. “Obviously, everything is going to be way, way down because fleets aren’t flying,” Marcontell says. “And even when we do start flying, it will be a slow buildup. But on a per-unit basis, you would have imagined that an NG would have gone into retirement or been relegated to a lesser utilization role as it was replaced by the MAX.” But that is not happening now. The NG is going to stay in service longer than it would have previously, he says.

AIRWORTHINESS DIRECTIVES

In the past 18 months, the FAA has issued a number of airworthiness directives (AD) that apply to the 737NG, primarily for inspections.

The most notable of the ADs resulted from the discovery of cracks last year in what is known as the pickle fork, a structure that attaches the wing to the fuselage. The cracks were found on multiple 737-800s that had accumulated 35,578-37,329 flight cycles. Cracks were first discovered during a passenger-to-freighter conversion

and eventually led to the temporary grounding of a few dozen aircraft. AD 2019-20-02, which became effective Oct. 3, requires repetitive inspections for cracking of the “left and right-hand side outboard chords of frame fittings and failsafe straps” at a certain station and that the structure be repaired if any cracking is found. The AD is applicable to 737-600, -700-, -700C, -800, -900 and -900ER models.

Earlier in 2019, Boeing informed the FAA that certain 737NG and MAX leading-edge slat tracks might have been improperly manufactured and could be susceptible to premature failure or cracks. As many as 133 NGs and 179 MAX aircraft worldwide were affected. The FAA subsequently issued an AD requiring a maintenance records check to determine if any of the slat track assemblies had been removed, an inspection of the assemblies for a suspect lot number or a lot number that could not be determined, and applicable on-condition actions. Ⓢ

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Mobile MRO Structures

Lindsay Bjerregaard Chicago

1. Inflatable Hangars

Company: Buildair

Specifications: Buildair's modular, inflatable hangars can be delivered to customers via air freight or standard sea containers and erected easily without construction-permit requirements. MRO customers are using Buildair's hangars for line and base maintenance operations such as service bulletin retrofits, cabin interior refurbishment and C checks. Buildair says the transparent structure of its hangars enables satellite Wi-Fi or GPS signals to be checked from inside. The company is now working to develop designs combining airtight technology with solar panels connected to inflation motors to enable the assembly of hangars at remote sites with reduced access to electrical power. marketplace.aviationweek.com/company/buildair-engineering-architecture

2. Mobile Clean Room

Company: JB Roche

Specifications: Designed in collaboration with Airbus, JB Roche's CompShop is a mobile clean room built to ensure an optimal environment for repairing composite parts. The lightweight, weatherproof system can be erected in 15 min. and easily relocated to free up space in a hangar. CompShop is built to order, and JB Roche says aviation customers such as Airbus and Bombardier are using it for tasks such as composite repairs, spray painting, parts production and containment during grinding of composite material. JB Roche has also been repurposing the design to aid medical efforts during the COVID-19 pandemic. marketplace.aviationweek.com/company/jb-roche

3. Flexible Fabric Hangars

Company: Rubb

Specifications: Rubb's fabric tension hangars enable rapid deployment and construction with the flexibility to be relocated if necessary. Rubb says that its semi-permanent hangars



feature Thermohall insulated cladding for easy climate control and low lifetime maintenance costs, thanks to ease of repair and an exposed truss system for access to mechanical systems, cranes or equipment. Turkish Airlines is using a Rubb hangar for heavy maintenance during the construction of its new MRO campus at Istanbul Airport. It will later dismantle the temporary hangar for potential use at another airport. marketplace.aviationweek.com/company/rubb-building-systems

4. Weather-Resistant Portable Hangars

Company: Aviatech

Specifications: Aviatech's portable aircraft hangars are built to be deployed quickly and easily on any terrain at a lower cost than traditional structures. Aviatech says the hangars can easily be shipped by air because of their compact packaging and light weight, and then erected in two days on average. The inflatable hangar structures are built to withstand high winds and snow loads such as the portable maintenance and research facility Aviatech built for the Chilean Air Force's Union Glacier Camp in Antarctica. Aviatech says the hangars are suitable for all aircraft types for storage, repair and maintenance needs. marketplace.aviationweek.com/company/aviatech

5. Inflatable Spray Booth

Company: AeroElite Interiors

Specifications: AeroElite Interiors has started implementing a unique, OSHA-approved inflatable spray booth as part of its Mobile Interior business model. The inflatable structure, which was originally designed for painting cars, has been converted into a booth for spraying aviation dyes, glues, paints and adhesives at customer sites. According to AeroElite Interiors, the inflatable spray booth prevents overspray and the release of volatile chemicals into the atmosphere. marketplace.aviationweek.com/company/aeroelite-interiors

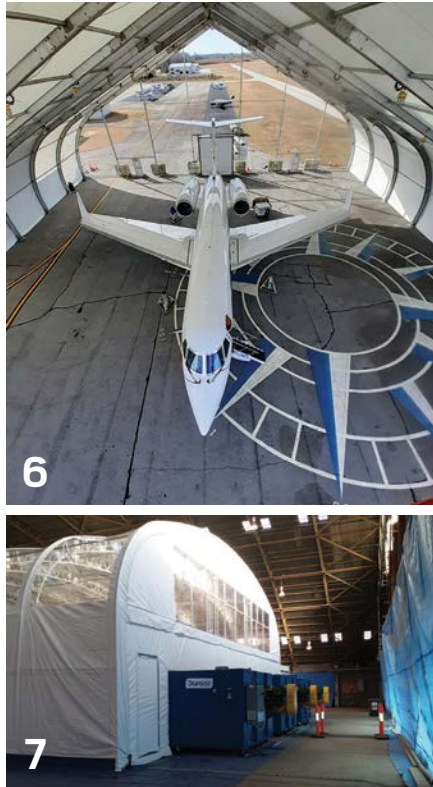
Go to MROLinks.com for more information.

6. Mobile Aircraft Hangars

Company: Mahaffey

Specifications: Mahaffey provides temporary mobile aircraft hangars that are custom designed and engineered to fit aircraft of any size. The company says it can construct hangars in as little as five days, which makes them ideal for covering aircraft needing repair—particularly in locations where aircraft hangar space is hard to come by. The hangar structures can be fitted with accessories such as sliding hangar doors, climate control, lights and fire-suppression systems. Mahaffey says it sees heaviest demand for temporary hangars during construction of new facilities or repair hangars at regional airports where there is insufficient hangar space.

[marketplace.aviationweek.com/
company/mahaffey-fabric-structures](https://marketplace.aviationweek.com/company/mahaffey-fabric-structures)



7. Portable Clean Rooms

Company: Duroair

Specifications: Duroair specializes in modular, portable enclosures combined with industrial air filtration to provide customizable, self-contained environments. The retractable clean rooms can be used for aviation tasks such as machining, welding, metal finishing, coating and painting to capture oil mist particles, airborne particulates and hexavalent chromium. Duroair says the portable clean rooms can be placed anywhere in a customer's facility without the need to install supplementary ductwork and can be moved between locations or stored when not in use. The company says it has delivered the portables to customers including BAE Systems, Delta Air Lines, GE Aviation and Lufthansa.

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Conversational AI

Delivering the right answer quickly and simply

Recently I read about a local company that is projecting future growth but must turn over its entire workforce within a decade because of retirements. That situation raises the question of what knowledge must be captured, shared and consumed for this company to retain its market position? What if we could address this challenge and the solution could be applied to another business, the aviation aftermarket? Enter conversational artificial intelligence (AI), digital assistants that trigger answers and action based on “listening” to everyday language. In fact, after the COVID-19 crisis is brought under control, conversational AI may have an even greater role in the emerging “new normal.”

Aerospace and defense companies are focused on artificial intelligence. Accenture's research indicates that over one-third of industry executives see AI as the technology that will have the greatest impact on our industry. What, then, does the term “conversational” add to AI? As in politics, access is everything. Data-rich fleets require faster, more targeted decisions and action from the line to the service desk. Coupling this with today's pressing need for remote work and, hopefully, returning demand for skills tomorrow suggests there is greater pressure to deliver information to help do jobs the right way the first time. A phone call or knowing which book or manual to consult are no longer good enough. Conversational AI helps users find the right answer faster, delivering precise information at scale through the simplest user interface: speech.

Conversational AI changes human-machine interaction in four ways. First, it senses and consumes inputs across multiple language inputs, from an airline maintenance engineer's typed instant message, to a line

maintainer's question spoken in the shadow of a nacelle. It rapidly comprehends that input using knowledge bases and machine learning. This understanding enables maintenance staff to react in real time, be

it through escalating questions to a person or triggering the delivery of a part, drawing or piece of software through process automation. Lastly, it can learn the nuances of the questions it receives to continuously improve its language under-

standing and ultimately the quality of the services that it delivers.

Customer service is a natural starting point for conversational AI. Accenture's research shows that other industries have used conversational AI to handle 40% of service desk interactions without a human agent and with a 60-80% reduction in cost-per-service-center contact. The technology has also helped manage call center seasonality by limiting the need to flex staff, an increasingly valuable feature in the current environment. Also enticing are the early returns on conversational AI in improving customer experience and retention. Conversational AI can

improve customer engagement and experience, an important consideration for OEMs and MROs looking to manage the present and prepare for what comes next.

Yet customer service may just be the start. The ability to obtain tech data, order parts or direct services hands-free can improve quality, efficiency and safety on the line and in the shop. Using voice inputs rather than keystrokes can increase the likelihood of technology adoption for workers who may lack the experience or comfort to engage with a traditional user interface. Pairing conversational AI with traditional or wearable displays can provide more intuitive access at the working level to other digital investments such as analytics and digital twins. But what do organizations need to get right?

As with other digital investments, there is a big difference between just getting started with conversational AI and getting off to a good start. First and foremost, the data need to be correct. AI engines simply run out of fuel without a reliable data foundation and architecture. Next, as my more expert colleagues say, it needs to “speak human but not pretend to be one.” Understanding how AI agents relate to users, designing conversations in the context of users' jobs, clearly defining the knowledge the technology will manage, and designing smooth handovers between AI and human agents are the foundation of starting conversational AI well.

Maintaining fleet availability requires fast, precise access to data, knowledge, parts and services across the aftermarket. Today's environment demands remote, safe and confident access to information. As flying resumes, aftermarket providers and operators will need better ways to do their jobs. By uniting the simplicity of everyday conversation with the power of artificial intelligence, conversational AI provides a new way for aftermarket providers to send information to customers, practical instructions to employees, and soon, aircraft out of hangars. 🌟

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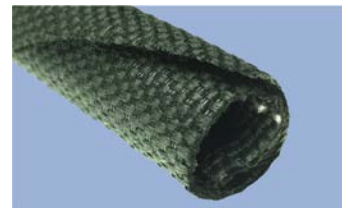
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The background of the entire advertisement is a dark blue, high-contrast image of a jet engine's fan section, showing the curved blades and the central hub. The lighting is dramatic, with the blades catching some light while the rest is in deep shadow.

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China Pushes Cargo Expansion and Mergers With Logistics

➤ FREIGHTERS ARE A PRIORITY

➤ GOVERNMENT PROMOTES FEDEX MODEL IN USE BY SF AIRLINES

Bradley Perrett Beijing

In English, people sometimes say one should never let a good crisis go to waste—meaning that during emergencies things can be achieved that could not be done under normal circumstances.

The idea is not often expressed in China, but the sentiment must have been on the minds of aviation administrators amid the depths of the country's COVID-19 crisis in February and March. For on March 24, the Civil Aviation Administration of China (CAAC) achieved an objective it had been trying to impose on airlines for at least a decade.

The State Council, China's national cabinet, on that day promulgated a policy demanding consolidation in the air cargo industry. Specifically, Beijing has called for the merging of air cargo operations with the general logistics sector. The government also set an objective of increasing the size of China's air cargo fleets. It particularly wants more freighters, though additional exploitation of belly capacity is not excluded.

China's cabinet said there would be a range of further measures to improve efficiency and help air cargo such as standardization, 24-hr. customs service and improved slot availability—even during airports' daily peaks. Details such as the intended size of the air cargo industry fleet and the timing of the measures were not set out, as is common for Chinese policy coming from the top. Lower-level officials can be expected to fill in the gaps.

This policy emerged as Chinese airlines strained to transport the country's exports against the backdrop of a global shortage of belly capacity. Airlines are working their freighters hard and pressing passenger aircraft into cargo service, with packages tied to seats or packed into luggage bins.

The policy of consolidation and expansion is aimed at rectifying an anomaly. While China wants to be a

giant in almost every industry, has the world's second-largest economy and is the biggest merchandise exporter, it is an air freight weakling. SF Airlines has the largest Chinese cargo fleet, with 58 aircraft. FedEx has 378.

Last decade, officials overcame managers' objections and were able to force mergers in many industries, creating enterprises that would have a scale advantage in global markets.



TIANJIN AIRLINES

Examples include shipping, steel and railway equipment. The airlines successfully resisted, however.

Amid a crisis in China, resistance to authority is simply out of line. And the airlines, in their weakened state, knew in February and March that they would be asking for government help: A cooperative attitude was in order.

That would have helped the CAAC finally get its way, but perhaps the clincher was that the carriers had let China down. As China suppressed the coronavirus and its factories restarted, exporters could not secure enough air freight service.

While other countries might shrug and accept the ways of a global market, the nationalist Chinese instinct is to be self-reliant. This implies that if China does become a heavy player in air cargo its freight carriers can be expected to put China first in any

future global capacity shortage. That would be exactly what the government would expect.

However, for the past 10 years the CAAC has probably seen more routine advantages in a larger air freight industry. "It could help to balance the revenue and earnings structure of the Chinese air transport industry," says Marc Szezan, an aviation expert at the University of Oxford. Carriers will not be so dependent on passenger traffic, he says.

The government is likely calling for mergers of air cargo with general logistics because it sees the integrated model, as used by FedEx, DHL and others as the best, Szezan says.

China already has a prominent company with such a business structure, SF Express, the air wing of which is

A Tianjin Airlines Airbus A330 passenger aircraft loaded with cargo to help move exports.

SF Airlines. The CAAC has previously pushed SF Express to take large equity stakes in the freight operations of state airlines, industry sources say. The private company refused to do so because it did not want to be encumbered by government enterprises.

Now it may be under greater pressure to integrate government companies into its operations. Each of the country's three main airlines (China Southern Airlines, Air China and China Eastern Airlines) has a freight subsidiary.

Szezan points out that there are other national advantages of China having a larger air freight industry: disaster relief and supplementing the air force's modest cargo capacity. 🌐

AIRCRAFT REC

> THE BUSINESS CASE MAY EMERGE FOR BETTER ALUMINUM SORTING

> CARBON-FIBER RECYCLING IS THE NEXT FRONTIER

GETS



RECYCLING SMART

Thierry Dubois Lyon



Converging trends are shaping the business of recycling aircraft, signaling the aerospace sector's rising willingness to implement higher environmental standards while striving to maintain aerospace grade in the sophisticated materials that are recovered. The overarching idea is to use resources more efficiently.

The first tendency is toward smarter metal processing. Dismantled aircraft primarily consist of aluminum. Given the effort required to produce a specific variety of aluminum alloy, it would make sense to reuse it as such. Although the process of sorting metals has improved, no economical solution yet exists for keeping different aluminum alloys separated throughout the recycling process.

In composite materials, the tantalizing goal of reusing carbon fiber-reinforced plastics (CFRP) in new airframes may soon be achieved. The growing proportion of CFRP in today's aircraft has made reuse key for the promoters of the material. It has been praised for its light weight and resulting fuel savings. OEMs would not like CFRP to be exposed to public contempt because of a poor environmental footprint over the product life cycle.

Meanwhile, aircraft owners are integrating greener principles into their internal guidelines, thus reinforcing the impact of stricter laws. Demand is therefore growing for more responsible—albeit more expensive—aircraft disposal.

In recent years, about 700 aircraft have been decommissioned annually for dismantling and recycling, according to the Aircraft Fleet Recycling Association (AFRA). In 2018, the average retirement age was 25.9 years for passenger aircraft and 32.5 years for freighter aircraft, the International Air Transport Association (IATA) notes.

"Aircraft dismantling and subsequent recycling should be seen as part of the life cycle," says Sebastien Medan, facility, environment, health and safety director at Tarmac Aerosave's facility in Tarbes, France. An Airbus offshoot, Aerosave specializes in aircraft maintenance, storage, dismantling and recycling. Other shareholders are Safran and waste treatment specialist Suez. "To preserve the aircraft's value, the owner should take care of maintaining airworthiness and compliance with environmental standards," Medan adds.

In terms of value, the purpose of dismantling an aircraft is to sell its components and parts.

The engines are by far the priciest element, even after two decades in service. "The engines are clearly the most valuable parts, with 70-80% of the end-of-life aircraft total marketing price [as indicated by leasing companies]," an IATA spokesperson says. Tarmac's salespeople suggest engines represent as much as 85%.

The next most valuable parts—in order of importance, according to consultancy SGI Aviation—are the landing



REMY MICHELIN

Tarmac Aerosave uses a diamond-wire cutting gantry cooled with water for improved safety and dust recovery.

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



Two Airbus employees have created the A Piece of Sky online shop, which sells furniture upcycled from aircraft parts.

gear, the auxiliary power unit, electrical power units such as generators, flight controls and navigation systems. They are commonly referred to as high-value components, and together they comprise as much as 70% of the value of the airframe, excluding the engines. Other components with noticeable value include escape slides and flap tracks.

"From an airline point of view, the most important aspect is to optimize the revenue from parts and components that can be sold and reused as spare parts," IATA states in its manual for Best Industry Practices for Aircraft Decommissioning (BIPAD). The BIPAD manual primarily addresses aircraft owners and operators. It is complementary to AFRA's Best Management Practices for application by specialized aircraft dismantling and recycling companies, IATA says.

Cargo carrier Kalitta Air sees the residual value of the aircraft as "often realized by removal of high-value parts ... prior to recycling the aircraft for its basic metals."

Some parts have to be scrapped, in which case thorough documentation is required to ensure that the components have been destroyed and professionally disposed of, says Germany-based MoreAero, a specialist in aircraft dismantling and recycling. The customer should receive a "proof of waste disposal," according to IATA. "This is an important step to prevent suspected unapproved parts or counterfeit parts ('bogus parts') entering the spare parts market," IATA states.

As for spare parts, a particular case has recently emerged—the Airbus A380. Late last year, when the first aircraft entered dismantling in Tarbes, it appeared the market was avidly looking at secondhand spare parts. Demand was so strong that the number of components Tarmac removed stood close to 6,000 per A380, up from 700-1,000 for an A330.

In an unusual step, Tarmac's technicians even removed engine pylons for reuse. Money savings from secondhand parts can be considerable: A new A380 main landing gear is priced at around \$25 million, according to Germany-based consultancy Scope Analysis.

Dismantling the A380 prompted the development of new tooling, due to its size.

Tarmac claims a 30% market share in Europe for Airbus and Boeing aircraft dismantling (measured in units) and 10% globally. It has a combined 40 employees working in the

dismantling and recycling activity in Tarbes and in Teruel, Spain. Since its inception, the company has recycled 220 civil aircraft and 135 engines.

"A new generation of aircraft is arriving on the market," Medan says. "We see many Airbus A330s and an increasing number of Boeing 777s, in addition to the first A380s."

Assuming a typical aircraft lifetime of approximately 25 years, most of the aircraft retiring by 2040 will still be the types that are currently in service today, which are primarily aluminum construction, IATA points out. Hence the focus on aluminum after the removal of reusable parts.

"The largest portion of the materials that can be recycled consists of aluminum (about 60%)," IATA states in its BIPAD. "A variety of aluminum alloys is used in aircraft. Identifying the different types of aluminum alloys prior to the dismantling operations, by mapping from the OEM's documentation, allows them to be recycled separately and obtain higher-quality end products."

Although the goal is commendable, the reality is still challenging.

Separation is labor intensive. "It requires a lot of manual work such as removing the rivets from the aircraft structure," the IATA spokesperson says. And the volume of series-2000 aluminum, for instance, is too small for it to be kept segregated, Tarmac's Medan says. "It would not be economical to recycle nuances of aluminum separately."

Media plants, where metals are sorted, have evolved from simply distinguishing ferrous metals in mixed ma-



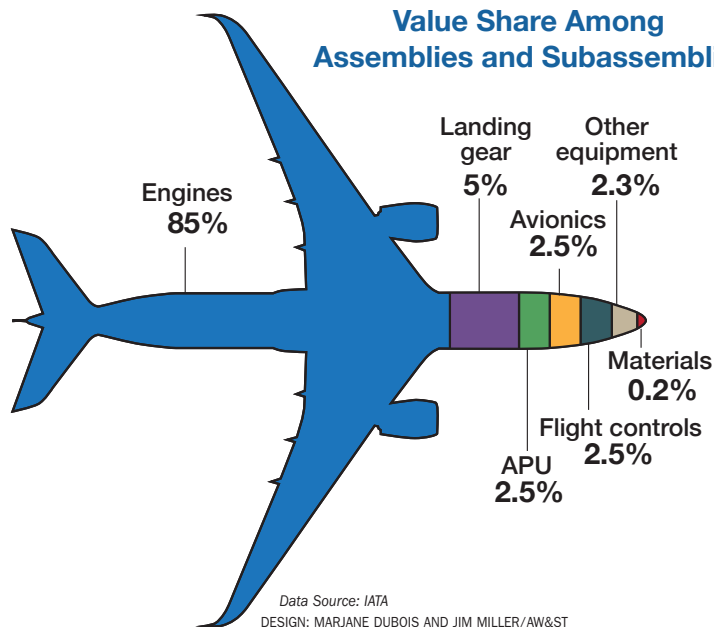
Upcycling aircraft parts may result in a smaller environmental footprint than recycling.

terials coming from cars and appliances. "It is a chicken-and-egg situation—who in the aircraft-recycling industry will partner with someone who has a media plant?" says Alasdair Gledhill, director of nonferrous metals at recycling specialist ELG Haniel Metals and commercial director at sister company ELG Carbon Fiber.

Recent progress in aircraft fuel efficiency, such as with Airbus' A350, has been helped by new, expensive aluminum nuances. So putting in place a closed loop in aircraft metal recycling would be justifiable.

But quantity is decidedly an issue. Compared with other industries, aircraft recycling generates a small volume of material. "We recover approximately 1,000 tons of alumi-

Value Share Among Assemblies and Subassemblies



num per year, and we do not know how to trace the portion that will be reused in aerospace,” Medan says.

And some technical challenges would have to be overcome. Aluminum alloys from aircraft are of very strict chemical composition. The more aluminum is recycled, the greater the amount of impurities, making it unsuitable for aircraft manufacturing, IATA says. “There is an inherent problem with aircraft aluminum because it is ‘contaminated’ with corrosion-prevention compounds that must be dealt with during the smelting process,” Kalitta Air adds.

Thus far, at least, series-2000 aluminum can be mixed with series-7000 aluminum and reused in aerospace, Medan says. Aluminum from aircraft can be recycled into other products, too.

As for titanium, specifications for the final product are so strict that titanium recovered from a dismantled aircraft would have to be incorporated at the beginning of the industrial process. It could then undergo every phase, including checks. Recovered titanium therefore usually becomes part of steel alloys.

Some companies manage to upcycle metallic components, transforming aircraft end-of-life parts into innovative and added-value products, as Bombardier puts it. In a pilot project, Bombardier, along with University of Montreal and the Consortium for Research and Innovation in Aerospace in Quebec, created various daily-life objects from aircraft parts.

The upcycled objects included a bicycle, an ambiance stand light, a leather fashion jacket, a folding table, a desk light and a wall clock. “After performing a comparative life cycle assessment of some of these prototypes, we observed that upcycling the parts results in a smaller environmental footprint than recycling,” Bombardier says.

Airbus’ BizLab business accelerator has supported two employees in a similar idea. They have created the online store A Piece of Sky, which sells furniture upcycled from aircraft parts.

Overall, the share of recovered metal is a minuscule portion of the total value that a recycled aircraft generates. Nevertheless, it helps to maintain the proportion of

the recycled aircraft’s weight at 89-91%, according to Tarmac’s numbers. “The proportion will not progress until plastic and composite materials can be recycled in greater volumes,” Medan says.

Until now, carbon fiber has been recycled into lower-value products, compared with initial high-performance designs. Thus current efforts try to recycle more fiber while retaining its features. Dismantling the A380 has prompted renewed interest because it contains 25% of composites by weight.

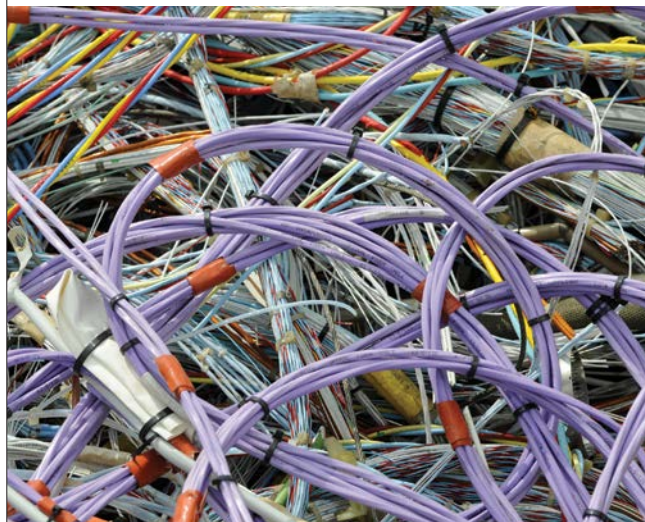
“We are in touch with European companies that have devised carbon fiber recycling processes and have managed to keep the fiber’s length,” Medan says. Length is key for airframe applications, which require fibers several dozen centimeters in length. For high mechanical performance, composite materials need fibers to be oriented consistently. Orienting short fibers is impractical.

The recycling processes developed thus far have involved shortening reclaimed fiber.

Medan has seen unspecified companies producing dozens of metric tons of recycled, long carbon fiber annually. He deems the technologies mature.

“These companies have yet to find customers,” Medan says. “But I am confident this nascent activity will thrive sooner rather than later, notably thanks to other manufacturing industries such as yachting and sports equipment.”

Another company, Xcrusher, has been developing a tech-



REMY MICHAUD

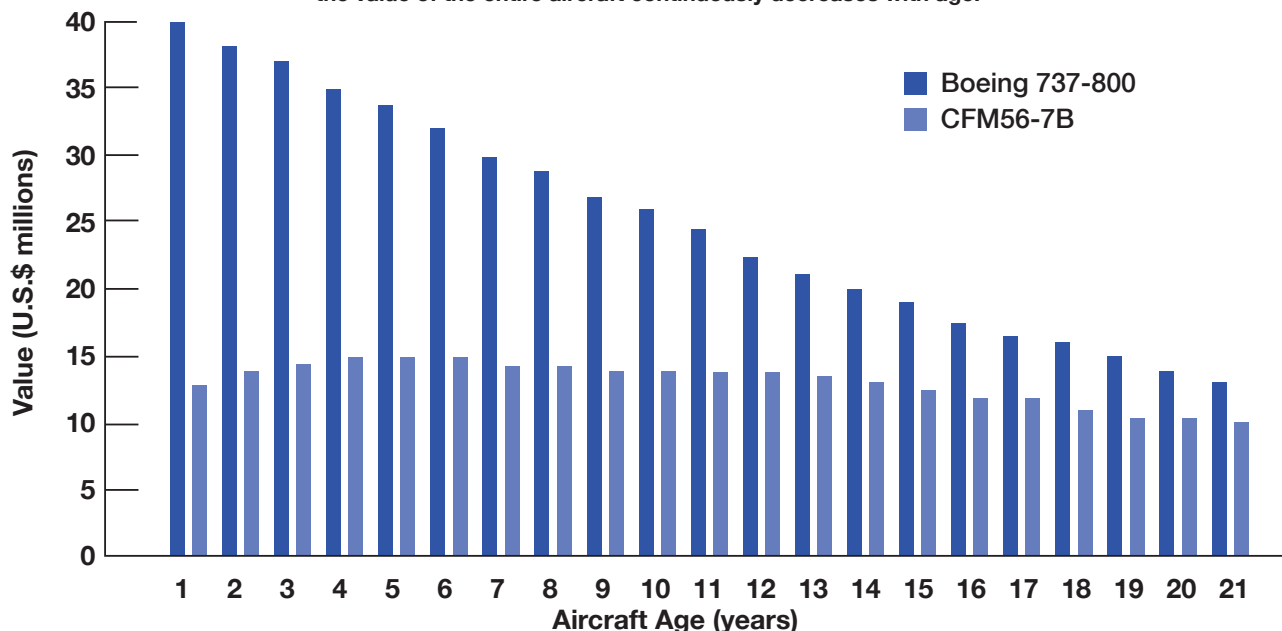
An aircraft can be recycled at 89-91% in weight, but the proportion will not increase until plastic and composite materials can be recycled in greater volumes.

nology to recover uncured composites from a factory. With offcuts of prepregged fabric, it makes the most of an electrical property of carbon fiber. Creating an electrical impulse on the order of a gigawatt through the fiber sublimates resin. It leaves the fiber as good as new, with intact mechanical and chemical characteristics, CEO Aziz Bentaj says. The duration of the electric pulse, about a nanosecond, makes it energy efficient.

“Our process yields fiber with constant section and constant specific weight,” Bentaj says. “We can produce kilometers of continuous fiber at 1 m/sec., and we aim at a manufacturing rate of 100 metric tons per year within six months.”

Price Evolution for Boeing 737-800 and CFM56-7B Engine

It is noteworthy that engines have a relatively stable value over time, whereas the value of the entire aircraft continuously decreases with age.



Source: IATA

The pilot factory that produces carbon fiber reels is located in Saint-Ouen, near Paris and is a partnership with Suez.

ELG Carbon Fibre is finding techniques to use recycled carbon fiber in structural applications. Last December, it unveiled the world's first train bogie made of such material—a collaboration with the University of Huddersfield's Institute for Railway Research in the UK. The new assembly, now in testing, is lighter than conventional bogies and optimizes vertical and transverse stiffness, ELG states.

The company has pioneered the pyrolysis technology to recover carbon fiber from offcuts and has a contract with Boeing, which supplies CFRP from 787 and 777X manufacturing. After pyrolysis removes the resin, the fiber is chopped and milled, then used as a reinforcement in thermoplastic composites.

The automotive industry uses them in nonwoven textiles for compression molding. The final products are car hoods and roofs, among other applications. Several car models use such recycled fiber, according to ELG's Gledhill. Recycled carbon fiber is thus making its way to higher-value applications.

Thermoplastics with recycled carbon fiber replace steel and magnesium with a better performance-cost ratio, Gledhill explains. "As vehicles go electric, they may be used for battery containers, where strength and lightness are key."

What prevents the recovered carbon fiber from being reused in airframes is the lengthy certification process, says Gledhill. He predicts it will first be used in less critical applications, typically in cabin interiors.

"It retains most of its performance," he says. If recovered carbon fiber is to be incorporated in an airframe, ELG will have to prove it meets the mechanical requirements despite the shorter fiber length.

In the future, the raw material going into ELG's pyrolysis process may come from dismantled aircraft. This would be

an advancement because it is better for an industry to reuse its own materials rather than export them to another one, in terms of environmental footprint control.

Last, but not least, a determining factor for the recycling business in the near term is compliance with environmental protection laws and best practices. For an owner, compliance—and possibly going the extra mile—boosts its public image. Conversely, a negative media report that reveals poor management of an aircraft's end of life can have devastating effects.

"Some examples that illustrate the need for better practices include aircraft stored in deserts without maintenance and/or proper decontamination processes and aircraft abandoned at airports or simply dismantled for aluminum recovery regardless of other materials that could be recovered, such as electronics or plastics," IATA states in its BIPAD.

The disassembly and dismantling phases generate hazardous waste that must be safely controlled. Likewise, companies must curb emissions into the air, such as paint dust containing heavy metals during the sawing dismantling phase. Emissions into soil should not contain fuel spills or wastewater.

Tarmac has been using a diamond-wire cutting gantry cooled with water. The system is deemed cleaner than the commonly used hydraulic pliers. Tarmac employs a cable to recover all the dust and cooling water. This process is also safer because it eliminates the risk of fire.

Tarmac has also created a mobile cutting facility in which it can process narrowbody fuselages in a closed environment, thus avoiding the dispersion of hazardous material such as asbestos. The mobile unit can be shipped to a site from which aircraft can no longer fly because they have been sitting for too long in poor conditions. The first contract was for 63 military aircraft in France. ☑

COVID-19 Crisis Will Affect Emissions in the Long Term

- > AIRLINES WANT CHANGES TO THE CORSIA SCHEME
- > RETIREMENT OF OLDER AIRCRAFT WILL IMPROVE EFFICIENCY

Helen Massy-Beresford Paris

The COVID-19 crisis has—temporarily and painfully for the aviation industry—solved the problem of airline emissions.

But once aircraft begin to fly again and some normalcy is restored, the coronavirus outbreak may prove to have a longer-lasting impact on industry efforts to boost sustainability.

As fleets have been grounded across the globe, environmental campaigners have taken the opportunity of almost empty skies and a short-term dive in CO₂ emissions to draw attention to the urgent need to reduce aviation's environmental impact.

The artificial plunge in emissions could last for some time, says John Strickland, director of JLS Consulting.

"We're going to see a reduction in aviation activity through airlines failing [and] demand itself being down—[due to] border closures but also the confidence and psychology of traveling, people not having money

in their pockets for leisure travel and businesses failing," Strickland says. "All this in a time frame running into years, not months."

But looking ahead to when aircraft will gradually return to the skies, the emissions debate centers on the International Civil Aviation Organization's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (Corsia).

Airlines are asserting that the unprecedented hiatus in global air travel should be taken into account in the Corsia scheme, which requires participating carriers to offset any emissions growth above a baseline of an average of 2019 and 2020 emissions.

As fleets remain grounded, those average emissions will be getting lower, making the targets harder to meet, the airline industry contends.

Airlines therefore want changes to the scheme—the International Air Transport Association has called on

ICAO to take account of the unprecedented dip in emissions in the past months and use only 2019 emissions data as the baseline for the first phase of Corsia—but environmental campaigners warn that any adjustments could damage the scheme in the long term. ICAO is expected to discuss the issue at its governing council session in June.

Before the COVID-19 pandemic began, European airlines had been coming under increasing scrutiny over their emissions, with new measures being implemented by governments including a controversial eco-tax in France. Ministers from many of the bloc's member states had also been calling for a Europe-wide aviation tax.

The COVID-19 crisis has turned the industry upside down, with many air-

Lufthansa is permanently retiring six of its 14 Airbus A380s, among other aircraft.



lines fighting for survival and governments scrambling to provide financial support for their carriers.

Air France-KLM is reportedly negotiating a loan of up to €10 billion (\$10.8 billion) with the governments of France and the Netherlands, while Norwegian Air Shuttle and SAS are among other airlines that have negotiated financial support from their governments.

Could this situation lead to opportunities for governments to push the sustainability agenda? The Austrian government has said its help for airlines should be linked to climate targets.

The European Federation for Transport and Environment, an environmental lobby group, says airlines should be supported through the current crisis but that any bailouts should be conditional on carriers adopting green technologies and paying environmental taxes once conditions improve, especially as crises that have hit the aviation industry, such as the Sept. 11, 2001, terrorist attacks and the severe acute respiratory syndrome historically have been followed by strong rebounds in air traffic.

“Governments should move to protect airline jobs but also to kick-start the just transition for aviation,”

Andrew Murphy, the group’s aviation manager, adds. “Taxpayers’ money must only be used if these big polluters commit to the EU Green Deal, including starting to pay tax and taking up greener fuels.”

Strickland agrees that the airline industry needs to use this deep crisis as an opportunity for a reset. “This is being seen as a wake-up call for humanity and the planet—aviation has to be seen to be playing its part.”

Airlines need to demonstrate that government support is justified, according to Strickland. “The only way to do that is to do something demonstrably positive,” he says. “The industry needs to lobby governments to ensure that money being taken out of the sector through taxes—and then not invested back into research into areas like biofuels and electric aviation and better air traffic management—is actually spent on such things.”

The coronavirus crisis has prompted some airlines to bring forward the retirement of older aircraft, a move that should help them emit less CO₂.

“We’ve heard clearly from groups like Lufthansa and [International Airlines Group] that certain older grounded aircraft are unlikely to come back at all,” says Strickland. “Even if nothing else changes, that means a shift in the

mix of aircraft. The aircraft left will be younger and more efficient, which on a per-seat basis improves emissions credentials.”

Lufthansa is already planning its future as an airline that is 20% smaller than pre-coronavirus, including the permanent retirement of six of its 14 Airbus A380s, seven of 17 A340-600s, three A340-300s and five Boeing 747-400s, as well as reductions to its short-haul fleets.

In the short term, financing new fleet additions may be unfeasible for some airlines that have had to strip their costs and investment plans to the bone to survive. But others may take advantage of lower market prices to further boost their orderbooks: Ryanair CEO Michael O’Leary has already signaled this is in the cards.

The COVID-19 pandemic is set to reshape the aviation industry in the months and years to come, and that could affect future programs as well as existing fleet plans, Strickland says. “It should be very much in manufacturers’ minds, too, to expedite programs that offer greater efficiency,” he says. “In the medium term, this could be a chance for manufacturers to advance efficiency elements through changes to forthcoming programs such as Boeing’s [new midmarket airplane].” ☒

By Plane or by Train? COVID-19 Could Mean More Travel by Rail

- GLOBAL AIR TRAFFIC COULD TAKE A LONG-TERM DOWNTURN AFTER COVID-19
- AIR TRAVEL LOSS COULD BE HIGH-SPEED RAIL GAIN IN CHINA AND EUROPE

Michael Bruno Washington

Gravelly Point is too serene for comfort. These days, the popular public park just north of Ronald Reagan Washington National Airport’s Runway 19/1 is more conducive to a restful picnic than aircraft spotting.

Indeed, if visitors listen closely against the noise of joggers and bicyclists along the George Washington Memorial Parkway, they might hear the distant rumble of local Metro and long-distance Amtrak trains ferrying passengers across the Potomac River. It is a frightening glimpse into a potential future for commercial aviation that could be accelerated by COVID-19, according to new analyses.

In an April 2 report titled, “By train or by plane? [The] traveler’s dilemma after COVID-19 amid climate change concerns,” UBS researchers surveyed more than 1,000 people in China and Europe and discussed how soon a shift by Chinese and European consumers away from air to rail could happen.

The takeaway: The authors of the report see air traffic growth slowing to 4.6% annually through 2028, below the long-term average of 5%. That portends a potentially permanent throttling back for commercial aviation. By region, they see no growth in intra-European revenue passenger kilometers through 2028, compared with just 1.8% in the U.S. and 6.1% in China’s domestic aviation market. That compares with 4.1%, 3.2% and 8.1%, respectively, in OEM forecasts from last year.

“Some investments for projects to lower carbon emissions may be diverted to supporting the transport and travel industries [after the COVID-19 crisis], but we do not believe the developed world will abandon its ambition of ‘net zero’ carbon emissions by 2050, nor that consumers will no longer want to optimize the use of their time by taking longer train journeys,” the UBS team says. “We, therefore, expect an acceleration in the shift from planes to high-speed rail (HSR) in both Europe and China.”

In addition, a survey conducted by global consulting and technology services firm ICF in late March and early April

captured similar views from senior- and mid-level executives across all parts of the commercial aviation value chain worldwide. Despite the economic uncertainty resulting from the novel coronavirus, one in five respondents reported that their company's commitment to environmental sustainability would increase.

"When we get to the other side of this, we should see carbon emissions reemerge as a very important issue," AllianceBernstein analyst Doug Harned said April 16 on a teleconference call. "I was just on a working group on that, and it's a very big deal for everyone involved. I think cutting emissions and having a modern fleet will turn out to be very important within a couple of years."

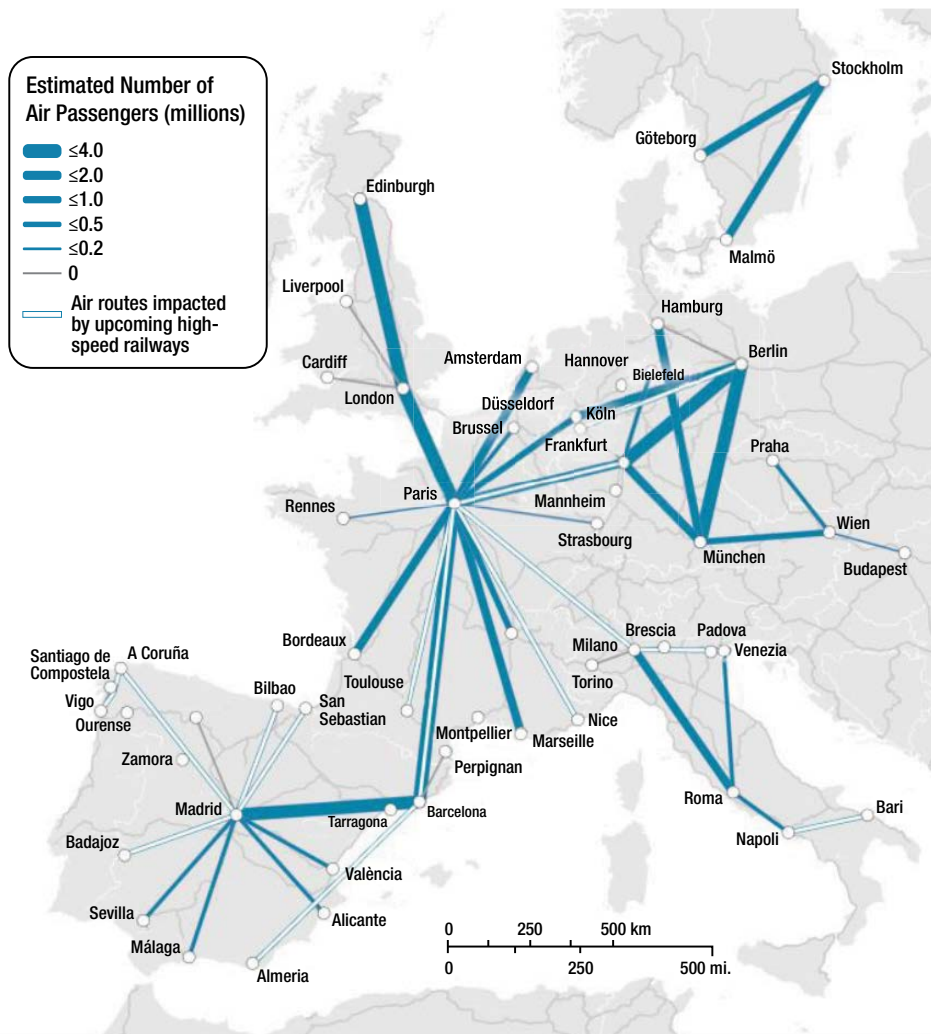
HSR long has been a potential threat to global airliner growth. Asked what he once watched most closely, chief Boeing salesman Randy Tinseth told Aviation Week that adoption of HSR overseas was a key variable.

In one ironic example closer to home, aerospace executives, analysts and advisors on the U.S. East Coast often prefer riding Amtrak's Acela between Boston and Washington. Quietly they will tell journalists they find the curb-to-seat, boot-up-the-computer experience of HSR more convenient than airport and airline travel, especially as the latter is more susceptible to bad weather and traffic delays.

According to data from the UBS Evidence Lab survey of 1,000 people in France, Italy, Germany, Spain and China, leisure travelers will tolerate 5-6 hr. on a train. EU business travelers would be willing to accept up to 4 hr. compared with the consensus of 2-3 hr. Meanwhile, HSR in China has taken more travelers off the roads than away from airlines, according to UBS. But that could change. Service and frequency are key drivers of demand for longer train journeys, and both can be improved when competition among operators is introduced.

In turn, UBS estimates around 12% fewer single-aisle aircraft would be needed in 2018-28, as that class dominates routes shorter than 1,000 km (600 mi.). Much of the fleet reduction likely would come from accelerated retirement of older, inefficient narrowbodies such as the Boeing 737 Next Generation and Airbus A320ceo. Their

Air Routes Impacted by Existing and Upcoming High-Speed Railways



Source: UBS Evidence Lab

High-speed rail long has been a potential threat to global airliner growth.

successors feature 15-20% better fuel burn and count 10-15% more seats, dropping carbon dioxide (CO₂) per passenger. In the end, the cuts could save 2.7-3.4 million tons of CO₂ per year.

The relatively good news for aircraft OEMs and suppliers is that new-generation aircraft and deliveries are not seen as vulnerable. The bad news, however, is that after-market revenue tied to older aircraft is at greater risk.

How accurate the forecasts are remains to be seen, but UBS researchers are certain COVID-19 will lead to lasting changes. "As well as the economic downturn triggered by COVID-19, movement restrictions may also be remembered for having abruptly reduced emissions in developed and emerging countries for weeks, [and] triggered new habits—remote working, the use of social video-calling apps—and given a majority of the population the experience of much lower levels of pollution," UBS says. 🌱

Ambitious Flight-Test Regime Planned for RACER Demonstrator

- > THE FIRST FLIGHT IS PLANNED FOR THE FOURTH QUARTER OF 2021
- > THE TEAM IS FINALIZING THE MAIN GEARBOX CONFIGURATION



AIRBUS HELICOPTERS

Tony Osborne London

Airbus and its partners may have cut metal on the first components for its Rapid and Cost-Efficient Rotorcraft (RACER) demonstrator, but the world will have to wait until late 2021 before it takes to the skies.

Program management complexities have nudged the first flight back a year, says RACER Chief Engineer Brice Makinadjian. Airbus is working with 50 copartners and 30 entities, and “this is slowing the speed of the development,” he says. “But we are paving a new way of collaborating with our partners. . . . So if this is the price to pay, it is worthwhile.”

The €200 million (\$217 million) RACER’s development was funded through the European Union’s Clean Sky 2 aerospace research initiative, and it builds on and aims to refine the company’s work with its X³ high-speed compound rotorcraft that took to the air in 2010. On the X³, lateral tractor propellers with variable pitch provided anti-torque, while the main rotor was slowed to reduce drag from the advancing blade tip and wings provided lift in cruise. On the RACER, the lateral propellers have been turned into pusher propellers, and engineers have

developed a box wing, which increases lift and allows the landing gear to be installed in the lower wing section.

Work began on manufacturing components following a successful critical design review (CDR) in 2019. Partners have already produced the windshield through a Clean Sky program called FastCan in conjunction with companies in the motor-racing industry. The canopy is designed to deal with bird strikes while operating at much higher speeds. Cockpit doors, fuselage longerons and frames have also been produced, along with elements of the landing gear. The fuselage will be delivered this summer.

Unlike the X³, which reused components from aircraft in the then-Eurocopter family lineup, the RACER is a largely new design. Makinadjian notes that the aircraft will use the H175’s main rotor system for its first flight, however; a new blade currently under development and optimized for high-speed flight will be installed later.

The new blade is part of a French research program and will feature an “evolution in the shape of the blade,” Makinadjian says, although he would not say whether it would use active systems like the company’s Blue Pulse active blade tested during 2009.

The RACER’s main gearbox remains in development, in collaboration with Italy’s Avio Aero, and is one of a handful of elements that has not been finalized through the CDR. The complicated gearbox design features two driveshafts, each running through the upper box wing to the lateral gearbox, which in turn drives the lateral propellers. The shafts are supercritical components that operate at up to 3,000 rpm. Later this year, the RACER team will run fatigue and endurance tests on the gearbox to prepare it for installation in the aircraft.

Similar to the X³ design, the RACER’s lateral propellers will be made from wood.

The RACER’s flight-test campaign “is quite ambitious,” Makinadjian notes, initially focusing on opening the flight envelope. The company is confident the aircraft can achieve cruising speeds of around 220 kt. and will likely go faster.

“The aim of the X³ was to demonstrate the formula,” Makinadjian says. “Now we want to be more ambitious [and] demonstrate some missions, some capability.”

One possible demonstration could be to try to fly from Paris to London in 1 hr, he suggests.

The Safran-developed eco-mode hybrid-electrical system, which allows one of the two Aneto-IX engines to be shut down while in cruise flight, will not feature in early flights. The capability will be added later in the flight-test campaign. “The RACER is a new formula, even compared to the X³, and there are significant differences,” Makinadjian explains. “With all these novelties, we will have to be a little humble and do things step-by-step. Before we stop an engine in flight, we would like to be able to master the way [the RACER] is behaving.”

The eco-mode uses a high-voltage system that can rapidly spool up the idled engine when additional engine power is required, such as during hovering, takeoff or landing. The RACER will feature a generator developed by Italy’s ASE S.p.A. fitted to the main gearbox of the aircraft, which will convert mechanical into electric power producing 270 volts direct current. The aircraft will also feature a generator control unit to regulate the power output in case of overvoltage and overcurrent.

The RACER aims to prove that even with additional performance, rotorcraft technology can deliver reductions of up to 20% in emissions and noise. ☛

AIRBUS TARGETS PRODUCTION ADVANCES WITH DIGITAL TOOLS



- > NEW TOOLS HELP INFORMATION CIRCULATE
- > BENEFITS ARE EXPECTED IN QUALITY AND ON-TIME DELIVERY
- > VIRTUAL AND AUGMENTED REALITY HAVE YET TO MATURE

Thierry Dubois Lyon

Airbus is reorganizing how it brings digital tools to production workers, looking to keep only relevant ones and increase adoption of their use. And further streamlining of manufacturing can be expected, opening the way to eradicate causes of delivery delays.

The airframer has been on a learning curve, and early initiatives have been abundant. “There was an era of proof-of-concepts that were not always delivering scalable benefits but were extremely useful to grow our digital maturity,” says Marie Hontans, vice president of the digital industrial value stream. “From last year, we stepped back on the number of tools, which was growing fast across the

company.” Hontans is in charge of digital transformation for all Airbus sites.

Profusion was creating problems such as a lack of awareness of tool usage, she notes. And a cybersecurity issue was looming, as increasing the number of tools increases exposure.

So Hontans’ team is building “a new way to orchestrate tools and processes.” The idea is to have fewer but better-integrated tools. They should cre-

Airbus’ manufacturing execution system now has 8,000 users.

ate more value, involve less support and generate less associated cost.

The approach establishes links between interdependent organizations that did not realize they were working in silos. “We have to enhance synergy between sites and functions,” says Hontans. “Instead of introducing several tools that do the same thing on different sites, let’s have sites codesigning.”

In commercial aircraft production, lead times need to be predictable, standardized and reliable. “Last year, the aerospace industry was nowhere close to that, and variability was prodigious,” says Jerome Bouchard, aerospace partner at consultancy Oliver Wyman. “The cycle at a given station could double due to a need for rework, a missing part, a discrepancy or damage caused by a worker.”

Complying with the takt time—the target duration of a cycle at a workstation—is key. “You need digital tools to meet your takt time,” says Bouchard.

Digitized information, such as an

aircraft's digital mockup (DMU), has been very design-engineer-centric in the past, but it is now being shared with workers on the production floor, adds Eric Ciampi, Oliver Wyman partner and head of its of operations practice in France. Digital continuity creates links between four categories of employees: design engineers, manufacturing engineers, workers on the production floor and quality inspectors, adds Bouchard.

Some of the tools and systems are achieving results in Airbus factories. The manufacturing execution system (MES) now has 8,000 users, most of them in blue-collar positions. It helps them accurately regulate their timing, certify their operations and escalate issues when they need support, says Hontans.

In Broughton, Wales, the MES has

tal tool involves working the same way at every site, in every country. The benefit is that it standardizes the way of working, down to the detail level.

Operations during a takt cycle are supposed to be executed in the same

duced to the minimum steps to follow.

Nonexpert employees receive complete work instructions, with more details and DMU extracts to position themselves. The ISOI tool adapts automatically to a person's skill level,

"Instead of introducing several tools that do the same thing on different sites, let's have sites codesigning."

—Marie Hontans, Airbus vice president of the digital industrial value stream

order, as sequences are interdependent. This translates into efficiency and quality improvement. "At stake in digitizing production is reducing quality issues," says Ciampi.

The interactive standard operating instructions (ISOI) tool is a com-

classified via a personalized ID.

With ISOI, an alert can be contextualized, adds Hontans. The worker receives an alert if a quality issue was noticed previously at the stage they were working on.

The MES creates an improvement loop. Thanks to Digital Design Manufacturing and Services (DDMS), the way a factory runs can be simulated thoroughly. In the near future, "we will be able to model the industrial system and highlight problems before they even happen," says Hontans. "Changes to the industrial system will be based on extremely detailed knowledge of what causes problems." Digital tools are integrated with DDMS.

Feedback can improve lead-time consistency. If a task is estimated to last 4 hr., and data shows it regularly takes 6 hr., manufacturing engineers can rethink it, says Ciampi. They can either

Digitized information, thus far design-engineer-centric, is now being shared with production workers.

been introduced into the wing manufacturing process. "We have faced challenges, but use rates are now very high, and the advantages are visible to all," says Keith Baxter, Airbus digital plateau leader. "Managers used to find out about disruptions at the end of a shift or even week. Now we are moving toward real-time information."

Change management has been a challenge, says Hontans. Using a digi-

ponent of the MES. It personalizes instructions so that each worker receives the level of detail they need. It displays a version of the digital mockup, as opposed to a PDF document.

Available on smartphones and tablets, the tool is in use at the Airbus fuselage assembly plant in Saint-Nazaire, France, for example.

For the expert worker, the ISOI tool highlights changes to previous work instructions. Every modification or warning is dynamically sent to the operator, pointing out that it is new. The expert view is simplified, re-

streamline operations or update work instructions to match reality.

ISOI may follow a trend seen in other industries, where work instructions are becoming more intuitive and based on user experience. Cameras may be used for quality checks and feedback sent to the manufacturing engineering office, says Ciampi.

The A321neo final assembly line in Toulouse, the creation of which is now on hold, was understood to be the Airbus Factory 4.0 showcase, with the facility's layout to be designed from a clean sheet.



P. PIGEYRE/AIRBUS

Projection can help workers find the right location for their task.

Next year, Hontans expects that smart, connected tools will start being used. A smart drill knows the parameters for on-time and quality drilling: It will perceive whether it was done correctly, she explains. Applying the wrong torque will cause the operation to be rejected.

Such tools have been used by Airbus Defense and Space for satellite manufacturing. However, there is no such thing as a copy-and-paste process between divisions, and smart tools have yet to mature for commercial aircraft, Hontans says. They need to be integrated into the information system's landscape.

Some applications of digitization are only emerging. "Warehouses have



AIRBUS

operator can then focus on that 10%, drastically cutting the inspection task's lead time.

AI may also help improve quality by establishing a relationship between a problem and input parameters, Ciampi suggests. A system may find that


that can be found at some suppliers' production facilities.

Moreover, mixed-reality technology has yet to achieve convincing results for Hontans. Prototypes of Microsoft HoloLens goggles have been used at several sites for various tasks such as guiding the installation of wiring harnesses on the A330 military Multi-Role Tanker Transport in Getafe, Spain. Airbus hoped there would be a considerable improvement in work speed, as operators can see instructions and diagrams layered over the work they are carrying out.

However, making the goggles comfortable enough to be worn for several hours is a complex ergonomical problem. "The technology may be spectacular, but it does not necessarily meet our needs from a content standpoint," says Hontans. The device has been found to be better suited for inspection and maintenance than for production.

Despite all the benefits, digitization cannot solve every issue. Would A321neo delivery delays have been avoided with such tools? "A digital tool is no magic wand. It helps a process if the process was well-designed and is well-executed," Hontans answers.

Some serendipity may come into play. Digitization has been improving the image of perhaps unappealing production jobs. "[M]ore people will be able to be trained for production jobs because the repetitive, handcraft aspects will see their importance decreasing," says Ciampi.

This is in line with the industry's effort to allocate employees to high-value-added tasks. 

"If a task is estimated to last 4 hr. and data shows it regularly takes 6 hr., manufacturing engineers can start rethinking it."

—Eric Ciampi, Oliver Wyman partner and head of its operations practice in France

yet to digitize entirely for automated part inventory management," says Hontans. "We use several technologies for tracking, such as 4G and Wi-Fi. Such automation is in progress and part of the digital transformation. It brings efficiency and process adherence to our logistics."

Using the Internet of Things, some companies are now able to pinpoint the location of objects in the factory, helping to prevent tools from being mislaid in a hidden nook of an aircraft. Current technologies, such as the use of smart light bulbs, will evolve with 5G wireless telecommunications.

Digital continuity may simplify quality inspection, a complex task involving much paperwork. A 3D scanner may shorten the inspection cycle through the use of artificial intelligence (AI). On a large subassembly, the system can confirm 90% compliance and indicate uncertainty about the remaining 10%. The human

80% of a problem's occurrences correspond to certain conditions. Using that data, training may be improved or work instructions revised.

Hontans is cautious, however, about augmented and virtual reality. They are used in a few situations, mostly for post-assembly inspection purposes. A virtual reality tool can project the right configuration, superimposing it onto the actual aircraft in construction so that the inspector can see any deviation. In production, frames are projected to show the locations where holes should be drilled.

The reasons virtual or augmented reality are not often used can be found in the layout of a workstation and the industrial maturity of the existing solutions, says Hontans. In most assembly stations, more than 10 people work simultaneously in a relatively small space. This is different from fixed jigs with a couple of workers walking around, a configuration

Hypersonic Mass Production

- > PENTAGON FORMS HYPERSONIC INDUSTRY “WAR ROOM”
- > UNIT PRICING FOR MISSILE PRODUCTION IS STILL UNCLEAR



LOCKHEED MARTIN

Steve Trimble Washington

As the U.S. hypersonic weapons strategy tilts toward valuing a quantity approach, the new focus for top defense planners—even as a four-year battery of flight testing begins—is to create an industrial base that can produce missiles affordably enough that the high-speed weapons

can be purchased in volumes of hundreds or even thousands.

Officially, the Pentagon has not adopted any plans to move beyond the prototype phase for the three acknowledged rocket-boosted glider programs: the Air Force's AGM-183A Air-Launched Rapid Response

A single B-1B is now expected to carry up to six AGM-183As, which is part of a strategy shift driving Pentagon planners to focus on laying the groundwork for affordable large-scale production of future hypersonic missiles.

Weapon (ARRW), the Army's Long-Range Hypersonic Weapon (LRHW) and the Navy's Conventional Prompt Strike (CPS) missile. DARPA's scramjet-powered cruise missile, the Hypersonic Air-Breathing Weapon Concept (HAWC), remains a demonstrator.

Only the Common Hypersonic Glide Body (the front-end shared by the LRHW and CPS) has even been tested: The preweaponized Block 0 version completed a successful test flight on March 19. The ARRW's DARPA-led demonstrator, the Tactical Boost Glide, is scheduled to enter flight tests later this year, along with the HAWC. Beyond the 40 prototype missiles on hand, the Pentagon's latest spending plans show no funding to produce operational hypersonic weapons at any scale.

To pave the way for an affordable production strategy, the Pentagon's Research and Engineering division has teamed up with the Acquisition and Sustainment branch to create a “war room” for the hypersonic industrial base, says Mark Lewis, director of research and engineering for modernization.

“At the end of the day, we have to be careful we're not building boutique weapons,” he says. “If we build boutique weapons, we won't—we'll be very reluctant to—use them. And that again factors into our plans for delivering hypersonics at scale.”

Defining what affordability means in the hypersonic market segment still is not clear. Will Roper, assistant secretary of the Air Force for acquisition, technology and logistics, said more than a year ago that an ideal unit cost of a hypersonic missile at full-rate production should be similar to that of an advanced air interceptor, such as the Patriot missile. The average cost of the latest version of the Patriot is about \$4 million per missile.

But Air Force and defense officials have been promoting concepts for operating air-launched hypersonic missiles in swarm attacks. The B-1B, for example, will be modified to carry six AGM-183As, with each including a hy-

personic glide vehicle and a 30-in.-dia. booster. However, Lewis bristles at drawing unit-cost comparisons between hypersonic missiles and long-range, subsonic and stealthy cruise missiles, such as the roughly \$1.2 million AGM-158B Joint Air-to-Surface Standoff Missile-Extended Range.

"I think it's a poorly posed question to ask about affordability per unit," Lewis says. "We have to think of it in terms of the affordability of the capability that we're providing. By that I mean: If I've got a hypersonic system that costs twice as much as its subsonic counterpart but is five times more effective, well, clearly, that's an advantageous cost scenario."

There are signs the industry is preparing for the production ramp-up. On Jan. 10, Spirit AeroSystems, a large-volume fuselage supplier for Airbus and Boeing commercial aircraft, announced the acquisition of Fiber Materials Inc. (FMI), a Maine-based company specializing in manufacturing 3D-woven carbon-carbon structures for high-temperature applications. Spirit AeroSystems' announcement of the acquisition pointed to potential hypersonic missile production, given the possible combination of FMI's high-temperature skill and the Kansas-based supplier's high-volume production system.

But the stakes for industry remain

uncertain. Meeting the Pentagon's affordability goals requires making investments now in hypersonic production capacity. The Pentagon still has no funded programs of record, however, and has only completed one flight test since 2017. The presidential election later this year could bring with it possible implications for the military's spending priorities. How the industrial base scales up for production as testing continues over the next years will be critical.

"The simple answer is: We don't know what these things cost," Lewis says. "We've asked the primes to consider costs as they're developing, and I think they are." ☛

MBDA Patent Offers New Glimpse Into Europe's Hypersonic Weapon Plans

- > PATENT INVOLVES NOSE-MOUNTED ENDGAME SEEKER
- > MBDA LEADS FIVE-NATION INTERCEPTOR EFFORT

EUROPEAN UNION



Steve Trimble Washington

A newly filed patent application offers a rare glimpse inside European missile house MBDA's hypersonic weapon technology program and shows how the company has started working to solve one of the most difficult challenges posed by hypersonic weapons.

The April 9 application filed with the U.S. Patent and Trademark Office by MBDA France comes as France and the UK deepen interests in pursuing hypersonic speed for a future class of cruise missiles, projectiles and interceptors.

Last November, MBDA accepted the lead in a five-nation pact called the Timely Warning and Interception

with Space-based Theater surveillance (Twister) program, which seeks to develop by 2030 an interceptor against a range of threats, including hypersonic gliders and cruise missiles (AW&ST April 6-19, p. 14).

"This patent relates to applications linked to very high-speed missiles, including hypersonic," MBDA tells Aviation Week. "Be aware that MBDA is pursuing a European program for an interceptor against hypersonic and maneuvering ballistic threats that could be an application for this patent."

The application with the U.S. patent office, which follows French approval in 2018, focuses on a critical tech-

nology for an interceptor missile: a nose-mounted endgame seeker. Long-range flight above Mach 5 exposes the interceptor to airflow temperatures of several hundred degrees Celsius. As a result, the nose-mounted seeker must be shielded within a nose cone until the last few seconds.

The problem then becomes how to eject the nose cone without damaging the seeker. Using a pyrotechnic as the actuator for an explosive bolt

MBDA has started working on solving some of the hardest challenges posed by development of an interceptor for maneuvering hypersonic missiles.

is problematic; even if the skin temperatures do not accidentally set off the pyrotechnics, the explosion risks damaging or blinding the sensor.

MBDA's patent proposes a one-piece assembly for the actuation device, which includes thermal insulation to shield a pyrotechnic charge and prevent an accidental explosion. At the right time, the charge would be set off inside the device. Instead of blowing open the bolt, the charge would generate an overpressure within the device. The overpressure would actuate a piston rod to slam into the shell of the nose cone. The sensor could then be activated to lock onto the target.

MBDA's hypersonic development extends beyond interceptors: It also is creating the ASN4G, a scramjet-powered, air-launched cruise missile to replace the French ASMP-A nuclear deterrent by the mid-2030s. ☛

Raytheon's LRSO Prize Completes Nuclear Modernization Supplier Roles

➤ RAYTHEON IS NOW THE SOLE SOURCE FOR THE \$4.5 BILLION MISSILE

➤ LRSO PRESERVES THE B-52 NUCLEAR ROLE AFTER 2030

Steve Trimble Washington

Raytheon now stands as the sole remaining bidder for the Long-Range Standoff (LRSO) program, a \$4.5 billion cruise missile that replaces the AGM-86B and preserves a nuclear strike role for a portion of the B-52 fleet beyond 2030.

Competitive bidding processes sometimes do not end as planned, and that sentiment has proved true for the U.S. Air Force's nuclear modernization portfolio. The bidding war between Northrop Grumman and the tandem of Boeing and Lockheed Martin to build the B-21 ended formally in 2015 with a

on April 17 without any fanfare on the website of Global Strike Command, and it went unnoticed there until April 20.

The Air Force Nuclear Weapons Center (AFNWC), which manages the program, later clarified the key events that led up to the sole-source decision in favor of Raytheon. The Air Force completed a preliminary design review for Lockheed's LRSO concept in October 2019, followed by Raytheon's version in November. A traditional downselect process did not follow, but the Air Force decided to end the competition.

Maj. Gen. Shaun Morris, the AFNWC

the Air Force still believes an LRSO can be developed on time and affordably.

"I am confident in the program office's ability to execute the next phase's contract negotiations in a single-source environment and maintain schedule and affordability," Morris said.

The end of the LRSO competition comes less than seven months before a presidential election with potentially dramatic implications for the Pentagon's nuclear modernization plan. Former Vice President Joe Biden, the presumptive Democratic Party presidential nominee, was serving in the administration of former President Barack Obama when the LRSO and GBSD acquisition programs launched, but his support for both is not assured.

An essay by Biden published in the March/April issue of the journal *Foreign Affairs* states that he believes the U.S. nuclear arsenal should be used only for deterrence and retaliation. If elected, that statement suggests Biden could become the first U.S. president to declare a "no first use" policy for nuclear weapons. Byron Callan, an analyst for Capital Alpha Partners, said in an April 22 note to investors that such a policy would continue to value the role of submarine-launched missiles as a deterrent and retaliatory strike option but would make the GBSD and LRSO options vulnerable.

The Air Force launched the LRSO program in 2010 to replace 375 AGM-86Bs that entered service after 1982. With the Boeing-designed cruise missiles scheduled to be retired due to obsolescence in 2030, the B-52 will need a new missile with standoff range to perform the nuclear strike mission. The Air Force's requirements for LRSO include the capacity to navigate to a target in a GPS-denied environment and the ability to survive against a complex, integrated air defense system.

Raytheon's status as the LRSO sole-source supplier also offers the Air Force a new industrial option for a future conventional cruise missile. Lockheed Martin already supplies the conventional AGM-158 Joint Air-to-Surface Stand-off Missile, including versions with extended range. At the same time, the Air Force is considering proposals for developing a hypersonic cruise missile with a conventional warhead. The service has never clarified if the LRSO requirement calls for a missile with subsonic, supersonic or hypersonic speed. ☐



In November 2019, an Air Force ground crew demilitarized the last AGM-86C conventional air-launched cruise missile. The nuclear version will continue in service until replaced by the LRSO in 2030.

\$21.4 billion contract award to Northrop Grumman. However, the competition for the Ground-Based Strategic Deterrent (GBSD) program has been less fierce. Activity fizzled when Boeing decided to withdraw last year, leaving Northrop as the sole bidder for an \$80 billion contract expected to be signed shortly.

The competition for the nuclear LRSO weapon also ended abruptly. The Air Force simply decided to continue with Raytheon as the sole-source supplier for the secretive LRSO missile, even though two years remained on a 54-month risk-reduction contract awarded to both bidders in August 2017.

Despite billions of dollars at stake, the Air Force's decision was released

commander, said the terms of the risk-reduction phase "enabled us to select a high-confidence design at this point in the acquisition process." Meanwhile, Lockheed continues to offer its expertise on sensors and nuclear certification for the LRSO, but formalizing that role will require a new contract from the Air Force, which has not yet been offered. The service expected to close out Lockheed's risk-reduction contract on the LRSO by the end of April. The AFNWC also is considering options to accelerate the start of the engineering and manufacturing development (EMD) phase with Raytheon.

Despite the absence of a competitive bidding process for the EMD contract,

Airbus Automated Refueling a First Step Toward Autonomous Capability

> FIRST FULLY AUTOMATIC REFUELING TOOK PLACE WITH AN F-16 RECEIVER IN APRIL

> SINGAPORE SET TO BE FIRST CUSTOMER FOR A3R TECHNOLOGY

Tony Osborne London

Airbus says aerial refueling operations could be performed with just two crewmembers on the flight deck by the end of the decade.

As the company refines its automatic aerial refueling (A3R) for its A330 Multi-Role Tanker Transport (MRTT), with the aim of certifying the technology as ready for operations in 2021, it is already looking toward the next step. An autonomous automatic aerial refueling (A4R) capability would remove the need for an aerial refueling officer (ARO), or boom operator, from the aircraft.

First, Airbus has already taken several steps to finalize development of the A3R capability. In mid-April, the company confirmed it had carried out the first fully automatic A3R operation with its A310 Aerial Refueling Boom System testbed and a Portuguese Air Force F-16 acting as a receiver. The A3R system flies the refueling boom and positions it over the receiver aircraft's receptacle until

it selects the optimum moment to extend the telescopic boom and achieve the connection that allows the fuel transfer to begin.

The system uses a combination of sensors, with image processing the main contributor, Juan Cabrera, head of testing and autonomous refueling at Airbus defense and space in Spain, tells Aviation Week.

"The system is able to conduct everything: boom positioning and insertion in the receiver receptacle, fuel transference and separation after the disconnection," he says. "It can also safely separate the boom in case the receiver maneuvers erratically." The A3R has been developed to work with any receiver aircraft, without

any modifications required for them.

Image processing determines the location of the receiver's receptacle, but this has to be done with accuracy, notes Cabrera. "The alignment for a successful connection is as tight as a few centimeters," he says.

The geometry of the receptacle is also important, as it helps determine the safe separation distance the boom maintains before contact.

Motion rates and receiver size are other factors, as a small fighter has a different influence on the tanker com-



The A3R system's image processing function looks for receiver attributes so that the boom can be safely prepositioned, ready to make the connection with the receptacle.

pared to a receiver of similar size or larger such as on a tanker or airlifter.

"This is nothing new in the way that we currently qualify a tanker and a receiver. The differences are that this was previously based on human perception and now it is done by analytics and precise data," says Cabrera.

Using data collected for new receiver aircraft, the A3R system configures itself to adapt for the new types.

Development of Airbus' A3R system began in 2015. The first dry contacts—without fuel—were performed in 2017, again with Portuguese F-16s. Dry-contact trials were also performed with an A330 MRTT a year later.

Airbus believes the automated refueling process will be safer and will

optimize the rate of aerial refueling, potentially allowing more aircraft to be refueled in a sortie than with a human boom operator.

On the MRTT, the ARO operates the refueling systems from a position in the cockpit behind the pilots, where they are presented with a camera view underneath the aircraft's rear. That setup is similar to Boeing's KC-46. With the A3R, the ARO monitors the refueling process but has to set the receiver type and fuel amount requested. Airbus is looking to automate these processes with the A4R, too.

"Among the different tasks in refueling an aircraft, the most complex is the connection with the receiver. But when you can do it, then you have opened the door to the A3R," says Cabrera.

"The automation of any process always save costs and reduces risks; this is evident in any sector," he says. "But we have to implement it progressively and step by step according to the maturity of the solution."

Ultimately, the A4R is "the target in aerial refueling, but we have to achieve A3R first," he adds.

The Republic of Singapore Air Force will be the launch customer for the A3R capabilities. The service is supporting the flight-test campaign with one of its newly delivered Enhanced MRTTs. The Royal Australian Air Force has also supported the project in previous flight trials.

The capability is also attracting considerable interest in Europe, where the A3R technology is seen as one way of overcoming shortfalls in European aerial refueling capacity. Last year, the European Defense Agency called on members to begin developing requirements for A3R capabilities to help reduce life-cycle costs, technical and operational risk and human workload. Cabrera says Airbus was participating in such forums and had already been involved in several assessments of A3R's concept of operations.

The A3R technology will primarily apply to the Enhanced version of the MRTT, as the model features an updated vision system, but this can be retrofitted to earlier models of the MRTT, Cabrera notes. ☐

GERMAN REJUVENATION

Tony Osborne London

EUROPE'S RICHEST COUNTRY IS COMMITTING

to modernizing its armed forces, aiming to gradually meet NATO's spending target of 2% of gross domestic product on defense as it pushes toward becoming one of the pillars of European security. But Germany is struggling to spend the cash. Cumbersome procurement policies demanding that all deals are approved by parliament means programs are often subject to lengthy delays. Meanwhile, materiel agencies are short-staffed and constrained by stringent red tape.

Yet there is an urgent need to modernize: The capability gap for an airborne signals-intelligence capability is now a decade old, and plans to replace ground-based air defenses are closing in on a fifth year of negotiation. Nonetheless, progress is being made with plans to change out front-line combat aircraft, airlifters, tankers and helicopters. There are even plans to introduce new electronic warfare platforms. Here is a look at some of the major aerospace procurements and programs in the German armed forces.

DETERRENT DILEMMA

Critics argue that replacing

Germany's Panavia Tornado fleet with a split buy of Eurofighters and U.S.-sourced Boeing F/A-18 Super Hornets is a compromise too far. Mired in politics, German ministers have had to tiptoe through a minefield of demands—Luftwaffe commanders calling for an American type in the inventory, French demands that the F-35 not be chosen and appeals from workers' unions for a Eurofighter selection to protect industry. Berlin is hoping a proposal formally announced on April 22 to purchase up to 55 Eurofighters and 45 Super Hornets, including 15 electronic warfare EA-18G Growlers, will please its skeptics. The intended Eurofighter buy could also help to ensure Germany's place in a Future Combat Air System with France, while the Super Hornet will help maintain Germany's role in NATO's deterrence mission with free-fall nuclear weapons. However, the acquisition still has to obtain parliamentary approval. This is not expected until 2022, after Germany's next general election.



TONY OSBORNE/AW&ST

QUADRIGA CONUNDRUM

Unlike the other Eurofighter

partner nations, Germany wants to retire its Tranche 1 fleet and replace it with a batch of up to 38 Eurofighters fitted with the Captor-E active, electronically scanned array (AESA) radar. Airbus had hoped to secure a contract for the so-called Project Quadriga fleet in the first months of 2020, but the order has been politically linked with the Tornado replacement. Parliamentary approval of the Quadriga aircraft is expected this year. Unlike Tranche 2 and 3 Eurofighters, the Tranche 1 aircraft cannot be upgraded with an AESA radar without significant cost since they lack the cooling, electrical and computing



BACKGROUND ART: GETTY IMAGES



STRENGTHENING AIRLIFT

Germany's airlift capacity is being transformed with the arrival of the Airbus A400M, allowing the tired Transall C-160s to be retired. Despite the Airbus aircraft's troubled early career in the Luftwaffe—a result of reliability issues—the type is finding its feet, supporting aerial refueling missions in Iraq and Syria and medical aid operations during the COVID-19 coronavirus pandemic. The Luftwaffe has 32 A400Ms and will take delivery of 53 more, with the last arriving in 2026. The service is also purchasing six Lockheed Martin C-130J Hercules to form a joint tactical airlift squadron with the French Air Force. The type will be used for some limited tactical air transport duties that the A400M is deemed too large to handle. Germany hopes to take delivery of its first C-130J in 2021. Three of the Hercules will be KC-130J tanker variants.



power required for the sensor. A separate program to install the AESA radar on the Luftwaffe's Tranche 2 and 3 Eurofighters was also due to be contracted for during early 2020, but the time frame has not yet been finalized.

Spain and the UK have adapted their Tranche 1 fleets for the air defense mission, leaving only Tranche 2 and 3 aircraft to perform the swing-role mission with air-to-ground weapons.

HEAVY-LIFT HELO FACE-OFF

A decision on Germany's long-awaited \$3-4 billion STH heavy helicopter procurement is still pending. The competition to replace the Luftwaffe's locally assembled Sikorsky CH-53G Sea Stallions remains a face-off between Boeing's CH-47 Chinook and Sikorsky's CH-53K King Stallion. Both OEMs responded to Berlin's STH tender in January for 44-60 helicopters. A selection is expected during 2020, followed by a contract award in 2021 after approvals from the German parliament. First deliveries are expected in 2024, and all the rotorcraft could be delivered by the end of 2032.



BUILDING TANKER CAPACITY



Germany's entry into the Netherlands-led Multinational Multirole Tanker Transport Fleet (MMF) in September 2017 allowed the pooled fleet of Airbus A330 Multirole Tanker Transports (MRTT) to grow by five aircraft.

Participation in the MMF significantly bolsters the air force's air-to-air refueling capacity, which has been reliant on four Airbus A310 MRTTs with two underwing hose-drogue units. This capability has also been expanded by pod-equipped Airbus A400Ms, one of which has been supporting coalition operations over Iraq and Syria. The first MMF A330 is due to be delivered to the Netherlands in May; the third MMF aircraft will initially be based in Germany and is expected to arrive toward year-end.



THE BACKBONE OF THE GERMAN NAVY

Having been reliant on Westland-built Sea Kings and Lynx helicopters, Germany's naval air service has chosen the NH90 to replace both platforms. The move allows the navy to maintain commonality for training and logistics with three of its neighbors operating the type—Belgium, France and the Netherlands. The NH90s will be operated in two versions. The 18 Sea Lions, the first of which have already been delivered, are replacing the Sea King and will be tasked with search and rescue and the naval transport mission. The 31 Sea Tigers, replacing the Lynxes, will perform the anti-submarine and anti-surface warfare missions while operating from the back of the navy's surface combatants. The Sea Tiger purchase is subject to German parliamentary approval, but there is hope a contract can be signed in 2020 for deliveries by 2022.



EYES IN THE SKY

Germany will be one of the recipients of the pan-European EuroDrone unmanned aircraft system. The aircraft has been built according to Germany's civil airspace requirements, including the need to be twin-engine. In the interim, the German government will lease five Israeli Aerospace Industries Heron TP UAS through a service contract worth €720 million (\$780 million) signed in June 2018 with Airbus. The program is currently in a setup phase, with the operational phase expected to begin this summer, according to Airbus statements.

SIGINT REQUIREMENT



German Split-Buy Fighter Plans Face Political and Industrial Complications

- > SUPER HORNET WOULD PERFORM DCA NUCLEAR MISSION
- > AIRBUS CALLS FOR "REGULATED COMPROMISE" TO ACCELERATE EUROFIGHTER CONTRACT

Tony Osborne London

Germany's decision to purchase a fleet of U.S.-made Boeing F/A-18 Super Hornets has rattled its industry and fragile governing coalition.

Replacing the German Air Force's (Luftwaffe) aging Panavia Tornado fleet was never going to be easy: The subject is fraught with questions about the country's role in nuclear deterrence, complicated by industrial relations, military capability compromises and questions about the future of European aerospace.

Airbus says the proposals would, if approved, lead to "massive, lasting harm" to the German defense indus-

try. It is no surprise, then, that those approvals have been kicked deep into the long grass.

Germany's parliament, the Bundestag, will not have a final say until 2022, more likely 2023. But a contract is far from certain even then, as a new administration will be in charge.

"Knowing the established, parliamentary processes, we are only at the beginning of a procurement that will take years," says Defense Minister Annegret Kramp-Karrenbauer.

The proposals finally revealed on April 22 call for the purchase of 93 Eurofighters and 45 Super Hornets, 15 of which will be electronic warfare EA-18G Growlers.

The numbers are partly political window dressing. Up to 38 of the Eurofighters are envisaged for an entirely

Not so fast: Germany's Super Hornet procurement proposal still needs to be approved by the Bundestag.

different requirement—the Quadriga program—that will replace Tranche 1 standard Eurofighters, which are prohibitively expensive to upgrade with active, electronically scanned array radars and air-to-ground weaponry. That leaves up to 55 Typhoons to cover the Tornado replacement requirement.

The deciding factor in the Super Hornet decision was the need for a



ARMY LIGHT UTILITY

Following the successful introduction of Airbus' H145M Light Utility Helicopter to support German special forces, and more recently the H145 commercial model taking on the army's search-and-rescue mission, army commanders are mulling a buy of 60 H145Ms for training, liaison and light attack needs, regaining a capability lost with the 2016 retirement of the MBB-Bolkow Bo 105. The H145 could also replace the army's EC135 training helicopters and be used as a companion in training front-line regiments, allowing pilots to keep up their hours in a platform less expensive to operate than the NH90 or Tiger attack helicopter.



The Euro Hawk debacle continues to reverberate through the German defense ministry as it struggles to fill its signals-intelligence (sigint) capability gap. Plans to use the Northrop Grumman MQ-4 Triton as an alternative to the Global Hawk were abandoned in January, prompting commanders to look instead at using manned business jets to fulfill the requirement now known as the Pegasus. Berlin is hoping the transition to business jets will enable the capability to enter service by 2025 to meet NATO requirements.

platform to perform the controversial dual-capable aircraft (DCA) mission, supporting NATO's nuclear deterrent with U.S. dual-key free-fall B61 weapons based at Buchel.

The Tornado has performed this mission for three decades, the only European type wired and certified for it. But Berlin has long had doubts whether the Eurofighter could have, or would have, been certified by the U.S. to carry the B61. The U.S. is currently in the process of modernizing the B61 arsenal with the more capable B61-12 and beginning the long and costly process of certifying aircraft to carry it. Certifying the Eurofighter would have been low on the list of priorities. The Super Hornet is not certified either, but given that the predecessor legacy Hornets were, it should be a formality.

"Nuclear participation and the nuclear protective shield are part of the architecture of our security policy," says Kramp-Karrenbauer. "That may sound old-fashioned to some, but to keep promises made is a high value of German security policy for me. This also includes nuclear participation, and I

think it should remain so in the future."

The 15 Growlers could help Germany develop an airborne electronic attack (AEA) capability to meet a standing NATO commitment, called LuWES, but this has not been confirmed by Berlin.

The F/A-18s are seen as a "technology bridge," an interim capability paving the way for development of the FCAS and more capabilities for the Eurofighter. If the Tornado is retired, the Luftwaffe will "lose capabilities that are currently only offered by American manufacturers," says Kramp-Karrenbauer. It is unclear whether this interim status will influence how the Super Hornets are procured. Leasing could be one option, but officials would not comment on that subject.

Airbus has previously proposed a similar AEA capability for the Eurofighter using a podded system, called the Typhoon ECR. Those proposals have seemingly not been ignored: Kramp-Karrenbauer says Berlin would "advocate" the development of electronic warfare and AEA capabili-

REPLACING THE PATRIOT

It has been nearly five years since Germany selected the Medium Extended Air Defense System (MEADS) for its TLVS ground-based air defense requirement, and a contract decision seems no closer. The TLVS GmbH consortium of Lockheed Martin and MBDA submitted a final proposal to Germany's defense materiel agency in June 2019 and still awaits its approval. The contract could be worth up to \$8 billion. A proposed TLVS system would offer Germany's early-model Patriot missiles with a combination of the MEADS and Diehl's IRIS-T surface-launched short-range missile system with surveillance provided by a 360-deg. radar.



ties for the Eurofighter, but noted that such developments would take time.

A less-than-impressed Airbus has called on Kramp-Karrenbauer to compromise and make fixed orders for all 93 Eurofighters (10-15 are optional), bring forward contracting for all the aircraft rather than just those being purchased under the Quadriga program to this year and accelerate funding for the Eurofighter's Long-Term Evolution plan. Such a "clearly regulated compromise" says Airbus, would ensure the continuity of the supply chain, maintain production and development capacity and ensure that the Eurofighter remains competitive in export campaigns. The aircraft continues to be marketed in Finland and Switzerland.

The company also called for an F/A-18 fleet to be supported at the German Military Air Systems Center in Manching, where front-line combat aircraft are maintained by Airbus and military personnel.

Germany wants to begin replacing the 85-strong Tornado fleet in 2025, with it phased out in 2030. 🇩🇪

Japan Boosts Detection by Fusing Radar andIRST

> IRST CHECKS TARGETS FROM RADAR ACCEPTING WEAK SIGNALS

> TESTS VERIFY PASSIVE-RADAR PRINCIPLES

Bradley Perrett Beijing

The Japanese defense ministry has reported a 20% improvement in detection range with a fused sensor system for use against stealth aircraft and ballistic and cruise missiles.

The infrared and radar system is evidently intended for a contemplated long-endurance surveillance aircraft, though no such development program is in published planning. The technology is surely also a candidate for Japan's Next Generation Fighter, especially since the Lockheed Martin F-35 Lightning already has such composite functionality.

To test the technology, Japan has fitted a Lockheed Martin UP-3C trials aircraft with a large infrared-search-and-track turret (IRST) in a dorsal position and a ventrally mounted side-looking radar. The ministry's Acquisition, Technology and Logistics Agency (ATLA)

is running the program from the fiscal year beginning April 2012 to fiscal 2021. Its name can be translated as the Composite Radio and Light Sensor System.

ATLA says the system's IRST operates in medium wavelengths to search for ballistic missiles and in long wavelengths to track them and to search for and track stealth aircraft. The radar uses the S band, has gallium-nitride technology and faces to the left of the UP-3C.

Reporting on testing up to March 2019, the agency describes a specific objective of seeing whether the system could detect targets farther away by making the radar accept fainter signals—which also has meant allowing it to generate more false targets. The IRST was used to check detections and reject false ones. This idea has been applied in other countries.

ATLA says the accepted signal-to-noise ratio was reduced by 3 dB—presumably from the normal operating level of the radar, which was not named.

The evaluations confirmed that targets could be detected at 20% greater ranges, ATLA says. For a 3-dB reduction in accepted signal-to-noise ratio, that is approximately the theoretical result from the radar equation, a standard formula that relates detection range with various factors.

A further advantage of fusing such sensors is that radars are precise in range but not in direction, whereas IRSTs have the opposite characteristics. Together, they can locate a target far more precisely than either can do

separately. But the IRST needs satisfactory atmospheric conditions, while radar operation must not expose the carrying aircraft to detection and attack.

The agency has not said whether the system also worked in the other direction, with the radar verifying the IRST detections achieved from weak signals. This seems to be a likely requirement, since a stealth aircraft's infrared emissions may well be detected before its radar reflections can be. If one sensor made a detection in scanning, it could cue the other to stare in the target's direction until good data were acquired—or nothing found.

The tests also validated theoretical principles for sensor operation as a passive radar. The term usually refers to a mode in which a radar detects a target's reflections of radiofrequency energy that happens to be present, such as television transmissions. Outlining the program in 2012, the ministry described this function as using emissions from radars, which seems to suggest a cooperating source.

Accuracy in passive-radar mode can be improved by



JAPANESE DEFENSE MINISTRY

The UP-3C trials aircraft with the dorsal IRST and ventral radar.

using multiple ground stations, ATLA says, evidently referring to the transmitters. The agency stresses that this was only a theoretical evaluation. It has not elaborated.

The IRST showed very good results against Japanese rockets used in the trials, ATLA says. The 2012 program outline suggested that the turret would be derived from Airboss, a Fujitsu IRST that was used to detect a ballistic missile target off Hawaii in December 2007. One change was addition of long-wavelength capability for better detection of ballistic missile warheads; the sensor formerly operated in only medium wavelengths.

The fused sensor system used the track-before-detect technique, ATLA says. This is a process in which imaginary tracks are projected ahead of a target to work out whether its apparent movement is plausible.

Japan has three aircraft types that could serve as long-endurance carriers of such a system: the Kawasaki Heavy Industries C-2 airlifter and P-1 maritime patroller and the Mitsubishi Aircraft SpaceJet regional jet. Since the P-1 has a fuselage similar in size to that of the UP-3C used for the trials, it should be a likely candidate—although it would be a new type for the Japan Air Self-Defense Force, which would presumably field the operational system. An unmanned aircraft could be preferred.

The NGF is supposed to enter service in the mid-2030s. 🇯🇵

Norwegian-U.S. Ramjet Tie-Up Could Lead to More-Lethal Missiles

> UNGUIDED PROTOTYPE RAMJET MISSILE TO FLY IN 2021

> NAMMO AND CHINA LAKE ENGINEERS WORKING ON THOR-ER SINCE 2019

NAMMO CONCEPT

Tony Osborne London

Norway and the U.S. are partnering on solid-fuel ramjet technologies to improve the lethality and range of future missiles.

The bilateral Tactical High-speed Offensive Ramjet for Extended Range (THOR-ER) program, revealed on April 20, appears to represent renewed interest from the U.S. in investigating ramjet propulsion for missiles, in parallel with the Defense Department's accelerated development of hypersonic weapons in response to Chinese and Russian advances in the field.

THOR-ER is an Allied Prototyping Initiative that will build on the work already carried out by the Norwegian Defense Research Establishment, state-owned armaments company Nammo and the U.S. Naval Air Warfare Center at China Lake, California.

The two countries will codevelop ramjet missile flight demonstrators, and the project could lead to "closer defense industrial base cooperation," says Norwegian National Armaments Director Morten Tiller.

The program calls for developments in solid-fuel ramjet technologies that are affordable, attain high speeds and achieve extended range.

It aims to launch an initial unguided prototype in 2021 to verify the capabilities of the propulsion system, Frank Moller, Nammo's vice president for business development for aerospace propulsion, tells Aviation Week.

This will be followed by a controlled missile launch 2-3 years later. Both of the missiles will be ground-launched but the technology, Moller says, will

be applicable to both air- and ground-launched systems.

Last year, Nammo revealed it was working on scalable ramjet technology, boosting missile range and speed.

Nammo CEO Morten Brandtzaeg said at the time that the technology had "the potential to disrupt the whole missile and artillery sector as well as NATO air defense."

In a conventional rocket motor, oxygen can account for up to 80% of the fuel weight, but the ramjet instead uses oxygen from the outside air. By replacing that oxygen with propellant, capacity can be increased 3-5 times.

The technology, the company said, had the potential to boost weapon ranges 300-500% and transform the performance of missiles without having to increase the size of the weapon or make extreme adjustments to form factors. Sustained ramjet propulsion can power a missile to speeds of Mach 5-6.

Nammo has already performed extensive trials of the propulsion system on a specially built test rig.

Engineers from China Lake and Nammo have been quietly working on THOR-ER since 2019, but Norway and the U.S. have missile development ties that date back decades. It is Nammo rocket motors that power Raytheon's AIM-120 Amraam and the Evolved SeaSparrow Missile, while Norway's Kongsberg developed the Naval Strike Missile now being adopted by the U.S. Navy for its littoral combat ships, and the Joint Strike Missile is being integrated onto the Lockheed Martin

Nammo's ramjet technology has wide applications, including air-to-air missiles, as this concept for a ramjet Amraam suggests.

F-35. With Norway's limited defense budget, few avenues were open for Nammo's ramjet technology: either Europe or the U.S.

Europe, through MBDA, has already taken its first steps into ramjet propulsion: A Bayern Chemie-developed ramjet powers the Meteor beyond-visual-range air-to-air missile.

THOR-ER is receiving equal funding from Norway and the U.S., but the amounts are not being disclosed for now.

The new disclosure comes weeks after Aviation Week revealed that the U.S. Air Force Research Laboratory and the UK's Defense Science and Technology Laboratory were collaborating on a weapon concept called Thresher (Tactical High-Speed, Responsive and Highly Efficient Round) (*AW&ST April 6-19, p. 21*).

"This ramjet-technology provides a game-changing capability for our armed forces. It also brings bilateral cooperation to a whole new level," Tiller says.

"To stay ahead of potential adversaries, allies need to cooperate to better utilize our collective resources, be it innovative talent, finances or production capabilities," he adds.

China Lake's involvement may hint at naval applications such as a high-speed anti-ship missile, perhaps a response to the Russian P-800 Oniks anti-ship cruise missile, and fill in the performance gap between the subsonic Harpoon and the hypersonic SM-6 Block-1B and Conventional Prompt Strike systems. The Navy was also the first U.S. service to adopt a ramjet-powered missile in the form of the RIM-8 Talos surface-to-air weapon.

"There is a rationale for investments in higher-speed weapons able to use ramjet sustainers to attain speeds in the high-supersonic regime, so Mach 4 plus, or even in the low hypersonic [Mach 5-6 range]," says Douglas Barrie, Senior Fellow for Military Aerospace at the London-based International Institute for Strategic Studies.

"It also provides the U.S. insight into what a close ally can produce and [the ability] to perhaps project such a level of capability for some countries it may not be as close to," he adds. ☛

Drive to 5G Threatens GPS After FCC Ruling

- > LIGADO AND GPS WILL SHARE L-BAND SPECTRUM
- > FEDERAL AGENCIES REGISTER STRONG DISSENT



Bill Carey Washington

A controversial decision by the Federal Communications Commission (FCC) to approve, “with conditions,” Ligado Networks’ deployment of a 5G network using L-band spectrum between 1 and 2 GHz exposed deep disagreement within the U.S. government and failed to alleviate concern over interference with GPS signals at adjacent frequencies.

On April 20, the FCC voted unanimously to approve Ligado’s license modification applications to use mobile satellite services spectrum to roll out the low-power terrestrial network for 5G cellular and Internet of Things data services. Signaled days earlier when FCC Chairman Ajit Pai released a draft approval order, the decision ratified a network proposed a decade earlier by LightSquared, a predecessor company, amid a similar controversy.

The FCC order allows Ligado to use the 1526-1536 MHz, 1627.5-1637.5 MHz and 1646.5-1656.5 MHz frequency bands. The GPS L1 signal is centered at 1575.42 MHz; the newer L2 signal operates at 1227.60 MHz.

The seemingly sudden resolution of a protracted and evolving spectrum licensing proceeding had powerful, politically bipartisan support, including from U.S. Attorney General William Barr, Secretary of State Mike Pompeo, and U.S. Sen. Mark Warner (D-Va.), a former telecommunications executive.

“Swift FCC action on spectrum is imperative to allow for the deployment of 5G,” said Barr after the release of Pai’s draft order. “This is essential if we are to keep our economic and technological leadership and avoid forfeiting it to Communist China.”

Freeing L-band spectrum for use in tandem with the C-band, as Pai has proposed, “would be a major step toward preserving our economic future,” added Barr, who in the past served as executive vice president and general counsel of Verizon Communications.

Arrayed in opposition were the bipartisan leadership of the House and Senate Armed Services Committees, House Transportation Committee Chairman Peter DeFazio (D-Ore.) and a veritable army of federal government agen-

The first improved GPS III satellite built by Lockheed Martin for the U.S. Air Force was launched in December 2018.

cies, aerospace companies and trade organizations.

Five days before the FCC’s vote on Ligado’s license modification applications, a coalition of aviation, satellite communications and weather information user companies delivered a letter to the agency, urging it to reject the proposed network.

“The commission and other stakeholders have now devoted over 9,000 pages of filings, multiple congressional hearings and countless meetings to addressing one company’s spectrum arbitrage effort, and the public has nothing to show for it,” the letter states.

“[G]iven Ligado’s failure to adequately address the harmful interference at the heart of its proposals and the convoluted and dated record for this proceeding, the most appropriate action for the FCC to take is to deny the Ligado applications by terminating the associated dockets.”

The coalition members include the Aerospace Industries Association, Iridium Communications, and Southwest Airlines, Delta Air Lines, JetBlue Airways and FedEx.

“We have spent billions of dollars and worked for 20 years to perfect a satellite service in satellite spectrum that’s proved critical in emergencies and disasters, all [assuming] that our government would ensure our operations would be protected,” tweeted Iridium CEO Matt Desch, who has sharply criticized the FCC proceeding. “Ligado’s scattered, low bandwidth-impaired spectrum has nothing to do with the global race to 5G.”

On April 10, the National Telecommunications and Information Administration (NTIA) submitted supplemental materials for the FCC to consider; the package followed a December 2019 correspondence that indicated the NTIA was “unable to recommend the commission’s approval of the Ligado applications.”

An agency of the Commerce Department, the NTIA chairs the federal government’s Interdepartment Radio Advisory Committee (IRAC), which represents the military services and executive branch agencies, including Barr’s Justice Department.

The second package from the NTIA included letters

from the offices of the secretary and deputy secretary of defense, both expressing strong opposition to the Ligado license modification. A memorandum from Thu Luu, Air Force executive agent for GPS, advised that modifying or replacing legacy GPS receivers across the military to avoid adverse impacts from the new network “even if a solution were shown to be feasible, could take on the order of billions of dollars and delay fielding of modified equipment needed to respond to rapidly evolving threats by decades.”

The Transportation Department, the FAA’s parent organization and a member of the IRAC, provided Aviation Week a statement by Diana Furchtgott-Roth, deputy assistant secretary for research and technology.

“There is reason for significant concern that the FCC’s approval of the Ligado application could lead to widespread interruptions in essential GPS-dependent services,” said Furchtgott-Roth.

“GPS is used daily by Americans for all forms of transportation, both passenger and freight, in cars, trucks, buses, planes, rail and ships, as well as modern emergency response systems,” she added. “GPS is the invisible utility we all take for granted, and the Federal government has a duty to public safety to ensure that GPS remains accurate and available.”

The two Democrats on the five-member, Republican-majority FCC board, Commissioners Jessica Rosenworcel and Geoffrey Starks, in a concurring statement described the April 20 decision as a close call. “In the end, we are compelled to support the expert technical analysis done by the FCC’s engineering staff” in green-lighting the Ligado network, they said.

But the process “has exposed a fault line in spectrum decision-making,” the commissioners added. “As we move to the next generation of wireless service, it is imperative that we have an improved interagency system and a stronger whole-of-government approach to our 5G effort.”

The FCC’s order mandates that Ligado provide a 23 MHz guard-band with its own licensed spectrum to separate its base station transmissions from nearby operations using radionavigation satellite service space-to-Earth allocations, including GPS. The company must limit its base station power levels to 9.8 dBW, a reduction of 99.3% from the levels proposed by Ligado in 2015, the agency says.

Transmitted power levels were evaluated in a GPS Adjacent-Band Compatibility Assessment by the Transportation Department, which addressed transmitters in bands adjacent to the 1559-1610 MHz band used for GPS L1 signals at 1572.42 MHz.

The study found that much of the noncertified GPS equipment used for general aviation aircraft and drones would experience interference more than a kilometer from a Ligado transmitter.

Avionics certified for instrument flight rules by the FAA were much less susceptible than noncertified avionics and would not experience interference unless a receiver were within 250 ft. of a transmitter, still a concern for police or emergency medical service (EMS) helicopters flying low-level missions, observes Dana Goward, president of the Resilient Navigation and Timing Foundation.

The Alexandria, Virginia-based foundation, which advocates for GPS system protections, has calculated that

GPS-reliant helicopter terrain awareness and warning receivers would be unreliable for low-level missions in about 12% of an area served by Ligado Networks, based on the 433 m (1420.6 ft.) minimum spacing of its transmitters.

“I wouldn’t want to be an EMS helicopter pilot landing in unprepared areas and highways in the middle of the Ligado network,” says Goward, a pilot and retired Coast Guard captain. “I’ve landed on ships that are 210 ft. long and stayed overnight, so it’s not unreasonable to think that an EMS helicopter will be within 250 ft. of [Ligado] towers.”

Despite the FCC’s conditions, independent critics say the approval ignores the internationally accepted 1 dB Standard for radiofrequency-based services to protect GPS receivers from harmful interference.

The standard sets a 1-dB increase in the noise floor—the noise level that occurs naturally at a receiver—as the threshold between tolerable and harmful interference. This can be reliably measured by a 1-dB decrease in the signal carrier-to-noise ratio reported by the receiver, says the GPS Innovation Alliance (GPSIA).

The alliance planned to review the details of the approval but says it was “deeply disappointed” by the FCC’s decision.



FCC Commissioners (from left) Jessica Rosenworcel, Michael O'Reilly, Chairman Ajit Pai, Brendan Carr and Geoffrey Starks.

“[The] GPSIA has consistently advocated for adoption of the 1 dB Standard as the only reliable mechanism that provides the predictability and certainty to ensure the continuation of the GPS success story,” Executive Director J. David Grossman said in a statement. “The 1 dB Standard for radiofrequency-based services is critical for Global Navigation Satellite Systems.”

Ligado rejects this argument. “They falsely claim that GPS receivers require protection in spectrum not assigned to GPS when the device-reported signal-to-noise ratio fluctuates by an amount as small as 1 dB. Seeking this type of protection in an adjacent band is unprecedented and unnecessary to ensure GPS continues to work,” states a video on the company’s website.

“In spectrum, the signal-to-noise is in a constant and perpetual state of fluctuation, often by much more than 1 dB. It’s normal,” Ligado adds.

Asked about the protection afforded by the 23 MHz guard band, Goward said: “It doesn’t matter how big your guard band is if your power is going to override it. Considering the power differential between Ligado and GPS, the guard band should probably be at least twice as big.”

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Aerospace Calendar

To submit Aerospace Calendar Listings

email: aero.calendar@aviationweek.com

April 30-June 26—RTCA Plenary Sessions. Virtual or Various locations. See rtca.org/content/upcoming-committee-meetings

June 15-19—American Institute of Aeronautics and Astronautics (AIAA) Aviation Forum. Virtual Event. Reno, Nevada. See aiaa.org/aviation

June 24-28—Eurasia Airshow 2020. Antalya International Airport. Muratpa/ Antalya, Turkey. See eurasiaairshow.com

July 20-21—DoD Hypersonic Capabilities Symposium. Mary M. Gates Learning Center. Alexandria, Virginia. See hypersonics.dsigroup.org

July 20-26—EAA AirVenture Oshkosh Fly-In. Wittman Regional Airport. Oshkosh, Wisconsin. See eaa.org/en/airventure

Aug. 4-6—Space and Missile Defense Symposium. Von Braun Center. Huntsville, Alabama. See smdsymposium.org

Aug. 10-12—Space Tech Expo & Conference USA. Long Beach Convention & Entertainment Center. Long Beach, California. See spacetechexpo.com

Aug. 10-12—Association for Unmanned Vehicle Systems International (AUVSI) XPONENTIAL 2020. Boston Convention Center. Boston. See xponential.org/xponential2020

Aug. 24-27—Defense Services Asia Exhibition & Conference. Malaysia International Trade and Exhibition Center. Kuala Lumpur. See dsaexhibition.com

Aug. 30-31—2020 Humans to Mars Summit. National Academy of Sciences Building. Washington. See exploremars.org/summit

Aviation Week Network Events

+1 (800) 722-6344 or Events.AviationWeek.com/

June 23-24—CAPA Airline CEOs in Amsterdam & Gala Dinner. Amsterdam.

Aug. 5-6—CAPA Australia Pacific Aviation Summit 2020. Adelaide, Australia.

Aug 25-26—Speednews Aerospace Manufacturing Conference. Charleston, South Carolina.

Sept. 1-3—MRO Americas. Dallas.

Sept. 2-3—Military Aviation Logistics & Maintenance Symposium. Dallas.

Sept. 5-8—World Routes 2020. Milan.

Sept. 14-16—Commercial Aviation Industry Suppliers Conference-Europe. Toulouse.

Sept. 16-17—Aero-Engines Europe. Stavanger, Norway.

Sept. 17-18—CAPA Latin America Aviation & LCCs Summit. Salvador, Brazil.

Sept. 22-24—MRO Asia-Pacific. Singapore.

Sept. 22-24—Aero-Engines Asia-Pacific. Singapore

Oct. 8-10—Routes Asia 2020. Chiang Mai, Thailand.

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Opportunity in Crisis

By **Scott Thompson** and **Bill Lay**

You only find out where you are on the technology curve when the tide goes out. COVID-19 has ended the near two-decade boom in aviation and plunged the industry into crisis—and it is compounded by a lack of technological preparedness. What is worse is the significant uncertainty about the speed and strength of the recovery, which for aerospace is likely to be more prolonged than for the overall economy due to long-term damage to the airline industry. Airlines have taken on an enormous amount of debt, and that will dominate their capital allocation priorities.

This ebb tide has exposed the dated technology chains in our industry. These are not just information technology systems. Every company operates on technology chains—a combined set of approaches to deliver customer value. Look at three important technology-chain elements: digital transformation, the supply chain and the workforce of the future.

Digital Transformation

It has been said that “data is the new oil,” yet the aerospace industry as a whole has been slow to get the memo. Certainly there have been some advancements, including widespread use of 3D printing, but overall it has been slow to invest in digital transformation. One area ripe for a digital upgrade is design and development of new aircraft. The industry should significantly reduce the time to design new aircraft by adopting enhanced data analytics and artificial intelligence. There should also be increased investment in greater automation and analytics in operations, factory production, assembly and MRO. Examples abound in other industries. The relative insularity of the industry has done little to modernize its technology chains.

The aerospace industry is rich with data, but it is typically difficult to mine and analyze because of its sheer scale and the fact that it originates from myriad and disparate sources and systems. Investment in automated analytical tools makes it possible to access and digest data in real time, enabling better decision-making. Often these improvements go far beyond improved efficiency because the data, in its current state, is so cumbersome and manual that it is not even possible to accumulate it all for analysis. The technology curve for data manipulation, analysis and monetization is moving at exponential speed. It is critical, then, for the industry to ensure it can put its data—and new data analysis tools—to better use to truly operate in dynamic environments.

Supply Chain and MRO The aerospace supply chain lacks speed, agility and visibility. True lead times are often years. We have seen how this lack of agility hindered the recent production ramp-up by extending the schedule and creating bottlenecks. These dynamics create challenges in scaling down and then ramping back up.

Furthermore, while much of the value chain is highly consolidated, there remain thousands of small suppliers that

create risk around performance, agility and viability. Beyond the immediate triage to preserve capability, the industry should consider further consolidation, which would reduce risk and create appropriate scale for suppliers to invest in technology.

For supply chain management, blockchain is a promising technology, creating visibility through the entire ecosystem and thereby validating authenticity and identifying bottlenecks in real time. Blockchain also creates an individual digital twin of each aircraft, including the life history of all its components. The technology can help the industry steepen its technol-

ogy chain curve by improving predictive maintenance, safety and reliability and improving MRO cost and performance.

Workforce A digital value chain requires a digital workforce. Companies should invest in accelerating the workforce of the future by creating a digital culture and training. The entire workforce is affected by digital transformation and requires new skills. COVID-19 will undoubtedly add layers of expense around the workforce, including work continuity issues, medical costs and implementation of health testing. To counter these costs, productivity will need to increase. This degree of change can be daunting and requires deliberate change management practices to create a pervasive and lasting digital culture. Drawing an analogy to computer skills, not everyone needs to understand programming to operate a computer. Yet all employees need digital acumen to identify applications and better decision-making skills to apply to new data analytics.

It has been said that management makes money in an economic expansion but earns it in a recession. While companies are appropriately managing costs in this crisis, it is critical that they invest in strategic priorities to ensure their long-term competitiveness. It is time to get on the right technology curve. 📌

Scott Thompson is the aerospace and defense leader and Bill Lay is an aerospace and defense principal at PwC U.S.



AEROSPACE COMPANIES MUST INVEST IN STRATEGIC PRIORITIES NOW TO ENSURE LONG-TERM COMPETITIVENESS.

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