Boots On The Moon In 2024

Boeing 737 MAX Pilots vs. Automation
UTC Goes All-In on Electrification

AVIATION WEEK & SPACE TECHNOLOGY

AVIATION WEEK NETWORK
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ON THE COVER

Hardware for the Space Launch System structural testing is arriving at NASA’s Marshall Space Flight Center in Alabama, including a behemoth, 537,000-gal. liquid-hydrogen tank being prepared for compression tests in June. But it may be too little too late. Space Editor Irene Klotz’s report begins on page 16, and her related column is on page 15. NASA photo by Tyler Martin.

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

Aviation Week & Space Technology staff won two Jesse H. Neal Awards for design in March. Art Director Lisa Caputo and Artists Scott Marshall (left) and Colin Throm shared the award for Best Art Direction for a Cover for “SpaceX’s Heavy Lift” (Feb. 12-25, 2018). They also won the Best Art Direction of a Single Article award for “Passing the Torch” (June 18-July 1, 2018, p. 88), along with Space Editor Irene Klotz. The Neal Awards, now in their 65th year, are considered the Pulitzer Prizes of business-to-business journalism.

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FOR ‘MAX’ SAFETY, TRAIN PILOTS
Long before aeronautical engineers were telling us how to fly jets, I didn’t need a magenta line to know it was time to start my descent or auto throttles to maintain a proper airspeed.

Except for the Boeing 727, the Boeing 747-100/200 had an autoland system, which I never used except in the simulator to make the training department instructors happy.

Boeing and Airbus have had to rewrite their software because of pitch-down and other problems causing fatal and near-fatal accidents.

However, as a line pilot with more than 19,000 flight hours plus a fighter pilot background, my simple solution is: Reinstate the big red button on the control column that could instantly disconnect the autopilot.

Aeronautical engineers design great airframe structures and reasonably well-designed cockpits, but they are not professional pilots.

Reemphasize pilot skills.

Terry Higgins, Anaconda, Montana

MANY DROPPED THE BALL
The Indonesian safety committee reports that in the days before the Lion Air crash, other failures on Boeing 737 MAX 8s were encountered by crews flying that same type of aircraft. After maintenance actions, the angle-of-attack (AOA) vane was providing inaccurate readings.

A Lion Air crew on a Bali-Jakarta route encountered a situation in which control of the airplane was almost lost. That airplane should have been grounded after landing in Jakarta.

Reports indicate the pilots did not report the faulty stall-warning activation during the Bali-Jakarta flight.

Pilots are required to report relevant details of such serious incidents to flight operations management upon landing. At that point, it is the responsibility of airline management to take immediate action. All of Lion Air’s 737 MAX 8 pilots should have been briefed before any further flights with that aircraft were authorized. And Lion Air’s flight operations management should have informed Boeing immediately about this issue.

Peter Jong, Amsterdam, the Netherlands

LOOK INTO INSTABILITY
“737 MAX MCAS Explained” (March 25-April 7, p. 16) mentions that the Boeing 737 MAX has a “pitch-up tendency at elevated angles of attack (AOA),” which suggests that the aircraft is unstable in pitch for some load conditions, apparently during takeoff with a heavy fuel load. Pitch instability means the aircraft cannot be trimmed to fly at a stable AOA without some engineering corrections or active pilot intervention.

Pitch instability has been well understood for 100 years. It depends upon the relative locations of two points along the longitudinal axis of the aircraft: the center of gravity (COG), and the aerodynamic neutral point about which an aerodynamic force moment does not change with changing AOA. If the COG is aft of the neutral point, the aircraft is unstable. The instability can be resolved in two ways: Move the COG forward or increase the tail effectiveness to move the neutral point aft. Evidently, the CFM Leap 1 engine cowls move the neutral point forward of the COG under some takeoff conditions.

The usual way to move the neutral point aft is to increase the area of the horizontal tail. An alternative is to adopt a stability augmentation system, which increases the AOA of the tail (or elevator) when the aircraft pitches up, and decreases it when the aircraft pitches down.

With proper system design and a sufficiently rapid tail actuator, the aircraft can be made stable even with a tail too small for passive stability. The system does not need an AOA sensor, since it can use pitch-rate gyros as input. The key issue for the MAX is not stall but aerodynamic instability.

Steven Crow, Boulder, Colorado

TRUE TIMING
“MAX Chaos” (March 25-April 7, pp. 14-15) features two graphs that show flight profile data from Ethiopian Airlines Flight 302 and Lion Air Flight 610. The caption states that the data plots “have clear similarities, including vertical speed and altitude variations.” However, since altitude is apparently not plotted as a variable on either graph, a clear similarity cannot be specifically demonstrated.

The plots do not depict the same periods of time in the flights (1-3 min. elapsed time vs. 4-7 min.), so it is inappropriate to conclude there are relevant similarities when other factors may be at play in the different time spans.

No comparison can be made regarding ground speed, since no scale is presented to determine the actual values of the respective speeds.

The vertical scales are drastically different, so this too makes direct comparisons difficult. Granted, both plots show anything but level flight, but it is a stretch to make any further comparisons.

Hank Caruso, California, Maryland

MISSING LINKS
Didn’t Airbus have an almost identical problem—triggered by faulty AOA information—on an Airbus A330-300 in October 2008? Qantas Flight 72, en route from Singapore-Perth encountered what some call “psycho automation,” but the pilots managed to right the aircraft. Is there a comparison?

Robert D. Dyson, Portland, Oregon

CORRECTION:
In the graph accompanying “FAA Reviews Enhanced MAX Flight-Test Data” (March 25-April 7, p. 17), the indicators for speed and altitude were reversed (see revised version, above).

Address letters to the Editor-in-Chief, Aviation Week & Space Technology, 2211 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.
Aireon has hired Jonathan Astill as vice president/general manager of its new air traffic flow management services and Hal Martin as vice president of global supply chain. Astill joined Aireon from UK air navigation service provider NATS, Martin from Aerojet Rocketdyne.

Marc Bouliane has appointed to the newly created position of vice president of strategic business development at Universal Avionics. He was product director for avionics display solutions at Esterline Avionics Systems and CMC Electronics.

Hartzell Propeller has promoted JJ Frigge to executive vice president and general manager from day-to-day business leader.

Janas Associates Investment Bankers has named Bart Webb practice director of the aerospace transaction division. He was CEO/owner of Keeley Aerospace Inc. Anca Mihalache has joined APOC Aviation as vice president of engine trading. She had headed trading and leasing at Vallair.

Raytheon has appointed Wesley D. Kremer president of missile systems, succeeding Taylor W. Lawrence, who is slated to retire in July. Ralph H. Acaba succeeds Kremer as president of integrated defense systems.

Mesa Air Group Inc. has promoted Mark Ade to vice president of United Express operations. Ade was regional manager of United Express performance for United Airlines.

Alien Science and Technology has named Sid Fuchs chief operating officer. Before joining Alien in August 2018, he was president and CEO of MacAulay-Brown.

Nicolas Bouverot has been named vice president for Thales in Southeast Asia. He was vice president for South Asia at Nokia.

director of the aerospace transaction division. He was CEO/owner of Keeley Aerospace Inc.

Anca Mihalache has joined APOC Aviation as vice president of engine trading. She had headed trading and leasing at Vallair.

Mike Vetter has been promoted to senior director of product development at East/West Industries.

HONORS & ELECTIONS

The Wings Club Foundation Inc. and International Aviation Women’s Association have awarded Brig. Gen. Jeannie M. Leavitt the 2019 Outstanding Aviator Award.

To submit information for the Who’s Where column, send Word or attached text files (no PDFs) and photos to: whoswhere@aviationweek.com For additional information on companies and individuals listed in this column, please refer to the Aviation Week Intelligence Network at AviationWeek.com/awin For information on ordering, telephone U.S.: +1 (866) 857-0148 or +1 (515) 237-3682 outside the U.S.
Airbus is the world’s leading independent supplier of cutting edge defence and space technologies. We deliver strategic advantages in a rapidly changing environment – thanks to a network of connected smart assets. From military aircraft, satellites and unmanned systems to services such as cybersecurity, geointelligence and secure communications we’ve been serving governments across the globe for over fifty years.

Security. We make it fly.
S-400 vs. F-35: Turkey Tumult

Though Turkey and the U.S. are talking about fighter aircraft and air defense systems, they do not seem to be listening to each other.

The Pentagon has decided to halt delivery of F-35 equipment to Turkey because of its decision to buy the S-400 Triumf anti-aircraft system from Russia. Acting U.S. Defense Secretary Patrick Shanahan says he is “confident” Turkey will opt to purchase the Raytheon Patriot missile defense system instead. U.S. and NATO officials fear that co-locating the F-35 and S-400 could compromise the security of the stealth fighter.

But at a 70th anniversary celebration for NATO, Turkish Foreign Minister Mevlut Cavusoglu said he intends to proceed with the purchase because the S-400 is needed to combat instability “in the neighborhood” and is strictly for its own defense. NATO’s concern is that it is not compatible with other NATO systems.

Turkey should be able to own both the S-400 and F-35 because the arrangement to buy the former was in place before U.S. sanctions were imposed, Cavusoglu contends. He says President Donald Trump told Turkish President Recep Tayyip Erdogan that the previous administration made a mistake in not approving the sale of Patriots to Turkey some time ago, and he adds that Trump assured Erdogan he would “take care” of the issue.

“The S-400 is a done deal,” Cavusoglu says.

Taiwan has submitted a request to acquire 66 new Lockheed Martin F-16V fighters. Reports indicate the Trump administration has approved the sale to Taipei, which is modernizing 144 F-16A/Bs to V standard.

The U.S. has approved Morocco’s request to upgrade 23 Block 52-standard F-16C/Ds to F-16V standard and expand its fleet by purchasing 25 new Block 72-standard aircraft with the same APG-83 active-array radar.

The U.S. executed the first “salvo engagement” of its Boeing-led Ground-based Midcourse Defense System on March 25, using two ground-based interceptors to engage a ballistic-missile target.

The U.S. Air Force paused acceptance of Boeing KC-46As for a second time on March 23 after additional foreign object debris was discovered on one of the tankers.

Boeing flew the first CH-47F Block II on March 28, but the latest Chinook upgrade’s future is uncertain as the U.S. Army’s fiscal 2020 budget cancels planned procurement of 542 Block IIs (page 46).

The U.S. Army has awarded Martin UAV and Textron Systems contracts for evaluation of potential replacements for the RQ-7B Shadow under its Future Tactical Unmanned Aircraft System program.

COMMERCIAL AVIATION

Ethiopia’s transport minister says the crew of Ethiopian Airlines Flight 302 followed proper checklist procedure in the March 10 crash of a 737-8, but many questions remain. Meanwhile, Boeing is finalizing software upgrades for the system that apparently triggered the event (page 22).

Russia has tested a new wing for the MC-21 narrowbody airliner produced by AeroComposite without using U.S. composites. The new materials were developed jointly with Rosatom State Atomic Energy Corp.

Cathay Pacific is poised to enter Asia’s low-cost carrier market, announcing a deal March 27 to purchase 100% of Hong Kong Express from China’s HNA Group and operate it as a subsidiary.

An appellate body of the World Trade Organization has upheld European and Airbus claims that the U.S. has failed to withdraw tax breaks granted to Boeing by Washington state (page 12).

Icelandic ultra-low-cost carrier WOW Air ceased operations March 28 after talks with Icelandair Group and, separately, with U.S. private-equity fund Indigo fell through (page 14).

China Aviation Supplies Holding Co. has signed an agreement with Airbus—during a state visit to France by
China President Xi Jinping—for 290 A320-family aircraft and 10 A350s.

**Aireon’s satellite-based air traffic control surveillance system**, which for the first time enables continuous tracking of aircraft over oceans and remote regions, went live on April 2 (page 66).

**UTC is modifying** a Bombardier Dash 8 Q100 regional aircraft into a 2-megawatt hybrid-electric flight demonstrator set to fly in 2022 (page 56).

**UPS and drone delivery system** developer Matternet have launched a service to deliver medical samples by drone at WakeMed Health and Hospitals in Raleigh, North Carolina.

**SPACE**

A **$95 million Israeli spacecraft**, launched six weeks ago as a secondary payload on a SpaceX Falcon 9 rocket, fired its braking rocket to slow its velocity by about 600 mph and slip into an elliptical lunar orbit in preparation for a touchdown on the surface of the Moon on April 11.

**India tested an anti-satellite system** on March 27 by destroying one of its low-Earth-orbit satellites, likely Microsat-R at an altitude of 300 km (page 42).

**Flight tests of Boeing’s CST-100 Starliner space taxi, planned to begin as early as this month, will not take place until August and November, but NASA will pick up the option to turn the second, crewed flight into an extended International Space Station mission.**

**Rocket Lab’s Electron small-satellite launcher** took off from New Zealand March 28 on its first flight for the U.S. military, carrying DARPA’s R3D2 satellite with an antenna that will unfurl to 7.4-ft. dia. in orbit.

**OBITUARY**

Andrew Marshall, founder of the Pentagon’s Office of Net Assessment (ONA) and a master strategist, died on March 26. He was 97. As the director of ONA for 42 years until semi-retiring in 2015, Marshall helped craft U.S. strategy during the Cold War, defined a new way of warfare with precision-guided weapons and predicted the rise of the Chinese military as a peer competitor, among other accomplishments.

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**Top MRO Spenders in North America**

The 10 largest air carriers in North America will spend about $12.7 billion on maintenance, repair and overhaul (MRO) this year, according to the Aviation Week Intelligence Network’s 2019 Commercial Fleet and MRO Forecast. American Airlines leads the list, followed by Delta Air Lines and United Airlines.

For more information about the forecast, go to pages.aviationweek.com/forecasts

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**60 YEARS AGO IN AVIATION WEEK**

A prototype of the T-38 Talon supersonic jet trainer made its first flight on April 10, 1959, from Edwards AFB, California. Powered by two General Electric J85 turbojets, the Northrop-built aircraft entered service in 1961 and has served as the U.S. Air Force’s primary trainer ever since. The Air Force took delivery of more than 1,100 T-38s at an initial unit cost of $756,000 ($6.4 million in today’s dollars) before production ended in 1972. The aircraft proved so reliable that the service did not move to replace it until September 2018, when it awarded a $9.2 billion contract to Boeing for 475 T-X trainers and up to 120 simulators. The T-X is scheduled to enter service in 2024, 65 years after the T-38 first took to the skies.

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**AWARDED**

Aviation Week & Space Technology Space Editor Irene Klotz won the National Space Club & Foundation’s Press Award, which was presented during the 62nd Annual Goddard Memorial Dinner on March 22 in Washington, where Klotz was joined by Apollo 11 astronaut Buzz Aldrin.

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COMMERCIAL AEROSPACE HASN’T experienced a jolt for a new aircraft model like that of Boeing’s 737 MAX 8, which suffered two crashes in just five months, since the Lockheed Electra in 1959-60 and the Boeing 727 in 1965-66.

The MAX’s automated flight-control system, known as the MCAS, appears to have played a central role in the crash of Lion Air Flight 610 in October and possibly in the Ethiopian Airlines Flight 302 accident, too.

China’s CAAC became the first regulatory agency to ground it. Other countries quickly followed, and the FAA brought up the rear. While Boeing’s last new aircraft, the 787, was also grounded, this is different. The 787 battery issue resulted in no fatalities, and in 2013, some 50 aircraft were grounded for three months. In contrast, the two MAX 8 crashes resulted in 346 fatalities—the most for any new jetliner its first two years of operation. Global social media is abuzz, and nearly 400 aircraft are grounded. This raises the questions: How long will the MAX be out of service? And what are the implications for the aerospace supply chain?

Much of the industry is thinking—and hoping—that it will be out of service for a short time—perhaps 2-3 months. In this scenario, Boeing delivers the MCAS software fix in April, FAA approval quickly follows, and other regulatory agencies follow suit. Boeing is able to continue the 737 production rate of more than 50 units per month and store the aircraft until the approved software fix is available. Both Boeing and the FAA suffer black eyes, but the impact on airlines and aerospace suppliers is minimal. This is the optimistic scenario.

Another scenario addresses the perception that “regulatory capture” has occurred—i.e., Boeing and the FAA are just too close. How could the MCAS be categorized as non-flight-critical dependent on a single angle-of-attack sensor? Already, Transport Canada indicated that the MAX likely will not reenter service until July 1. Holding the key to its timely reentry are the European Aviation Safety Agency (EASA) and the CAAC, which will take their time in approving the proposed MCAS changes. EASAs independence under the circumstances is to be expected, but the CAAC’s aggressiveness in being the first to ground the MAX caught some by surprise. Though government-controlled, the CAAC can be conservative on flight safety matters. And China’s plans for the Comac C919 are well known. In this scenario, which can be deemed “nominal,” the MAX is not fully back in service globally for another 3-6 months. If this occurs, Boeing may be forced to reduce production rates.

Finally, there is a pessimistic scenario. The CAAC and EASA may determine that additional flight-testing is required to allow the MAX back into service, significantly delaying its entry into service in vital markets. Additional training could also be required. Or the issue could become intertwined in U.S.-China geopolitics. The MAX is an alluring bargaining chip for China to oppose a new round of U.S. tariffs. China isn’t pleased with the Trump administration’s backing of F-16 sales to Taiwan—the first such deal since 1992. Its recent order of 300 Airbus jetliners—including 290 A320 neo models—underscores its dissatisfaction with the situation. A wildcard in the pessimistic scenario is the role of global public opinion in the age of social media. Indonesian public opinion may have contributed to Garuda’s attempt to cancel an order for 49 MAXs valued at $4.9 billion. Regulators, facing unprecedented public scrutiny, are incentivized to err on the side conservatism. This includes the U.S., where the Justice Department subpoenaed Boeing as part of a criminal investigation. Actions like these could delay the MAX global reentry by 9-12 months or more.

While aerospace stakeholders hope for the optimistic outcome, they must also plan for the pessimistic scenarios. What are the implications? First is the financial impact on Boeing itself. Bank of America Merrill Lynch’s Ron Epstein estimates that each three months the MAX is out of service means Boeing must carry $5.5 billion of inventory on its balance sheet and pay $500 million to airlines for alternative lift. It is hard to see Boeing launching the new midmarket airplane under these circumstances. Second, Boeing’s suppliers face critical decisions. Do they embrace the optimistic scenario, or reduce orders from their own suppliers to conserve capital? Ironically, they are less able to support a production slowdown because Boeing extended its supplier payment terms to 90-120 days in recent years. Finally, the FAA certification process could be redefined, which could affect service entry of the 777X and other aircraft models.

737 MAX Fallout

Backlash for suppliers could be minimal—or very painful

Contributing columnist Kevin Michaels is managing director of AeroDynamic Advisory in Ann Arbor, Michigan.
Though government-controlled, the CAAC can be the first to ground the MAX caught some by surprise. As expected, but the CAAC's aggressiveness in being the key to its timely reentry are the European Aviation Safety Agency (EASA) and the CAAC, which will take their time in approving the proposed MCAS change—leading to more than 50 units per month and store the MAX likely will not reenter service until July 1. Holding that it will be out of service for a short time—perhaps 2-3 months. In this scenario, Boeing delivers its first two years of operation cost will exceed the 727 in 1965-66.

Another scenario addresses the perception that "regulatory capture" has occurred—i.e., Boeing and the FAA brought up the rear. While Boeing's last new aircraft, the 787, was also grounded, this is different. The 787 battery was non-flight-critical dependent on a single angle-of-attack sensor, which may have contributed to the crash of Lion Air Flight 610 in October and possibly in the Ethiopian Airlines Flight 302 accident, too. The MAX's automated flight-control system, known as MCAS, appears to have played a central role in the two MAX 8 crashes resulting in 346 fatalities—the most for any new jetliner since the Lockheed Electra in 1959-60 and the Boeing 737 MAX 8, which experienced a jolt for a new aircraft model in just five months, sufered two crashes in just five months, as the MCAS, appears to have played a central role in the two MAX 8 crashes resulting in 346 fatalities. This is the optimistic scenario.

A wildcard in the pessimistic scenario is how additional flight-testing may be required. The MAX is required to allow the MAX back into service, significantly delaying its entry into service in vital markets. Additional training could also be required. Or the issue could become intertwined in U.S.-China geopolitics. The Trump administration's backing of F-16 sales to Taiwan is one example. China isn't pleased with the additional training could also be required. Or the issue could become intertwined in U.S.-China geopolitics. The Trump administration's backing of F-16 sales to Taiwan is one example. China isn't pleased with the MAX is an alluring bargaining chip for China to oppose additional training could also be required. Or the issue could become intertwined in U.S.-China geopolitics. The Trump administration's backing of F-16 sales to Taiwan is one example. China isn't pleased with the MAX is an alluring bargaining chip for China to oppose Additional training could also be required. Or the issue could become intertwined in U.S.-China geopolitics. The Trump administration's backing of F-16 sales to Taiwan is one example. China isn't pleased with the MAX is an alluring bargaining chip for China to oppose Additional training could also be required. Or the issue could become intertwined in U.S.-China geopolitics. The Trump administration's backing of F-16 sales to Taiwan is one example. China isn't pleased with the MAX is an alluring bargaining chip for China to oppose

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While aerospace stakeholders hope for the optimistic scenario, they are less able to support a production slowdown because Boeing extended its supplier payment terms to 90-120 days in recent years. Finally, the FAA certifcation process could be redefned, which could afect service impactful on Boeing itself. Bank of America Merrill Lynch's Ron Epstein estimates that each three months the MAX costs $450 million, which could translate into a criminal investigation. Actions like these could delay global social media, and EASA may determine that additional flight-testing is required to allow the MAX back into service, signifcantly delaying its entry into service in vital markets. Additional training could also be required. Or the issue could become intertwined in U.S.-China geopolitics. The Trump administration's backing of F-16 sales to Taiwan is one example. China isn't pleased with the MAX is an alluring bargaining chip for China to oppose

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The MAX's automated flight-control system, known as MCAS, appears to have played a central role in the two MAX 8 crashes resulting in 346 fatalities. This is the optimistic scenario.
**GOING CONCERNS**

**MICHAEL BRUNO**

**PRESIDENT DONALD TRUMP SAYS,**

“Trade wars are good and easy to win.” But if the 15-year-and-growing World Trade Organization (WTO) dispute betweenthe EU and U.S. over large commercial aircraft is any indication, it is the words of former Defense Secretary Donald Rumsfeld on how another war turned out to be a “long, hard slog” that will seem more apropos.

The aerospace and defense sector was forced to revisit this inconvenient truth on March 28 when an appellate body of the WTO issued the latest finding in one of two transatlantic trade disputes over government subsidies for manufacturers of large commercial aircraft (LCA). The ruling, in a case brought by the EU and Airbus against the U.S. and Boeing, found that the latter had yet to rectify a Washington state business and occupancy tax benefit worth $325 million that proved both illegal and harmful under WTO rules.

The March 28 ruling ended the findings segment of the Airbus and EU unfair trade case against Boeing and the U.S., and it kicks off a months-long arbitration over how much in trade sanctions the Europeans can seek from the U.S. Meanwhile, an announcement about how much Boeing and the U.S. can seek in retaliation against the Europeans in their own case is expected within weeks or a month, Boeing proponents tell Aviation Week.

While historians will point to those final retaliation numbers as indication of who “won” this dispute, lawyers and spokesmen from both sides are laboring to cement an image of triumph in the public’s mind.

“This is a clear victory for the EU and Airbus,” says Airbus General Counsel John Harrison. “It vindicates our position that Boeing, while pointing fingers at Airbus, has not taken any action to comply with its WTO obligations, contrary to Airbus and the EU.”

For its part, Boeing reiterates that it is committed to complying with WTO ruling and that it will support U.S. and Washington state officials as they comply with the March 28 ruling. “We trust that our example will prompt Airbus and the EU to immediately bring themselves into full compliance with the substantial rulings against these parties by the WTO,” the company says. Boeing also touts its own victories in the ongoing trade spat. And U.S. Trade Representative Robert Lighthizer argues American government support is fairer than Europe’s. “For years, European governments have provided massive subsidies to Airbus that dwarf any U.S. subsidies to Boeing,” he says.

Therein lies the rub. The only thing that has been accomplished to date is proving that both sides subsidize their aircraft OEMs. Was it worth it? Retaliatory tariffs may be coming, but they probably will not matter anymore. When the George W. Bush administration launched this dispute—which began in 2004 when the U.S. withdrew from the 1992 Agreement on Trade in Large Civil Aircraft—there was nothing like it. The economic penalties, which could be applied in general and not to aerospace sectors specifically, will be superseded by the greater trade wars. Besides, each country remains desperate for the high-paying jobs and ancillary benefits that come from having indigenous A&D industries, so they will not pull back. But because those domestic industries depend on foreign exports to support local jobs, WTO tariffs could just become an additional cost of doing business—costs that are ultimately paid by taxpayers and passengers. Meanwhile, China is waiting in the wings while the two archrivals battle.

Boeing and the U.S. have long demurred over reaching a new grand bargain, and representatives say their top goal continues to be to make Europe pay for the launch aid on the widebody programs. Europe says its preference remains that the U.S. and Boeing work with it for a new settlement.

“Whatever happens, Europe and the U.S. will almost certainly be compelled to negotiate a new civil aircraft agreement of some description, eventually,” Airbus representatives say. “The question is simply how long the U.S. will drag out the dispute.”

Maybe it is time for Trump to insert himself directly. If he could strike a deal before the 2020 election, he could claim it really was easy and that only he could get it done. Believe it or not, everyone could win.
COMMENTARY

INSIDE BUSINESS AVIATION

WILLIAM GARVEY

IF AIRCRAFT HAD DNA, THIS ONE’S
Ancestry.com trace would point to Third Reich Germany.

Once the guns of World War II quieted, engineers from North American Aviation, builder of the P-51 fighter and B-25 bomber, made their way to the Messerschmitt factory to have a close look at what those German engineers learned in developing the Me 262 Schwalbe, the world’s first operational jet fighter. Of particular interest was the aircraft’s slightly swept wings, a design element that helped it outrun North American’s Mustang by 120 mph.

By October 1947, North American was test-flying what would become the F-86 Sabre Jet, America’s first swept-wing fighter jet. The manufacturer would eventually deliver more than 6,000 Sabres of various models. Built for a high-G, high-speed and fast-turning environment, the aircraft came to dominate MiG adversaries during the Korean War. So when the U.S. Air Force put out a call for a utility trainer in the late 1950s, North American adapted elements from the F-86—mainly its wings and tail—and mated them to a cabin-class, pressurized jet fuselage and won the contract for what became the T-39. Ultimately, the model—used for radar-intercept training as well as general transport—was also operated by the U.S. Navy and Marine Corps. And since it, with the appropriate interior and avionics, could serve civilian operators, the manufacturer acquired a type certificate from the FAA and offered the NA-265 Sabreliner for purchase by corporations and individuals. In so doing, it—along with Lockheed’s JetStar—created a new class of aircraft: the business jet.

Fast forward two-plus decades. North American and Rockwell International, its Sabreliner production successor, together delivered some 800 of several models—including 200 T-39s—before ceasing assembly in 1981. By then, the business jet market had become crowded and fiercely competitive. But here’s the thing: While those other jets prevailed in the marketplace, there is only one not yet prohibited from intentional aerobatics. Yup. The son of the F-86 and distant kin to the Me 262. And some Sabreliners are today pulling highGs—the Sabre has a 3g rating—which can be physically and visually alarming for those whose daily experience involves smooth, blue-up/brown-down, 1g flying.

Still, as uncomfortable as the training might be, he says: “Anybody carrying passengers ought to know how to do this stuff,” since upsets can occur unexpectedly and “you better understand what’s happening.”

Randy Howell, CEO of the Patriots Jet Team and a retired airline pilot who flies a Sabreliner in air shows, has similar views. “You’ve got to use a corporate airplane to get the client to understand the recovery technique,” he says, and do so in a cockpit with two pilots, small windows, a control yoke and slow roll response. During Patriots Jet training, the Sabre may go fully inverted and 20-40 deg. nose-low—attention getters, for sure—but maneuvers and recovery never exceed 2.8g.

The two programs are not inexpensive—$15,000-20,000 for an initial—but the payoff can be incalculable. And for that, crews and passengers walking away from upsets should give thanks for money well-spent. Or, considering the NA-265’s heritage, a “danke schoen” might be equally appropriate.

William Garvey is Editor-in-Chief of Business & Commercial Aviation
THERE IS A PART OF TOULOUSE — Blagnac Airport that is reserved for difficult cases. When around 100 Airbus A320neos were waiting for engines last year, many of the “gliders” were parked there, a little east of the A380 final assembly line. The A320neos are gone, but two A330neos in the pink livery of WOW Air are parked there now. Lessor Avolon, which owns the two WOW airplanes, is looking to place them with other airlines.

WOW, one of the most interesting new airline projects in Europe, is history. In the hope of attracting new investors, the airline hung on a few weeks after having halved its fleet, but it was not successful and consequently ceased operations. The collapse of WOW does not show that long-haul/low-cost does not work—that is a separate question. One might argue that most of the sectors WOW was flying were not true long-haul services—3-4 hr. to European destinations, 5-7 hr. into the U.S. It also does not illustrate the popular view that an airline has to be big to survive. It simply shows that big strategic mistakes have the potential to kill an airline, particularly if its model is risky.

Founded in 2011, WOW to a certain extent emulated a business model Icelandair had pursued for decades: flying narrowbody aircraft across the Atlantic connecting city pairs that do not economically justify widebody aircraft operations and taking advantage of the huge cost benefit of operating a hub situated between Europe and North America. WOW extended the model, selling seats for even less than Icelandair, which typically beats other legacy carriers on price. That stimulated a part of the market that wasn’t available to others, and it could have worked if other issues had not been insurmountable.

So where did WOW go wrong? Ben Baldanza, formerly CEO of Spirit Airlines and a WOW board member until the middle of 2018, has a clear view: “The A330 guaranteed the collapse of WOW,” he writes in an analysis on LinkedIn. “Widebody aircraft, like the A330, are significantly more expensive to purchase or lease and more expensive to operate. . . . Filling such a large plane . . . proved disastrous.”

The A330s allowed WOW to introduce flights to the U.S. West Coast that it could not do with A320s and A321s. But at the same time, the airline gave away its biggest advantage over its U.S. and European competitors: being able to serve small connecting markets at a fraction of the upfront investment or lease rates for the smallest widebodies.

WOW Air is the latest in a series of recent European airline failures. Primera Air, Germania and several others have disappeared in the last few months, preceded by the collapse of Air Berlin in late 2017. Most share an underlying theme: After a successful start based on an innovative business model, these carriers became too confident, overextended themselves and took too many risks they could not control. They built structural weaknesses into their setups that remained unaddressed.

In WOW’s case, one risk factor was always cyclicality. Admittedly, almost all airlines operating across the Atlantic (and many other markets) face similar issues. But WOW made its cyclicality exposure worse by introducing large aircraft. It had to fill many more seats at big discounts in winter, when fewer people want to travel. WOW also did not have a good strategy—or any strategy, actually—for redeploying capacity in the low season. That is understandable, as it operated from a unique geographical location. But other airlines have become creative, sharing or swapping feet. Thomas Cook Airlines and Air Transat are moving parts of their A330 and A320/A321 feet around, depending on the season, which takes advantage of different peak-season timing. Then again, WOW founder and CEO Skuli Mogensen wanted to grow operations as fast as possible and even introduced A330 services to India at the last moment, hoping to capture the significant market of Indian students traveling between U.S. universities and home.

For most European and North American legacy carriers, WOW’s demise is almost irrelevant. Even at its peak, it was too small to cause them pain, and it addressed a market segment they were not targeting. Norwegian now has one less competitor in the long-haul/low-cost market, although network overlap was limited. Even for its local rival, Icelandair, the effects of WOW’s collapse are mixed. On the one hand, WOW was a disruptor that pushed the more established carrier to make some costly network decisions. On the other hand, WOW played a big role in creating an unprecedented boom in Icelandic tourism from which Icelandair benefited.
Strange Bedfellows

Pairing the SpaceX Falcon Heavy and ULA upper stage could get NASA to the Moon

Flying a ULA Interim Cryogenic Propulsion Stage (ICPS) on a Falcon Heavy would take time and money. Bridenstine is due to report back to Congress in mid-April with a modified fiscal 2020 budget request to accommodate the Trump administration’s challenge to land astronauts on the Moon by 2024 (page 16). The Falcon Heavy-ICPS option also presents additional risks. “If we’re going to land boots on the Moon in 2024, we have time and we have the ability to accept some risk and make some modifications,” Bridenstine said.

In assessing existing commercial alternatives for SLS, engineers also considered ULA’s Delta IV Heavy and determined the rocket does not have the lift capacity to put Orion, with its European Service Module (ESM), into orbit. Flying the rocket with an upgraded ICPS—a Delta IV Heavy upper stage modified for early flights of the SLS—would make the rocket even heavier, further taxing its performance.

NASA then assessed launching the Orion Exploration Mission-1 (ESM) flight test on two Delta IV Heavy rockets, one carrying Orion and ESM and the other flying an ICPS. The idea would be to attach the upper stage to the service module in Earth orbit and fire it up to send the stack toward the Moon. It was another dead end.

“We could launch both of them, but we only have one Delta IV Heavy launchpad on each coast—and we don’t have any extra Delta IV heavies sitting around, so we’d have to steal two of those rockets from another agency,” Bridenstine said.

Even if NASA could obtain the rockets, the payload launched into polar orbit from California’s Vandenberg AFB would take too much time—and require quite a lot of propellant—to shift into position for a rendezvous and docking with the Florida-launched payload located in a lower-inclination orbit. “Two Delta IVs proved to be unworkable,” Bridenstine said.

In addition, the only automated rendezvous and docking system currently available is what SpaceX demonstrated in March aboard its Crew Dragon capsule. “We looked at taking a Crew Dragon and docking it to Orion and pushing it around the Moon,” Bridenstine said.

In that scenario, the Crew Dragon would launch on a SpaceX Falcon rocket and the Orion capsule with its ESM would fly on a Delta IV Heavy, with the two boosters taking off from Florida 90 min. apart. But the Crew Dragon does not have the thrust to take Orion to the Moon.

“That would basically be a replay of EFT-1,” Bridenstine said, referring to Orion’s December 2014 Exploration Flight Test in Earth orbit. “That isn’t what we’re trying to achieve here. We want to test it around the Moon.”

Moving on to SpaceX’s Falcon Heavy proved more fruitful. NASA determined it has the lift capacity to fly an Orion and ESM, but the rocket’s horizontal assembly and existing launch support equipment presented complicated integration issues and unknown technical risks, such as shockwaves generated by a new, larger payload fairing impacting the Falcon’s side boosters in new and unknown ways during ascent.

“We’d have to go back into wind-tunnel testing,” said Bridenstine. “At the end of the day . . . there was so much risk and so much cost and so much schedule involved that it wouldn’t accelerate on either cost or schedule. But it could be used in the future.”

The Falcon Heavy, however, would not be able to dispatch Orion into lunar orbit, not even the near-rectilinear halo orbit planned for NASA’s Gateway, a small command- and-control platform the agency is developing to stage sorties to the lunar surface and test hardware for deep-space travel.

In the end, the team found one potential commercial alternative to the SLS for reaching lunar orbit: the Falcon Heavy with an ICPS upper stage.

“The best option to get us into lunar orbit as soon as possible is SLS with an Orion and ESM. Nothing beats that capability,” Bridenstine said, “but we’re doing everything possible to accelerate that,” Bridenstine said. But, he noted, “There is nothing sacred here that is off the table.”
Late last year, the largest fuel tank ever built was loaded onto a barge for a 1,200-mi. (1,930-km) journey on the Mississippi, Ohio and Tennessee rivers, arriving in Huntsville, Alabama, in the midst of a government shutdown. Working at night when winds abate, the 149-ft.-tall, 27.5-ft.-dia. tank, built by Boeing, was hoisted into a new test stand at NASA’s Marshall Space Flight Center, where it will soon experience 3 million lb. of crushing force.

The liquid hydrogen tank, built for structural qualification testing, is not the only part of the Space Launch System (SLS) program facing a big squeeze. Vice President Mike Pence wants NASA to chop four years from its post-International Space Station human exploration program and land astronauts on the Moon in 2024. “The president has directed NASA and Administrator Jim Bridenstine to accomplish this goal by any means necessary,” Pence said at a March 26 National Space Council meeting in Huntsville.

The first order of business is getting the initial SLS core stage out of the Michoud Assembly Facility in New Orleans by Dec. 31 and prepared for a possible uncrewed launch of Exploration Mission-1 (EM-1) from Kennedy Space Center in 2020. “We’re running about two weeks ahead to finish by the end of the year,” Boeing Vice President and SLS Program Manager John Shannon tells Aviation Week.

“There are always surprises in rocket programs, and we still have a number of first-time activities . . . but we have the right team sitting shipside to immediately resolve any issues that we come across. That is really the key: to have the engineering team lined up perfectly with the production team so that as issues come up, you’re able to resolve them very quickly and move on,” he adds. “I’m feeling very good about getting the vehicle out this year.”

In March, NASA briefly considered launching the EM-1 flight test of the Orion capsule around the Moon using a pair of commercial vehicles, but quickly determined that neither U.S. option—SpaceX’s Falcon Heavy or United Launch Alliance’s Delta IV Heavy—could accomplish the task any faster than waiting for the SLS (AW&ST March 25-April 7, p. 70). The commercial option also would cost nearly $1 billion, U.S. Rep. Jose Serrano, a New York Democrat who chairs the House Appropriations subcommittee overseeing NASA, noted during a March 27 hearing on the agency’s fiscal 2020 budget request.

Bridenstine told Serrano the SLS was going to miss its June 2020 debut, adding to a string of delays dating back to December 2017, the original launch date. “I don’t think [June 2020] is in the cards, but I do think we can accelerate significantly from when we were originally told that that launch date would occur, which could be a slip of almost a couple of years. I think we can accelerate well ahead of that,” Bridenstine said.

Kennedy Space Center is leading
a study, due to conclude in mid-April, that assesses options for launching EM-1 as soon as possible, including forgoing a “green run” full-duration static test-firing of the SLS core stage at NASA’s Stennis Space Center in Mississippi. “We do a very comprehensive check of systems at Michoud before the vehicle leaves the factory,” says Shannon. “This is a discussion about how much additional testing you need to do before you go fly.”

NASA’s current plan calls for green runs on at least the first two SLS core stage boosters, but Shannon notes that aside from scheduling issues, the tests are being assessed for potential operational impacts. “You’re essentially taking a vehicle that is designed to be flown once and flying it twice. There is a lot of stress on the vehicle because you’re holding it down and going through the full, 8-min. mission cycle,” he says. “It’s a risk discussion—if there is more risk to put the hardware through the cycle for whatever you are going to gain in knowledge.”

The propulsion test at Stennis accounts for 6-7 months of work remaining on the first core stage. “We’re challenged to be able to launch in 2020, so everything—every process, every procedure—is on the table right now,” says NASA’s Tim Flores, SLS stages integration manager at Marshall.

Boeing, the prime contractor for SLS core stages, and NASA have encountered and tamed more than a few technical gremlins miring the program’s progress. In 2015, engineers tackled a misalignment problem with the massive, state-of-the-art, friction-stir-welding tool built to manufacture the SLS tanks.

Friction stir welding uses a super-fast rotating pin to whip solid metal pieces into the consistency of butter and meld them together to bond the core stage’s rings, domes and barrel segments. The goal is to produce a stronger weld with fewer defects than traditional methods of joining materials with welding torches. “Getting the tooling dialed in to build the flight vehicle took longer than we anticipated . . . but we just put together the Core Stage 2 liquid oxygen tank, and it went together with absolutely no drama at all,” says Shannon. “All the welds came back 100% clean, and the team delivered on time. It worked perfectly.”

Last year, Boeing discovered that a supplier was not adequately cleaning some tubing for gaseous oxygen. It set up five laboratories and cleaning houses to go through all the tubing and revamped its oversight and inspection processes. Shannon attributes that issue to having to revitalize and retrain an industrial base.

“The SLS program was set up so that the first rocket we built was not a practice, developmental or qualification rocket. It is the rocket that will go fly for the first time,” says Shannon. “You’re learning how to put all your parts together, how to do testing, the processes that we use, all of that was done on the first vehicle you actually go fly.”

The idea was to save money, but the problems added months to the core-stage development calendar. Currently, the major schedule driver is completion of the section where four Aerojet Rocketydne RS-25 engines, previously used to power the space shuttles, will be housed. NASA salvaged 16 space shuttle main engines to outfit SLS core stages 1-4 and hired Aerojet to manufacture six new disposable RS-25s under a $1.2 billion contract.

With 18 mi. of cables and 500 sensors, the engine section is a spacecraft unto itself. It now sits squarely on the critical path toward getting the first core stage out of the factory door. NASA and Boeing recently decided to assemble the rocket horizontally, rather than the preferred vertical orientation, so that engine section
issues do not delay work on the rest of the rocket. Technicians also are building tools to construct the cable tray, which runs the length of the core stage separately, and then attach it to the vehicle later. It previously was to be constructed on the vehicle directly.

So far, the forward skirt, liquid-oxygen tank and intertank for the first core stage have been joined together. Still to come is connection of the hydrogen tank to the engine section, followed by mating of the hydrogen tank to the intertank. “Horizontal processing has the potential to buy back 2-3 months of schedule,” NASA SLS Program Manager John Honeycutt tells Aviation Week.

“We’re trying to move the engine section out of the critical path,” Bridenstine adds. “The key is, in as many places as possible, to do things in parallel rather than serially.”

Getting the SLS to the launchpad in 2020 will be a challenge, but that pales in comparison to President Donald Trump’s directive for NASA to land astronauts on the Moon in 2024, four years ahead of current plans. There is no SLS core stage in development for a potential lunar surface mission, nor an upper-stage motor powerful enough to propel an Orion crew spacecraft and a lunar descent vehicle onto a trajectory toward the Moon. And there is no lunar descent vehicle, either.

Further, the president’s $21 billion fiscal 2020 budget request for NASA, unveiled just weeks before Pence unveiled just weeks before Pence.
issued the 2024 Moon-landing challenge, not only suspends work on the Exploration Upper Stage (EUS) and a second mobile launcher at Kennedy Space Center, it also pares $700 million from the Orion, SLS and ground support systems program.

Boeing has meanwhile spent about $5.6 billion of its total $6.2 billion SLS contract, which runs through December 2021, to build two core stages and an EUS. Work on the EUS was suspended at NASA’s request last year while the agency mulled modifications. “We were rolling into a [critical design review] and went into a stop-work,” says Shannon.

NASA wanted a study to see if the EUS could be optimized for co-manifested payloads with a combined mass of at least 10 metric tons. Boeing determined that the EUS could carry 10.1 metric tons to the Moon along with a fully loaded Orion crew module. “That will be required for the lunar mission,” says Honeycutt. “We've got to keep the full-court press going on the EUS. It is key to get that turned back on as quickly as we can.”

Any SLS missions beyond Exploration Mission-2, a crewed flight test around the Moon slated for 2022-23, also will require core stages that have not yet been ordered. “It is certainly achievable” to put people on the Moon in five years, says Shannon, but “we have no spares, no long-lead items for core stage 3... It’s not critical now, but if we don’t get on contract to build it and subsequent cores, we’re going to drive a gap in the manifest. That is where we have to focus the funds.”

Before Pence’s call to land astronauts on the Moon in 2024, NASA planned to fly EM-3 with an EUS in 2024 with components for a lunar-orbiting Gateway, a small outpost to stage lunar surface expeditions and conduct science experiments and technology demonstrations. How the Gateway fits into NASA’s new mission to land crew by 2024 has yet to be determined, but Bridenstine told employees April 1 that the outpost plays a key role in not only sustaining lunar expeditions but speeding up the timeframe for those missions as well.

“We need to get the Gateway [elements] on orbit very, very rapidly, and we’re on schedule to do that,” Bridenstine says.

To accommodate a crewed landing on the Moon, the Gateway would need to include a transfer vehicle to reach low lunar orbit, a descent module to reach the surface and an ascent module so astronauts could return to the Gateway. “All of that needs to be launched and put in place around the Moon,” Bridenstine adds. “We’re looking at what is possible to put humans on the Moon in 2024. There is nothing off the table.”

NASA is looking at repurposing existing hardware for transfer vehicles and descent modules but also could opt for a solicitation, Broad Agency Announcement or commercial partnerships to accelerate lunar expedition plans. “This is a big charge, and it comes straight from the top,” Bridenstine says. “We have to embrace it... with everything we have and make it a reality.”

A Quicker Path to the Lunar Surface?

NASA is looking to shave four years off its timeline for landing astronauts on the Moon.

AviationWeek.com/awst
- Ion-Trap Mass Spectrometer for Lunar Surface Volatiles instrument to measure volatile contents in the surface and lunar exosphere.
- Magnetometer to measure the surface magnetic field.
- Low-frequency Radio Observations from the Near Side Lunar Surface instrument to measure the photoelectron sheath density near the surface.
- Stereo Cameras for Lunar Plume-Surface Studies to image the interaction between the lander engine plume and the lunar surface.
- Surface and Exosphere Alterations by Landers payload to monitor how the landing affects the lunar exosphere.
- Navigation Doppler Lidar for Precise Velocity and Range Sensing to make precise velocity and ranging measurements during the descent.
- Solar Cell Demonstration Platform for Enabling Long-Term Lunar Surface Power to demonstrate advanced solar arrays for longer mission duration.
- Lunar Node 1 Navigation Demonstrator to demonstrate a navigational beacon to assist with geolocation for lunar-orbiting spacecraft and landers.

NASA also has begun evaluating proposals in response to a Feb. 7 Broad Agency Announcement to study its three-tier approach for developing a human-class lunar landing system. The elements include a transfer vehicle from the Gateway to low lunar orbit, a descent vehicle to reach the lunar surface and an ascent vehicle to return crew to the Gateway.

Future technologies would include the ability to refuel and reuse the vehicles, first with propellants launched from Earth and eventually with fuel mined from indigenous lunar water ice and regolith.

NASA also will be looking to develop a spacesuit for extravehicular activities, including landing on the Moon.

Proposals, which were due the day before Pence’s announcement, were based on plans to test systems in 2024 and fly astronauts to the surface of the Moon in 2028. NASA is now looking to cut four years off that schedule. Six-month study contracts are expected to be awarded in July.

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**1989-93 Space Exploration Initiative** On the 20th anniversary of the Apollo 11 Moon landing, President George H.W. Bush laid out plans for what became known as the Space Exploration Initiative, which included a permanent base on the Moon and eventual human missions to Mars. The initiative was canceled by the next president, Bill Clinton.

**2004-10 Vision for Space Exploration/Constellation** In the aftermath of the 2003 shuttle Columbia accident, President George W. Bush unveiled plans for a sustained and affordable space exploration program, beginning with returning astronauts to the Moon by 2020. NASA began developing the Crew Exploration Vehicle, later renamed Orion, and the Ares rocket.

**2013-17 Asteroid Redirect Mission/Asteroid Redirect Crew Mission** With no funding for a lunar lander and other budget issues, President Barack Obama canceled Constellation, though the Orion program survived, and redirected NASA’s post-International Space Station human exploration initiatives to an asteroid. Funding started for the Space Launch System heavy-lift rocket. NASA later modified the plan to robotically bring a piece of an asteroid into a lunar orbit and send astronauts there to explore it.

**2017-present Deep Space Gateway/Lunar Orbiting Platform-Gateway** With a new administration in office, interest in the asteroid mission waned. NASA seamlessly repurposed the asteroid rendezvous into a power and propulsion module for a lunar-orbiting outpost known as the Gateway. The agency expects to announce one or more commercial partners for the module—primarily a commercial satellite bus with solar electric propulsion—by the end of May. The Gateway is expected to be a key part of NASA’s new charge to land astronauts on the Moon by 2024.
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Boeing is standing behind the baseline design of its 737 MAX as it seeks to restore industry confidence in the grounded twinjet and secure approval of a newly tested package of flight-control software and training upgrades meant to break links that helped form two 737-8 accident chains in five months.

The company, which continues to build the newest 737 version at full rate despite having to stop delivery of completed aircraft to operators, maintains that the MAX is fundamentally safe to fly and was developed in accordance with accepted industry hazard-classification practices and design procedures. But information shared in the just-released interim report on the second 737-8 accident, the March 10 crash of Ethiopian Airlines Flight 302 (ET302) suggests that failure modes envisioned for a key flight-control system were not well understood and emergency procedures relied too much on rapid analysis and prompt responses by pilots.

Boeing acknowledges there are key lessons to be learned from the two MAX accidents and that its updates are specifically designed to improve the “robustness” of the functionality of the flight-control law implicated in the Lion Air Flight 610 (JT610) crash in October 2018 and emerging as a factor in ET302. Boeing also is rolling out a package of crew-training updates that highlight the changes but do not require a complete syllabus rewrite.

The manufacturer’s priority is to convince regulators and operators that the software and training updates will safeguard against further accidents and allow the grounded fleet to return to service and deliveries of new aircraft to resume. There is high confidence within the company that the update will receive regulatory approval.

On April 2, based on recommendations from a team of former Boeing engineers, the company extended the timeline for presenting a finalized package to regulators. Brought in to review the software update, the team found “integration issues” between the software and the airplane that have to be addressed, a senior executive explains.

“It’s not because the government is telling us [the package] needs more work,” the executive says. “We’re saying we have some more work to make sure everything is compliant, to make sure the software rolls out [correctly] the first time, and works the first time.”

Boeing says the revised time line has the package being presented to regulators around May 1. From there, timing for implementing the changes and clearing the MAX to return to flight is in the hands of certification authorities. The FAA says it has assembled a group of representatives from at least nine national regulators and NASA to “evaluate aspects of the 737 MAX automated flight-control system, including its design and pilots’ interaction with it, to determine its compliance with all applicable regulations and to identify future enhancements that might be needed.” Former NTSB Chairman Christopher Hart is chairing the team.

At the heart of the upgrade are three major changes to the MAX’s Maneuvering Characteristics Augmentation System (MCAS) flight-control law, which was added to the twinjet’s speed trim system to make the new aircraft handle in the same manner as the 737 Next-Generation family. The changes prevent the system from activating in case of erroneous data from angle-of-attack (AOA) sensors as...
well as from activating multiple times for each elevated AOA input. Third, the revision now gives pilots ultimate elevator authority by limiting the degree of nose-down stabilizer commanded by the MCAS.

Outlining the changes, Mike Sinnett, Boeing Commercial Airplanes vice president of product development and future airplane development, reiterates the company’s confidence in the overall safety of the MAX, the way it was designed and the ability of the upgrade package to enable flights to resume. “We have built our reputation on safety, and every one of us feels the weight of the burden of safety,” he says. “The rigor and thoroughness of the design and testing that went into the MAX gives us complete confidence that the changes we are making will address all of these accidents. We look forward to working with all of our 737 MAX customers as we implement this, from the reentry into service to pilot training through the life cycle of the airplane.”

The system’s modifications, being developed as a software upgrade, were first demonstrated for the FAA on March 12, Aviation Week has reported (AW&ST March 25-April 7, p. 16). Boeing also will update training documentation as well as procedures. The proposed package of changes was demonstrated to 200 pilots and regulators gathered in Seattle on March 27.

Boeing stresses that it began developing the MCAS enhancement package over the past three months after issues with flight-control software, systems and pilot training were implicated early in the JT610 accident investigation. The enhancements were therefore already in development when ET302 crashed.

As well as helping the MAX to handle like the 737NG, the MCAS was introduced to decrease pitch-up tendency at elevated AOA. The changes in handling, which were found during testing in an extreme part of the flight envelope, were caused by the additional lift generated by the nacelles of the MAX’s larger CFM Leap 1B engines, which are located farther forward than on earlier 737 models.

The first change, “and probably the most important,” Sinnett says, “is that we compare data from left and right AOA sensors full-time and when the flaps are up—in a situation when MCAS would be armed. If they vary by more than 5.5 deg., the system will inhibit MCAS and the entire speed trim system for the remainder of that flight.” If an AOA disagree of more than 10 deg. occurs between the sensors for more than 10 sec., it will be flagged to the crew on the primary flight display (see box, page 24).

“In addition, as a customer option, we provide the capability to display raw data for AOA,” Sinnett adds. “Most airlines do not select this because it is purely supplemental information.”

In the current MAX design, the MCAS receives input from only one sensor during each flight. The left and right sensors alternate between flights, feeding AOA data to the flight-control computer and the MCAS. The single-point-of-failure potential of the original design was criticized in the wake of the Lion Air accident, where erroneous data appeared to activate the MCAS.

Boeing also confirms that the system will allow only one trim application for each new trigger of the MCAS by an elevated AOA event. The revision means the MCAS can never command more stabilizer input than could be countered by the crew pulling back on the control column. The company says its failure analysis of the system indicates there are no known or envisioned failure conditions in which the MCAS will provide multiple inputs.

In the original design, the MCAS trims nose down up to 2.5 deg. by moving the horizontal stabilizer at 0.27 deg/sec. for 9.2 sec., stops for 5 sec., then trims nose down again for 9.2 sec. and continues to do so until the trim reaches the stabilizer travel limit or the crew intervenes. Boeing emphasizes that the crew will retain the capability to override the flight-control law using electric or manual trim, or by following the existing runaway stabilizer procedure and

Data from the ET302 flight data recorder shows that the crew attempted to counter the MCAS inputs (see red box) but were unsuccessful.
using the cut-out switches, as reinforced in the Operations Manual Bulletin issued on Nov. 6, 2018.

The third major change is that “there is no situation in which more stabilizer input can be provided by MCAS than there is control column authority for pilot response,” Sinnett says. “The control column will always be able to override MCAS inputs. These are very important changes.”

Training programs will now include an updated level-B computer-based training program to enhance pilot understanding of the 737 MAX speed trim system, including the MCAS function and associated crew procedures and software changes. Alterations are also planned for the Airplane Flight Manual and Flight Crew Operations Manual as well as new notes for the speed trim fail checklist in the Quick Reference Handbook. The Airplane Maintenance Manual and Interactive Fault Isolation Manual are being revised as well.

“We are working with customers and regulators around the world to restore faith in our industry and also to reaffirm our commitment to safety, and earning the trust of the flying public,” Sinnett says.

Among the most criticized aspect of MCAS design is the single-string-failure potential of MCAS AOA input. The senior Boeing executive says the original design was based on a standard industry process of hazard classification, which defined the potential failure as one that could be mitigated “very quickly by a trained pilot using established procedures”—in this case, the stabilizer runaway checklist.

“In this particular case, because we don’t know yet what the ultimate cause is, we can look at that one link in the chain and say we know ways to update the MCAS functionality to make it more robust, and that is what we are doing,” the executive says. “Certification standards say a runaway stabilizer has a memory procedure associated with it—despite all of that, we are looking at it and saying, ‘We don’t want to intentionally provide the pilot with that scenario again.’ So in the design, we are using multiple inputs, even though in the original hazard classification, multiple inputs would not be required. We’ve seen two accidents, and we believe it is appropriate to make that link in the chain more robust.”

Evidence from both 737-8 accidents suggests the chain’s link was weak to begin with, as Boeing put too much stock in the pilots’ ability to quickly troubleshoot multiple-failure scenarios. Investigators have found similarities between the ET302 and JT610 accident sequences, notably that repeated horizontal stabilizer nose-down inputs from the MCAS, which was being fed erroneous AOA data, is believed to have confused the pilots.

The interim report on ET302 confirms the pilots managed to diagnose uncommanded and unwanted nose-down inputs as runaway stabilizer and followed the proper checklist procedure by toggling the cut-out switches.

“The crew performed all the procedures, repeatedly, provided by the manufacturer but was not able to control the aircraft,” Ethiopian Minister of Transport Dagmawit Moges says.

While the cutout switches were flipped, the pilots’ entire sequence of steps raises some questions. Among them: Should they have reacted more quickly to the uncommanded stabilizer input, and how did their high rate of speed—the entire flight operated at 94% N1—affect the accident sequence?

Flight-recorder data shows that ET302’s departure at 5:37:45 UTC was normal. Just after takeoff, the aircraft’s two AOA vanes deviated. The left vane’s value jumped to 74.5 deg. in less than a second, indicating a sharp nose-up attitude, compared to the right’s value of about 15 deg. Moges says investigators have no evidence of foreign-object debris affecting the AOA sensor. The left-side stickshaker also activated.

The crew continued its climb-out, retracting the flaps at 5:39:45 UTC. Ten seconds later, the autopilot disengaged, arming the MCAS in the process. The system, reading the faulty AOA data, detected the aircraft was nose-high and moved the stabilizer from 4.6 units to 2.1 units in 9 sec. The aircraft stopped climbing and began to descend.

Aft control-column force is recorded, as are nose-up commands via control-column-mounted electric trim switches, moving the stabilizer to 2.4 units.

At 5:40:20, or 5 sec. after the nose-up commands stopped, the MCAS—still detecting the left-side AOA sensor’s inaccurate data—adjusted the stabilizer to 0.4 units. At 5:40:28, the pilots interrupted the MCAS with electric trim inputs, moving the stabilizer to 2.1 units in 9 sec. The MCAS—still detecting the left-side AOA sensor’s inaccurate data—adjusted the stabilizer to 0.4 units. At 5:40:28, the pilots interrupted the MCAS with electric trim inputs, adjusting the stabilizer to 2.4 units. Seven seconds later—or 35 sec. after the initial MCAS cycle began and nearly 2 min. after the stickshaker started—they hit the cutout switches.

The crew attempted to pull the nose up with aft column pressure for much of the next 2 min. At 05:41:46, the captain asked the first officer “if he could try [the nose-up trim inputs] manually;” the report says. “The first officer replied that it is not working.”

The left-side indicated air speed was 340 kt.; the right side—was 20-25 kt. higher. The crew received an over-speed warning, asked to return to Addis Ababa and received clearance.

737 MAX Flight-Control System Changes

<table>
<thead>
<tr>
<th>MANEUVERING CHARACTERISTICS AUGMENTATION SYSTEM</th>
<th>PROPOSED REVISED SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Redundancy</strong></td>
<td>Fed by data from one of two angle-of-attack (AOA) sensors; the source alternates on each flight.</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
<td>Fed by data from one of two angle-of-attack (AOA) sensors; the source alternates on each flight.</td>
</tr>
<tr>
<td><strong>Pilot Interaction</strong></td>
<td>AOA DISAGREE flag and AOA indicator on primary flight display (PFD) are an optional add-on package.</td>
</tr>
<tr>
<td><strong>Training</strong></td>
<td>No specialized training or details in MAX flight manual.</td>
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By 5:43:11, the stabilizer was down to 2.1 units. The crew apparently toggled the cutout switches back on, because two brief nose-up inputs moved the stabilizer to 2.3 units. Five seconds after the nose-up inputs, the stabilizer automatically moved nose-down to 1.0 unit in 5 sec. The aircraft began pitching nose down and crashed about 25 sec. later.

All parties involved in the probe agree that the MCAS factored into the accident, and that Boeing's planned changes will make the system less aggressive and more reliable. But the sequence of events from the first MCAS activation through the repowering of the stabilizer is being interpreted in sharply contrasting fashions.

Evidence reviewed by the Ethiopian-led delegation, which includes representatives from Boeing, the FAA, NTSB, the European Aviation Safety Agency and France's BEA, is clear, Mogens says. The crew followed Boeing's published procedures.

Two sources with knowledge of Boeing's thinking tell Av-

Boeing MAX upgrades will make angle-of-attack warnings and indicators standard.

iation Week that the manufacturer disputes this, arguing that the pilots did not respond quickly enough and let the aircraft's nose drop too far before cutting off the automatic stabilizer input, instead of overriding MCAS with nose-up trim via the column-mounted inputs. As evidence, Boeing is pointing to the JT610 sequence, one source says. In that accident, the crew used the column-mounted inputs to counter MCAS nose-down inputs for about 7 min., or 1 min. longer than the entire ET302 flight sequence, before losing control.

Boeing’s stabilizer runway checklist does not state that the aircraft must be trimmed before the cutout switches are toggled. Trimming the aircraft should be second-nature, several pilots say, and is not something that needs spelling out on a checklist.

"Trimming is something you do constantly while hand-flying the aircraft," says one North America-based MAX pilot. "I do it without thinking about it, from nearly just after liftoff until right before we enter the flare. Whenever the airplane is slightly out of trim, I use the yoke-mounted switches to make an input. That’s why it is surprising to me that the Ethiopian [crew] didn’t use very much of the electric trim as the MCAS trimmed the nose down. To me, it would be the natural reaction, before you even realized what was trimming the nose down."

By not immediately recognizing the stabilizer runway, the crew was apparently left with fewer options. If investigators determine that the ET302 crew could not manually trim the aircraft once they stopped the MCAS because of the forces exerted on the stabilizer, both training and the checklist language will come under fire for not highlighting this risk. Conversely, the aircraft's high rate of speed may have put more downward force on the stabilizer, inhibiting the crew's ability to hand-trim.

The ET302 interim report includes two recommendations. Investigators called on Boeing to “review” the MAX’s flight-control system and update it as necessary and urged global regulators to ensure the update “adequately” addresses known safety issues before the aircraft is cleared for operations.

As Boeing works to improve the 737 MAX flight-control software and 737NG-to-MAX transition training, other quarters are launching what is expected to be a lengthy and detailed examination of the FAA’s certification processes—and the 737 MAX’s approval specifically. The Senate aviation and space subcommittee on March 27 held the first of what will be multiple congressional hearings on issues raised by the accidents.

Acting FAA Administrator Dan Elwell assured senators that the FAA played a central role in the MCAS certification, and the in-service issues uncovered following the JT610 accident do not signal errors made during the system’s design and risk analysis.

“The FAA was directly involved in the System Safety Review of” the MCAS, Elwell says. “The certification process was detailed and thorough, but, as is the case with newly certified products, time yields more data to be applied for continued analysis and improvement. As we obtain pertinent information, identify potential risk or learn of a system failure, we analyze it, find ways to mitigate the risk and require operators to implement the mitigation. And that is what has happened in the case of the 737 MAX.”

Senators pressed Elwell over the role the FAA’s Organization Designation Authorization (ODA) process played in the MAX's certification. Under ODA, FAA-vetted company employees verify that products meet certification requirements. This helps the agency keep certification projects moving faster, while ensuring they adhere to its regulations. Lawmakers expressed concern that the MCAS may not have been thoroughly vetted because it was part of ODA.

Elwell told the subcommittee that the FAA was in charge of verifying the MCAS early on in the aircraft’s certification process but later delegated it to Boeing once the agency was confident the company had the expertise to manage it.

“As a new device on an amended type certificate, we retained the oversight of” the MCAS, Elwell says. As the ODA process for the MAX was refined “under very strict review,” the MCAS was shifted to the manufacturer.

Elwell also clarified that the MCAS was not flagged by pilots as a relevant change from the 737NG during certification. The 737 MAX flight standardization board, which included 737NG pilots from multiple carriers, flew a 737 MAX simulator to compare the two models.

“After many scenarios and flights in all regimes, there was a consensus that there was no marked difference in the handling characteristics of these two aircraft,” Elwell says. This, he explains, was the primary reason that more information on the MCAS was not provided in pilot training documents.
Details emerging from investigations into two fatal Boeing 737-8 MAX accidents in five months are fueling a heated debate over whether the pilots involved were adequately prepared to face their inflight emergencies or simply could not overcome failure modes rooted in a flawed design. Either scenario implicates flight-deck human-factors shortcomings that will reverberate far beyond the software upgrades Boeing is counting on to help get the 737 MAX fleet flying again.

While the investigations into the Oct. 29, 2018, crash of Lion Air Flight 610 (JT610) and the March 10 Ethiopian Airlines Flight 302 (ET302) accident are ongoing, links between the two have been established. In each case, the flight crews battled to keep a new 737-8 aloft while the aircraft’s Maneuvering Characteristics Augmentation System (MCAS) pushed the nose down by applying stabilizer trim. The MCAS, which was added to the 737 speed trim system to help the new model handle like its 737NG predecessor in certain flight profiles, relies on data from one of the MAX’s two angle-of-attack (AOA) vanes. In each accident, investigators have confirmed the aircraft was getting unreliable data from an AOA vane, which triggered repeated MCAS nose-down inputs.

Boeing is developing a software upgrade that will prevent the updated system from activating if it is fed erroneous data (see page 24). It also gives pilots ultimate elevator authority by limiting the degree of automatic nose-down stabilizer. Additional training and updated flight manuals will also be provided. These changes will be part of safety regulators’ demands to lift 737 MAX revenue-service operations bans that have grounded the 376-aircraft fleet since March 13.

The changes are a de facto admission that the MCAS needed improvement. Beyond that, questions about how well-prepared pilots were to deal with the system’s failure remain paramount in many circles. Boeing did not include any MCAS information in 737 MAX flight manuals, which some point to as an egregious oversight. It was only after JT610 that Boeing provided pilots with extensive details about handling the MCAS.

Many pilots say that though they do not agree with Boeing’s philosophy of keeping the system in the background, they acknowledge Boeing’s logic that an MCAS failure would be recognized as uncommanded stabilizer input and managed via the common “stabilizer runaway” checklist was reasonable. The checklist, which is the same on the 737NG and MAX and includes a step that cuts power to the stabilizer, is supposed to be common knowledge for airline pilots.

“Pilots of large aircraft are trained from Day 1. When the pitch of the aircraft is doing something you’re not telling it to do, you do a runaway pitch trim checklist,” Acting FAA Administrator Dan Elwell, a former airline pilot, told a U.S. Senate subcommittee during a March 27 hearing about the MAX. “In every plane I’ve ever flown, it’s called a memory item. You’re not fumbling through books. It’s a time-critical procedure, and you go to that.”

The European Aviation Safety Agency Executive Director Patrick Ky, speaking to European Parliament members on March 19, said the procedure “is not that complicated.” But the fact that it was not followed by the Lion Air crew suggests they were confused. “If they knew what was really happening, they would not have done what they did, and they would not have crashed,” Ky said.

The ET302 crew had the benefit of knowing about the MCAS, and investigators determined that they followed the prescribed procedure—at least in part. The MCAS activated and pushed the aircraft’s nose down. The crew responded with manual inputs via column-mounted trim switches, which countered only a portion of the MCAS nose-down input. The automated system, still receiving erroneous data, activated two more times, dropping the nose even more. After the third MCAS nose-down input, the crew toggled the cutout switches. Struggling to maintain altitude, they turned the system back on, which triggered the MCAS again.

Investigators are looking closely at how the ET302 crew reacted, and why they reactivated a system that they identified as central to their problem. One possibility: With power to the stabilizer cut off, they would have needed to move it by cranking a center-console-mounted wheel attached to cables and pulleys. This may have taken more time than they believed they had, or been too difficult, so they opted to reengage stabilizer power and try the column-mounted switches.

Safety agency personnel as well as many pilots agree that more abnormal-scenario training in the simulators would be beneficial to pilots.
Another possibility: They may not have fully understood what they were facing. Boeing’s approach of keeping the MCAS in the background means its activation did not result in any cockpit warnings. Boeing’s assumption: Unwanted nose-down inputs, signified in part by a spinning trim wheel, would alert pilots to a runaway stabilizer and prompt them to execute the checklist.

“If I had been flying a MAX with stickshaker activation at liftoff after the Lion Air accident, shutting off the trim would have been accomplished in a matter of seconds, not minutes,” says one U.S.-based MAX pilot. “I probably would have activated the stabilizer trim cutout switches before the gear was even up. Why that didn’t happen on the Ethiopian flight is a mystery to me.”

The stickshaker warning, or artificial vibrating of the control column that signifies a stall is imminent, activated on both JT610 and ET302 because of the faulty AOA data. Meant to alert pilots of a problem, it can be more of a distraction than a help in certain scenarios, the MAX pilot says.

“Not only would the noise mask the operation of the trim [wheel], it is such a significant warning that it would command a lot of attention,” the pilot says. “Ultimately, it is not telling you anything useful, but it makes recognizing the trim runaway more difficult, especially since the trim was not continually running.”

The two MAX accidents underscore a larger concern: Is automation beginning to supplant, instead of augment, basic flying skills? While airlines have long used it safely, pilots who typically fly with automation who were involved in accidents “made errors when confronted with an unexpected event or [when] transitioning to manual flying,” the Transportation Department Inspector General’s office found in a 2016 report to Congress.

“As a result, reliance on automation is a growing concern among industry experts, who have questioned whether pilots receive enough training and experience to maintain manual flying proficiency,” Transportation Department Inspector General Calvin Scovel said in the March 27 hearing. The initial results from the ET302 accident “raise concerns about pilots’ abilities to recognize and react to unexpected events,” he added.

The FAA now requires that Part 121 pilots be trained in specific abnormal flight conditions, including stall and upset recovery and loss of reliable airspeed, and that training on the responses be performed in full-flight simulators. But the recent 737-8 accidents have raised questions about the availability and capabilities of simulators, Scovel says. According to the FAA, “existing simulators do not fully replicate the 737 MAX aircraft, and no U.S. airline currently has a MAX simulator,” he says.

Most airline standard operating procedures “recommend and encourage” using full automation to control an aircraft for safety and efficiency reasons, observes Hassan Shahidi, Flight Safety Foundation (FSF) president and CEO. Automated systems can improve pilots’ management of the flightpath, particularly during reduced weather minima, relieving them from repetitive tasks. But by depending on automation, they revert to monitoring the system rather than actively flying the aircraft. There are various theories about how complacency affects pilot performance, says Shahidi, a former Mitre Corp. senior executive who started at FSF in January.

With all of the advantages it confers, automation is not a substitute for the function of the pilot, who ultimately is responsible for flying the aircraft, says Shahidi. With respect to pilot training, “there needs to be sufficient understanding for the basis of the automation—why there is automation in the first place—and what happens with partial or full-use” of a system, he says. Also, pilots should understand the importance of monitoring an expected function so they can take timely and corrective action if there is a malfunction.

Training that focuses pilots on abnormal situations is important, whether in a simulator or non-simulator environment, Shahidi advises. For example, pilots who fly with the autothrottle engaged, even in small aircraft, may lose the habit of regularly scanning the speed indicator. When the autothrottle disengages for some reason, the pilot may not readily notice or react to even large speed deviations.

“Automation has the potential to cause significant issues if it is misunderstood,” says Shahidi. “Poor automation can reduce the pilots’ situational awareness and create significant workload as they are trying to figure out what the automation is doing, especially if the system fails. This certainly can lead to an aircraft getting into an undesirable state from which it is difficult or sometimes impossible to recover.”

The FSF issued a position paper on pilot training and competency in March 2018 saying the commercial aviation industry has reached a “crossroads” in determining how pilots should be trained and mentored and questioning whether the current approach can produce a “sustainable quantity and quality of pilots” for the expected future demand. Boeing has forecast a need for 790,000 new civil aviation pilots over the next 20 years. The Asia-Pacific region leads demand with a requirement for 261,000 new pilots over that time, the manufacturer predicts.

Shahidi concurs when asked if there is a need for more standardized pilot training across airlines that have different standard operating procedures and training requirements beyond what is minimally required by aviation au-
The looming pilot shortage is coupled with variation in the level of training worldwide," he tells Aviation Week.

National authorities lack uniformity in pilot-training regulation. Airbus safety experts also see “strange things in poor countries where air transport is growing very fast—suspiciously quick pilot qualification and fraudulent flight-hour accounting.” They are addressing the problem at the airline level. Especially for Asian carriers, it is useful to continue giving information on weather issues, they say. For example, a video was created recently to reexplain operations in convective conditions in a straightforward manner. With the massive demand for flight crew, “the aviation industry cannot afford that discrepancy any longer,” says Bigarre.

A manufacturer should not only deliver aircraft it also should take care of their being efficiently and safely operated, Bigarre notes. The company has long established a “flight training reference” that recommends a global harmonized standard for pilot training. It defines prerequisites for achieving type rating. “In essence, cadets have to fulfill specific prerequisites at every stage of their pilot training from ab initio to type rating. If a prerequisite is not met, then the cadet cannot move on to the next level,” he explains.

Airbus is adopting a “lead by example” approach. The national authority of a pilot-training organization is responsible for approving its programs. “Our implementing a program with this standard is encouraging the authority to follow us and raise the bar at other schools,” says Bigarre.

Airbus describes its ab initio training as competence-based, focusing on the development of key pilot technical and behavioral skills. “We look at the pilot’s ability to understand an exercise in an operational environment,” says Bigarre. A cadet who passes the ab initio curriculum exams has the prerequisites documented in the Airbus flight-training reference.

Escuela de Aviacion Mexico (EAM), a partner flying school in Mexico City, began training pilots under the new scheme in January. In May, Airbus
Flight Academy Europe will start operations in Angouleme, France, a rebranding of the former Cassidian Aviation Training Services, part of the Airbus Defense and Space division.

An online prescreening process selects candidates who demonstrate they will likely be able to acquire the competencies required to become “operationally ready” pilots in the expected duration, says Bigarre. He would not quote a tuition fee, only referring to “market prices” at each country’s level.

A few dozen pilots will embark on an 18-month ab initio program this year in Mexico City and Angouleme. Starting in 2020, 3-5 partner schools will be added every year to the ab initio training effort. By 2025, each will train 100-200 students per year, says Bigarre.

The European Aviation Safety Agency (EASA) last December certified the pilot cadet training program, which Airbus and Toulouse-based civil aviation university ENAC jointly developed. It includes 750 hr. of ground school and 200 flight hours. As national or regional regulations differ, Airbus also provides bridge courses. For example, EASA requires slightly more flight hours than Mexico. The program is open to high school graduates 18 or older.

In Angouleme, the Airbus Flight Training Academy Europe will use 26 Cirrus SR20/22 single-engine aircraft as well as one Diamond DA42-VI twin. Flight simulators will replicate the DA42 aircraft. Demand is expected for some 94,000 new pilots in Europe by 2037, according to Airbus’ forecast.

At EAM, Airbus cadets will fly on two types of single-engine aircraft—the Cessna 152/172 and Diamond DA40—and the DA42.

The Airbus cadet program in Angouleme, France, will use piston-engine aircraft and accompanying simulators, such as an Alsim AL42 (pictured).
ADP Privatization Moves a Step Closer With Latest Vote

> FRANCE OWNS 50.6% OF GROUPE ADP
> CONTROVERSIAL MARCH 16 VOTE HAS PAVED THE WAY FOR ADP PRIVATIZATION

Helen Massy-Beresford Paris

A s the French plan to privatize Paris airports operator Groupe ADP gathes momentum—despite some doubts—airlines will be looking at similar moves in other countries for clues on how the strategic shift will pan out.

After a long debate, France’s parliament approved a law governing the plan to privatize Groupe ADP. But the March 16 vote was controversial, following important modifications of the law by the Senate, and only a small number of members of parliament took part. Nevertheless, the law should now be formally adopted in the coming months.

That means a big change is one step closer for the operator of Air France-KLM’s hub and Europe’s second-biggest airport, Paris Charles de Gaulle—where traffic rose 4% to 72.2 million passengers last year—and of Paris Orly, where it was up 3.4% to 33.1 million. France owns 50.6% of Groupe ADP and is expected to offer a 70-year concession to run the airport while retaining a stake as part of the privatization process. Vinci Airports, already a shareholder in Groupe ADP, is seen as a front-runner; while Spanish group Ferrovial is also thought to be interested. Investment funds specializing in infrastructure could also play a role.

This is not France’s first foray into airport privatization: The Azzurra Aeroporti consortium controls Nice Cote d’Azur Airport in the southeast, while Toulouse Blagnac Airport in the southwest was privatized in 2015.

But the latter deal is now under scrutiny. Authorities are set to decide in the coming weeks whether proper procedure was followed. In parallel, Chinese shareholder Casil Europe is now looking to sell its stake in what is France’s fifth-biggest airport, reigniting a debate over its privatization.

Privatizing Groupe ADP, which also owns Paris-Le Bourget Airport and has stakes in other airports around the world, is a key part of French President Emmanuel Macron’s plans to reduce national debt.

Beyond bolstering state coffers, airport privatization—in theory at least—also offers advantages to passengers in the form of a more diversified commercial offering. Airlines should benefit from improved efficiency and competition as well as the potential for increased investment.

That last is an important factor in Europe. In a June 2018 forecast, Eurocontrol said the most likely scenario was for air traffic growth in 2018-40 of 1.9% per year, with a capacity deficit of 1.5 million flights in 2040.

But in France, the plans for Groupe ADP have raised doubts. Approval of the “Pacte” law that removes the state’s obligation to own a majority stake in Groupe ADP, and also covers other privatization projects and economic reforms, has been a slow process fraught with controversy.

Groupe ADP expects traffic at Parisian airports to grow 2.3% per year for the next 20 years. But with ambitious plans to meet this growing demand by modernizing Orly and expanding the passenger space with a new Terminal 4 at Charles de Gaulle as well as creating a fast-rail link—CDG Express—to central Paris already underway, some industry observers and government critics question the logic of privatization.

Those doubts are consistent with the caution expressed by airlines worldwide over privatization as a strategy, even if it is a popular one.

At its annual general meeting in June 2018, the International Air Transport Association (IATA) called on governments to prioritize the long-term economic and social benefits delivered by an effective airport ahead of short-term financial gains.

“It is wrong to assume that the private sector has all the answers,” IATA Director General and CEO Alexandre de Juniac said at the time. “Airlines have not yet experienced an airport privatization that has fully lived up to its promised benefits over the long term. Selling airport assets for a short-term cash injection to the treasury is a mistake.”

But France is not the only country in the throes of airport privatization: Saudi Arabia’s plans are proceeding slowly, while Brazil sold off concessions to operate several airports in a March 15 auction, as part of President Jair Bolsonaro’s broad general privatization drive.

Swiss group Flughafen Zurich and Spanish operator Aena SME were among the successful bidders in Brazil, and a further set of airport assets in the country is set to be offered for sale in the next two years.

In Greece, where a consortium led by German airport operator Fraport has been running 14 regional airports since 2017, the government announced a new wave of airports up for privatization late last year. IATA notes that about 14% of airports globally, handling about 40% of global traffic, have some level of privatization.
China Dashes Business Aviation Hopes Once Again

> SALES DRIED UP IN MID-2018, SAYS DASSAULT

> ECONOMIC AND POLITICAL FACTORS ARE UNDERMINING DEMAND

Bradley Perrett and John Morris

Chinese demand for business aircraft has flopped again, disappointing manufacturers for a second time this decade. Economic weakness is one of many factors; politics, never far below the surface in China, is another.

Usage of business aircraft in China is also falling behind expectations, especially operations by foreign owners. It looks like international interest in trade and investment deals in China has dropped and, with it, the need for top executives to go there.

Dassault has most clearly described the state of demand as poor, while Gulfstream says only that the market has tempered. Bombardier’s vice president of sales covering China, Khader Mattar, says growth has slowed over the past year. Those three manufacturers dominate sales in China, where few buyers are interested in anything but large, long-range jets.

The slump in contracts began in mid-2018, Dassault says. Sales elsewhere in Asia compensated for Chinese weakness last year, and the U.S. market was healthy, executives from the company said. The overarching factor is the slowing Chinese economy, which the government says grew 6.6% through the fourth quarter of 2018, the lowest rate since 1990. Beijing’s suspiciously smooth GDP figures are widely doubted, with many economists suspecting expansion is actually slower.

Jean-Michel Jacob, senior vice president for Dassault Falcon’s Asia-Pacific business, identifies other economic factors: the further threat to activity from the Sino-U.S. trade war, business’ difficulty in obtaining credit in China and tightened rules on exchanging yuan for foreign currency, which a buyer needs when acquiring an aircraft.

The political factor suddenly hit in July, the company says: The government directed businesses to keep a low profile and avoid extravagance. That was when orders dried up.

China is therefore disappointing business aircraft-makers for a second time. Early this decade, its demand for private aircraft was surging from a low base. But the accession to power of President Xi Jinping in 2012 was followed by a crackdown on corruption that led many rich Chinese to avoid being seen in private jets, especially those who were both officials and businessmen. That phase then ended around 2016, but now Chinese politics is again undermining the market. Jacob was unwilling to predict Chinese demand for this year.

“It has tempered a little bit,” says Scott Neal, senior vice president of worldwide sales at Gulfstream. “It might not be the level of activity we saw two, three, four years ago.” The reason “is probably some uncertainty related to the trade discussions underway, but I think it’s temporary,” Neal says. Gulfstream has maintained its investment in China. “We have not pulled back at all,” he says, adding that there is still solid activity in the whole Asia-Pacific region, including China.

Whatever the degree of order shrinkage in China, domestic usage of private aircraft in the country has flattened, according to the country’s largest operator of business aviation ground facilities, Shanghai Hawker Pacific. Early last year, the company expected about 3% annual growth in activity, measured by aircraft arrivals, says General Manager Carey Matthews. As Washington began applying tariffs on Chinese goods and Beijing retaliated, there were fears of further economic slowing in China; the company thought business aviation activity would drop. In the event, the pace of aircraft arrivals at the company’s two facilities, both in Shanghai, is about unchanged compared with a year ago.

The response of foreign owners to the Chinese economy has been more dramatic: Their arrivals at the Shanghai facilities dropped in November and have stayed low, at a level about 15% below that of a year ago, Matthews says. Chinese government directives cannot be affecting this activity, so the obvious reason is a fall in interest in doing business deals in China, no doubt related to the economic outlook.

The business aircraft fleet based in mainland China, Hong Kong, Macau and Taiwan grew 8% in 2017, to 512 aircraft at the end of that year, according to consultancy Asian Sky Group. Figures for 2018 are not yet available.

The old Chinese business aviation problem of access to airways and runway slots never goes away; the authorities seem to allow just a little more access each year. The opening of Beijing Daxing International Airport, due on Sept. 30, should markedly improve access to the national capital, which is severely constrained by capacity at Beijing Capital International Airport.
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TOGETHER, WE ARE REDEFINING AEROSPACE
Missing Missile

> BRAZIL AND SOUTH AFRICA DISCUSS MISSILE CO-DEVELOPMENT

> A-DARTER DEVELOPMENT PHASE NEARS END

Steve Trimble Rio de Janeiro, Brazil

As Brazil’s first Gripen E fighter moves down Saab’s assembly line, the final piece of the F-39 variant’s weapons package—a beyond-visual-range air-to-air missile—is still missing, but not forgotten.

A new air-launched version of South Africa’s Umkhonto surface-to-air missile has emerged to compete over the long term to fill the long-range, radar-guided missile requirement for the Brazilian Air Force.

Discussions have opened between the Brazilian and South African governments over a co-development agreement for the air-launched version of the proposed Umkhonto-R missile, says Japie Mare, Denel Dynamics’ program manager and system engineer for the A-Darter missile.

If selected, the Umkhonto-R would offer Brazil a low-cost alternative to the MBDA Meteor. The latter is already developed and integrated on the Gripen E test aircraft; the former offers an opportunity to revitalize Brazil’s broken industrial base for air-to-air missiles.

South Africa and Brazil have found several opportunities for defense collaboration over the years, especially in the missile sector. Since the late-1990s, Denel Dynamics partnered with Brazilian industry to develop the MAR-1 anti-radiation and the A-Darter infrared-guided air-to-air missiles. The A-Darter is now within months of completing an extended development phase.

But Denel’s Brazilian partner, Mectron, shut down in 2017. Its portfolio of missile programs—including the MAA-1 short-range air-to-air missile, the MAR-1 anti-radiation missile and its stake in the A-Darter collaboration—passed to other Brazilian companies, including ground-launched missile manufacturer Avibras and aerospace engineering services supplier Akaer. A company formed by former Mectron employees, SIATT, has taken up other missile projects including integrating the electrical systems for Brazil’s Mansup anti-ship missile.

A co-development deal with Denel could help focus this fragmented industrial base in Brazil for air-to-air missiles on a new project—albeit with great complexity.

The Umkhonto would have to be adapted from surface-launch to air-launch and exchange an infrared seeker for a radar-homing system. Denel Dynamics also may seek to extend the range by adding a booster rocket. The Umkhonto also creates options for commonality with the Brazilian Navy, which is already evaluating the surface-launched version of the weapon for air defense, Mare says.

It is also possible that Brazil could invest in foreign and domestic options. In 2015, the Brazilian Air Force awarded contracts for two short-range air-to-air missile options: Diehl’s IRIS-T and A-Darter. The former is a standard option on the Gripen E and the latter is a unique option for Brazil.

Denel completed airworthiness qualification testing on the A-Darter missile in September, Mare says. Additional work, including a performance audit by South African defense acquisition agency Armscor, should be wrapped up around June, he added.

But final integration of the A-Darter on the Gripen E may still be 2-3 years away. The fallout of Mectron’s demise as a joint-venture partner is still being worked through. It could take months or years to complete a new workshare deal on A-Darter production and sustainment with the South African and Brazilian industries, Mare says. In an April 3 press conference, Geovane Pellegrino, Embraer’s Gripen program manager, set the time frame for integration of the A-Darter as 2021-22.

By then, the Brazilian Air Force expects to be operating its first aircraft. The first test model ordered by Brazil should roll off Saab’s assembly line in Linkoping, Sweden, by the end of the year. The first operational aircraft should arrive in Brazil two years later.

Meanwhile, the Brazilian industrial team for the Gripen E is gearing up to support final assembly at a new factory in Sao Bernardo. The first Brazilian assembly technicians will move to Sweden later this year for training. Swedish workers will assemble the first 13 Brazilian jets. Brazilian workers then will assemble the next eight aircraft in Sweden. Assembly for the final 15 aircraft will move to Sao Bernardo.

Brazil’s involvement in the Gripen E program has continued to grow since the aircraft’s selection in 2014. Last November, Saab decided to standardize the Gripen E/F fleet with a large-area cockpit display designed by AEL Sistemas for the Brazilian F-39. The selection now makes AEL, a joint venture in Brazil set up by Elbit Systems, the supplier for the Gripen E/F’s head-up, helmet-mounted and large-area displays in the cockpit.
A co-development deal with Denel Dynamics, the former ofers an opportunity to revitalize Brazil's broken test aircraft; the latter is already de-
veloped and integrated on the Gripen E MBDA Meteor. The former offers Brazil a low-cost alternative to the A-Darter missile.

If selected, the Umkhonto-R would co-develop a new missile.

The Umkhonto creates options beyond-visual-range air-to-air missile—passed to other Brazilian companies, including ground-launched
orsation—ofered on the Gripen E/F's head-up, helmet-mounted and large-area displays in the cockpit.

The Umkhonto also creates options for commonality with the Brazilian MAR-1 anti-radiation missile and A-Darter. The former is a stan-
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Diehl's IRIS-T is the long-range, radar-guided missile re-
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The Umkhonto surface-launched version of the weapon—ofered on the Gripen E/F's head-up, helmet-mounted and large-area displays in the cockpit.

Meanwhile, the Brazilian industrial base for air-to-air missiles is still missing, but not forgotten. The Umkhonto-R would have to be
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A supersonic-combustion ramjet will power a future hypersonic cruise missile planned to replace France’s current air-launched nuclear deterrent. The government’s first confirmation of the propulsion system for the secretive ASN4G program was tucked into a news release from France’s Directorate General for Armaments (DGA) about a new supercomputer facility being opened by MBDA, the missile’s developer.

The European missile manufacturer will use the supercomputer to support further development of the ASN4G, the DGA says. The release then notes that the ASN4G will be a hypersonic missile powered by an innovative “superréacteur,” the French term for a scramjet. French aerospace laboratory Onera is supporting preliminary studies underway for the ASN4G program, the DGA release adds.

The ASN4G is the first confirmed future weapon with an air-breathing scramjet engine. A scramjet is capable of burning fuel in supersonic airflow, a necessity as vehicle speeds surpass Mach 5. Russia’s 3M22 Tsirkon (Zircon) hypersonic anti-ship cruise missile is reported to be scramjet-powered.

France first acknowledged it was working on ASN4G in 2014. The weapon is scheduled to enter service in 2035 to replace the air-launched ASMP-A, a supersonic cruise missile with a 300-kiloton nuclear warhead that is carried by the Dassault Rafale fighter.

MBDA CEO Antoin Bouvier confirms the company was awarded initial contracts by the French government in 2018 to begin technology demonstrations supporting development of the ASN4G. Hypersonics is “one of the technologies” being worked on for the ASMP-A successor, he says.

Although scramjets have been tested experimentally by the U.S., Russia and most recently China, no country has confirmed plans to develop a new hypersonic missile with an air-breathing engine. The U.S. Air Force Research Laboratory flew the Boeing X-51 Waverider above Mach 5 on scramjet power in 2013. Under DARPA’s follow-on Hypersonic Air-breathing Weapon Concept program, Lockheed Martin and Raytheon are expected to fly competing scramjet-powered missile demonstrators in 2020.

The U.S. plans to replace its airborne nuclear deterrent—Boeing’s subsonic AGM-86—with the Long-Range Stand-Off (LRSO) weapon but has not confirmed whether the new cruise missile will be subsonic, supersonic or hypersonic. Lockheed and Raytheon are competing to develop the LRSO and are working under 54-month technology maturation and risk reduction contracts awarded in August 2017.

Developed from the earlier ASMP missile carried by French Air Force Dassault Mirage IV bombers, the ASMP-A entered service in 2009 on the Dassault Mirage 2000N, now retired, and in 2010 on the Rafale. Powered by a liquid-fueled ramjet, the missile has a range of 500 km (310 mi.) and a speed of up to Mach 3. The ASN4G is expected to have a range exceeding 1,000 km.

MBDA and Onera have been working for some time on development of dual-mode ramjet/scramjet technology to extend operation to higher speeds, up to Mach 8 for military applications. The ASN4G also widens the French government’s interest in hypersonic weapons. In January, Defense Minister Florence Parly announced a study by ArianeGroup into a hypersonic glider called the Experimental Maneuvering Vehicle (V-MaX). The glider is planned to fly in 2021.

France has two pillars of its nuclear arsenal, the other being the M51 submarine-launched ballistic missile produced by ArianeGroup. This likely will be the platform for tests of V-MaX. ASN4G will probably equip the Next-Generation Fighter that forms the French element of the Franco-German Future Combat Air System program.

Despite its work on scramjet-powered missile technology, the U.S. is focusing on development of boost-glide strike weapons in its push to match advances in hypersonic weaponry by Russia and China. The U.S. Air Force plans to field the air-launched rocket-powered Hypersonic Conventional Strike Weapon—similar in concept to Russia’s Kinzhal missile—and boost-glide Airborne Rapid-Response Weapon early in the 2020s. © Steve Trimble 36  AVIATION WEEK & SPACE TECHNOLOGY/ APRIL 8-21, 2019
Japan’s New Anti-Ship Missile Needs More Range

Bradley Perrett Shanghai

If Japan had been able to develop the Mach-3 Mitsubishi Heavy Industries (MHI) ASM-3 air-to-ship missile on the original schedule, perhaps the weapon would have been immediately accepted for service. Instead, after a program launch delay of seven years, it was not ready until 2017, by which time it was not up to the job. Defense systems now have greater range.

So the ASM-3 will be modified to fly further, says Defense Minister Takeshi Iwaya. Anyway, the fighter that is supposed to carry it, the MHI F-2, is not ready for the ASM-3, even in its current form.

The current range is reported as less than 200 km (120 mi.). “Some countries” have recently deployed naval air defense systems of increased range, Iwaya told reporters in Tokyo, perhaps referring to new shipborne versions of the Chinese HQ-9 series. The Japan Air Self-Defense Force evidently worries that F-2s will be shot down before they can launch their missiles.

ASM-3 range will be extended to more than 400 km, the Mainichi newspaper says, although the exact reach depends on altitude. The ministry’s decision implies the missile will not enter service in its current form. This leaves Japan with only the subsonic MHI ASM-2 missile, which has been in service since 1993, until the Kongsberg Joint Strike Missile (JSM) or the extended-range ASM-3 become operational, whichever is sooner.

Kongsberg, a Norwegian company, said in March that Japan had become its first export customer for the JSM, which would arm Japanese Lockheed Martin F-35As. Australia appears to be assuming that the JSM, which it has not yet selected, will be operational at the end of 2023.

The F-2 fighter also carries the ASM-2. To step up to the ASM-3, it needs an Advanced Mission Computer, which is still under development, Iwaya says. It is unclear why Japan has so badly mismatched the development timing of the onboard and missile elements of the system.

The ASM-3 uses ramjet propulsion. Its development was originally intended to occur in 2003-10, but the program was deferred to 2010-16; the budget was set at ¥32.5 billion ($292 million). Development included a reported 15 test shots, one against a retired warship. The work on ASM-3 overran the schedule by just one year. Total spending, apparently including pre-2010 research, reportedly was ¥39 billion. But now more money will be needed.

The extended-range ASM-3 and the new mission computer will be brought into service together, the minister says. Later the Future Fighter, a new combat aircraft intended to replace the F-2 in the 2030s, will use the improved ASM-3, he adds.

The ASM-3 uses inertial navigation with a data link for midcourse updates. The data link is less useful when missile speed is high and range short, because the ship cannot move far during the flight time and is therefore likely to be found without missile course correction. But updates are more important as the range is increased. The weapon homes by radar and passive radio-frequency seekers. The dual seekers complicate the defense: If the target uses its radars to direct its infrared interceptors and guns, the missile homes in on the radars; if radars are kept silent, the missile uses its active seeker.

The Mach 3 speed, cited by the Yomiuri newspaper, may be the cruising velocity; dropping to a few meters above sea level for the attack, the missile would slow somewhat. It would still be vastly faster than the conventionally subsonic ASM-2. The higher speed gives the target less reaction time, including reduced time for assessing results of a first round of defensive shots and less time to again try to down the incoming missiles.

The performance of the Soviet Kh-31 ramjet anti-ship missile, published by Boeing when the company offered it as a target last decade, gives some idea of the capabilities of such weapons. Rather smaller than the ASM-3, the Kh-31 can cruise at Mach 3.5 at high altitude. Boring in on its target just 5 m (17 ft.) above the waves, it typically flies at Mach 2.5 while pulling maneuvers of up to 15g. The Kh-31’s maximum sea-skimming speed is Mach 2.7.

The JSM is subsonic but designed to use stealth instead of speed to present the target with the same problem of short reaction time: By the time it is detected, it is already close. The ASM-2, by contrast, is not only subsonic and nonstealthy, but it has only one means of homing, an imaging infrared seeker.

In a 2016 study based on open sources, the Taiwanese navy calculated that a Chinese Type 052D Kunming-class destroyer, armed with a naval version of the HQ-9, would be unable to defend itself against eight ASM-3s fired from four F-2s.

The ASM-3 is 6 m long and weighs 840 kg (1,850 lb.).

Japan has begun research for a hypersonic anti-ship missile using scramjet propulsion.
An alarm has sounded within the U.S. Air Force over the scale and pace of China’s investment in artificial intelligence (AI) and the possibility that its aircraft could encounter smart, autonomous defenses in a future conflict.

One response to that realization is Skyborg, an Air Force Research Laboratory (AFRL) program to rapidly develop and potentially field an unmanned combat air vehicle (UCAV) that can be used to gain experience with increasingly complex autonomy and AI capabilities.

The evocatively named Skyborg is another aspect of the overarching concept of “loyal wingmen,” reusable unmanned aircraft that can augment the capabilities of expensive manned platforms but are inexpensive enough to be sent into harm’s way to improve the survivability of those manned aircraft.

Skyborg was initiated in October 2018 by AFRL’s Strategic Development Planning and Experimentation Office. A capability request for information (CFRI) was released on March 15 to assess industry’s ability to develop a fighter-like autonomous vehicle that could be used to quickly update and field iteratively more complex autonomy.

AFRL is looking for a complete vehicle autonomy concept that can be developed on an accelerated timescale. Plans call for a first flight in fiscal 2021. Skyborg could be a new platform or based on an existing aircraft such as the Kratos XQ-58 or Boeing’s unmanned QF-16.

“AFRL’s Skyborg, a low-cost attritable unmanned combat air vehicle would be used to gain operational experience with AI.

“We know that low-cost, attritable unmanned air vehicles are one way to bring mass to the fight when it comes to addressing potential near-peer engagements in the future,” says Tran. “We also know there is heavy investment by our near-peer adversaries in artificial intelligence and autonomy in general. And we know that when you couple autonomy and AI with systems such as low-cost attritable [UCAVs], that can increase capability pretty quickly and be a force multiplier for our Air Force,” he says. “So the 2023 goal line is our attempt to bring something to bear in a relatively quick time frame to show we can bring that kind of capability to the fight.”

EOC in the case of Skyborg means a platform that can be used for early military operational utility evaluation in 2023. Whether the system developed by AFRL will be deployed to a combat command is “currently being debated by Air Force leadership,” Tran says.

The program’s goal is to develop a platform that can be used to gain operational experience with increasingly complex autonomous capabilities. “We see Skyborg as a sort of vessel for AI technologies that could range from rather simple algorithms to fly the air

Graham Warwick
Washington

The U.S. Air Force 412th Test Wing’s Emerging Technologies Combined Test Force began flight-testing autonomy technologies using small unmanned aircraft systems at Edwards AFB, California, in February.
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"We've been given an overall objective to have an early operational capability [EOC] prototype fielded by the end of calendar year 2023. So this is our step in determining what the current state of the art is from a technology perspective," says Ben Tran, Skyborg program manager. The question AFRL wants to answer is "How can we leverage some of the mature technology to provide that EOC in 2023?" he says.

The CFRI describes Skyborg as "a modular, fighter-like aircraft that can be used to quickly update and field iteratively more complex autonomy." AFRL is looking for a complete vehicle/autonomy concept that can be developed on an accelerated timescale. Plans call for a first flight in fiscal 2021. Skyborg could be a new platform or based on an existing aircraft such as the Kratos XQ-58 or Boeing's unmanned QF-16.

The XQ-58 is already demonstrating technology for inexpensive UCAVs.

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I’ve been an Avionics Technician for 12 years. Aviation is my passion. Using my experience and skills to provide you with the highest quality service is a no-brainer. I pay special attention to details when I’m working on aircraft instruments including ELTs, Smoke Detectors, Nose Wheel Steering systems, and Triple Pressure Indicators. Your satisfaction is always a top priority for me.

Alexandra, Avionics Technician

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MAINTENANCE CHECK

Old, New and in Between

MRO can almost be like remodeling a house. First you determine the workscope, budget and timing. After getting the work processes and labor ready to go, the demo starts, and you order the materials, making sure they are delivered at the right time. You keep the overall structure but move some walls (hoping there isn’t any unexpected electrical or plumbing in them), refresh the tired floors, update the lighting and add sleek energy-efficient appliances and monitor it all via a connected home system such as Nest.

With your new modern interior, some of your furniture looks old, so you reupholster it and add some new elements to compliment the new color scheme—mixing the old and new to create a harmonious interior.

While house remodeling is a lot easier than aircraft modifications, they both mix the old, new and something in between—but whether it’s repainting a mirror frame to give it a second life or incorporating used serviceable material or an engine with green time. That mix often works for budgets, but sometimes it’s not easy—and sometimes that favorite chair from college just has to go.

As our industry balances mature and next-gen aircraft—and at the same time tests new technologies for MRO efficiencies—operations regularly see a mix of the old, new and in between.

Like many carriers, Delta Air Lines is in a period of transition. As CEO Ed Bastian said about new technologies and capabilities at Delta TechOps, “we’re just getting going” (MRO 27). Bastian, pictured above with me at Delta TechOps’ new 150,000-lb.-thrust test cell in Atlanta, is delivering the keynote at MRO Americas on April 9. Data analytics’ use is in the “in between,” or transition phase, too.

In researching this issue’s big data outcomes cover story (MRO 18), two people told me about similar experiences: Predictive maintenance has become extremely accurate, but telling mechanics to pull parts that they think are still perfectly good takes convincing. The solution: Test the removed part and promptly tell the mechanics the test bench results. Doing that helps mechanics gain confidence in the big data outcomes and gives them pride in knowing they helped prevent a problem further down the line.

In rolling out new technologies—whether artificial intelligence, augmented reality or predictive maintenance—a key element to success seems to be not just telling your colleagues how to use it but showing how it fits in the overall ecosystem. It’s not just a new tool, so demonstrate how it advances your business goals. Make it part of your overall processes and outcomes.

I think the key word is “convergence.” Our industry is a mix of old and new and in between—as you prepare for the future, consider what needs to converge to deliver the results you seek in a harmonious way.

—Lee Ann Shay

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

We’re committed to keeping fleets flying. We do this through global repair centers, a robust spares inventory, AOG and technical support, and innovative exchange, lease and overhaul programs. Producing and maintaining airworthy avionics is what we do.
**Boeing 737 Demand and Pricing Firming Up**

After the Boeing 737 MAX aircraft fleet was grounded by regulators worldwide in March, some noticeable trends are occurring in the market for Boeing 737 Classic and Next Generation aircraft, according to Firoz Tarapore, CEO of Dubai-based lessor DAE Capital.

“Both demand and pricing are firming up,” Tarapore told Inside MRO. However, with changes due for the MAX, including a new software fix and overhaul of pilot training from Boeing, he does not see this being the new norm. “This phenomenon is likely to abate after a permanent and satisfactory fix has been put in place for the MAX,” Tarapore says.

**Southwest, Mechanics Reach Tentative Agreement**

Southwest Airlines and the Aircraft Mechanics Fraternal Association (AMFA) agreed to terms on a new contract that, if ratified by the mechanics, would end more than six years of often contentious talks. The Agreement in Principle (AIP), reached March 16 after a week-long round of negotiations, includes a 20% raise for mechanics effective April 1 and 3% base-rate bumps annually in 2019-23. It is also believed to include some added third-party maintenance provider flexibility for Southwest.

The AIP will be written as a tentative agreement for AMFA members to vote on. If approved, the deal would become amendable in August 2024.

**Latin America MRO Demand, 2019-23**

Expect aircraft MRO demand in Latin America to be dominated by Airbus ($8.1 billion), Boeing ($7.3 billion) and Embraer ($1.7 billion) over the next five years, according to Aviation Week Network’s 2019 Commercial Aviation Fleet & MRO Forecast. The total MRO demand for the region in 2019-23 will be $19.4 billion, with airframe MRO demand comprising just 8% of that total. The largest percentage, 36%, will come from engine maintenance demand.

**Sapura Technics To Open in Malaysia in July**

A new narrowbody MRO, Sapura Technics, is expected to open at Senair Airport in Senai, Johor, Malaysia, in July after it obtains its first regulatory approval from the Civil Aviation Authority of Malaysia. The MRO, owned by Sapura Resources Berhad, is taking over two hangars—one for one narrowbody aircraft—from Sapura Aero, which provides aircraft management services. Initially, the MRO plans to provide line and base maintenance (up to C checks) for Boeing 737 and Airbus A320-family aircraft, supported by backshops for composites, sheet metal, non-destructive testing, paint and battery charging.
Sapura Resources Berhad, is taking over two hangars—each for one narrowbody aircraft—from Sapura Aerpo, which provides aircraft management services.

A new narrowbody MRO, Sapura Technics, is expected to open at Senair Air Services to vote on. If approved, the deal would become amendable in August 2024.

Expect aircraft MRO demand in Latin America to be dominated by Airbus (38%), followed by Embraer (36%), and Boeing (26%). The largest percentage, 36%, will come from engine maintenance demand.

Fleet & MRO Forecast. The total MRO demand for the region in 2019-23 will be $19.4 billion, with airframe MRO demand comprising just 8% of that total.

Latin America MRO Demand, 2019-23

- 38% for engine maintenance
- 36% for APU repair
- 26% for airframe

Latin America MRO Demand, 2019-23

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Fast-Tracked

A recent FAA endorsement of industry-driven certification provides cost-cutting opportunities for employers looking to hire and qualify avionics technicians.

In response to a petition from the Aircraft Electronics Association (AEA) earlier this year, the FAA formally recognized the American Society for Testing and Materials (ASTM) International’s National Center for Aerospace and Transportation Technologies (NCATT) aircraft electronics technician (AET) certification as equivalent to formal training when showing eligibility for the issuance of a repairman certificate. The move better defines a pathway to repairman qualification, catching the eye of educational institutions looking for student placement opportunities and employers seeking relief from skills-gap training.

The FAA issues repairman certificates to individuals who are “specially qualified” to perform a job for an air carrier or repair station. In addition to an employer recommendation, a repairman must have either 18 months of practical experience for the specific job or training found “acceptable to the administrator.” In its letter, the FAA essentially deems AET certification acceptable training—equivalent to practical experience—for purposes of repairman certification.

The FAA buy-in does not create a new pathway—an employer could always make a recommendation for an individual’s repairman certification based on any number of training or certification programs—but it does provide some assurance to employers making the certification a condition of employment. An AET certificate should accelerate the repairman application process for new hires, assuming, of course, that the candidate is capable of performing the assigned task he or she was hired to do.

Companies relying on overtime and costly pre-employment testing to qualify personnel could instead turn to the avionics standard as a much-needed backstop. Increased industry demand would incentivize more educational institutions to incorporate the AET certification into current programs—or better yet, to create new stand-alone, short-term programs to fill a growing need for specialized avionics personnel.

Educational institution officials say they are not yet seeing a strong demand for the AET certification, but that may change as word gets out, says Steve Kane, executive director of CertTEC, the organization that facilitates job-oriented knowledge and practical skill certifications. “Industry certifications such as the ASTM NCATT AET reduce the risk in the hiring process by providing a baseline of skills and knowledge,” says Kane. “With 60% of the value of new aircraft in electronics and avionics, a credential driven by industry-endorsed standards provides a desirable occupation to individuals and reduces training costs for employers.”

Most of the 31 approved training providers offer the AET curriculum as part of a larger degree program, which typically takes anywhere from 15-22 months to complete. Some of these long-standing programs are making changes that will allow students to complete the courses for AET certification “a la carte.”

Alabama Community College System (ACCS) Director of Aviation Programs Michael McDaniel says his network of schools is using the AET certification to enhance flexibility for both students and employers. “Students can enroll in our avionics associates degree program and have the training necessary for AET certification in about a year,” he says.

Other institutions are developing similar tracks. The Aviation Institute of Maintenance offers AET certification as a stand-alone, 27-week program, meaning students could be eligible for a repairman certificate in as little as six months.

For ACCS, the “on-ramp” AET program creates an individual that is immediately employable. “While students completing the avionics coursework have the option of using credits earned toward a degree, the AET certification easily stands alone,” McDaniel says.

Certificate programs such as AET are enticing because they can be developed outside the rigid framework of Part 147—the regulation that governs educational institutions with airframe and powerplant programs—and are an easy sell to state workforce boards looking for ways to meet local employer needs. And they pair well with high school dual-enrollment programs. McDaniel says ACCS secondary students can complete half the AET coursework by the time they graduate, lowering overall costs to the student and producing an avionics technician candidate a mere one semester out of high school.

“It’s all about flexibility, both for the student and the employer,” says McDaniel. “Certificate programs like the ASTM NCATT AET provide a remedy for the students who find themselves in the catch-22 of no experience, no job. Not to mention the program is filling local employment needs. That’s a win-win.”

The AET NCATT certification is maintained by the ASTM F46 Aerospace Personnel committee, founded in 2014. The committee is made up of industry volunteers; interested parties can participate in future AET standards development through ASTM membership.

—Crystal Maguire
Inside MRO

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Still the Safest

Flying is the safest form of long-distance travel, says a recent International Air Transport Association (IATA) report. It is just not as safe as it was in 2017.

Last year, 523 fatalities occurred in international commercial air travel. That is a stark increase over the 19 onboard deaths in 2017, a year subsequently dubbed the safest in commercial aviation's history when IATA member-airlines experienced zero fatal accidents and no jet or turboprop hull losses.

While disappointing, last year’s numbers were not high enough to override long-term positive safety trends. IATA officials report that over the last decade, safety metrics have improved by more than half. Indeed, IATA Director General and CEO Alexandre de Juniac puts the latest statistics in context: “Based on the data, on average, a passenger could take a flight every day for 241 years before experiencing an accident with one fatality on board.”

The report is based on data gathered through IATA’s Global Aviation Data Management program. More than 90% of IATA member-airlines contribute to the system, which in turn provides access to data analytics and benchmarking capabilities. The association says it plans to enhance its data-driven approach through development of a new Incident Data Exchange and the IATA Safety Incident Taxonomy, systems aimed at providing better safety analysis and more refined risk assessment.

—Crystal Maguire

Draining Redundancy

Maintenance organizations approved by the Civil Aviation Safety Authority (CASA) are getting additional relief from redundant pre-employment drug and alcohol testing requirements. In February, Australia’s regulatory body renewed and expanded a blanket exemption for recently tested new hires.

CASA regulations require organizations to establish a drug and alcohol management plan (DAMP) that provides for testing of all new employees performing safety-sensitive aviation activities. Since 2016, new-hires tested in the last 90 days by another DAMP organization have been exempt from the requirement.

The renewal expands the exemption. DAMP organizations may now accept test results obtained in the last 90 days by any organization (not just those organizations with a DAMP), so long as the test was conducted according to CASA regulatory standards.

Hiring organizations are no longer required to report utilization of the exemption to CASA, assuming record-keeping procedures properly document the pre-hire test. And while the previous exemption was only applicable for pre-employment testing conducted in the same manner provided for in the hiring organization’s DAMP policy, that provision has been revised to require that the previous testing adhere to CASA regulatory standards.

—Crystal Maguire

Australian regulators expand pre-employment testing exceptions to better streamline hiring processes.
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*The CFM56 is a product of CFM International, a 50/50 joint company between Safran Aircraft Engines and GE.
Seeking Closure
737 MAX system changes do not alter system architecture or maintenance procedures

P

eeding changes to the 737 MAX that Boeing hopes will allow the grounded fleet’s return to service focus on improving the maneuvering characteristics augmentation system’s (MCAS) reliability and limiting its authority to push the aircraft’s nose down. The technical faults that apparently triggered erroneous MCAS inputs have not been addressed, underscoring how much more work investigators have to do before understanding why two MAX 8s crashed within five months.

The interim report on the March 10 crash of Ethiopian Airlines Flight 302 (ET302) is expected soon. But enough is known about the first 737-8 accident, the Oct. 29, 2018, crash of Lion Air Flight 610 (JT610), to conclude that technical faults and maintenance procedures figured prominently in the disaster’s chain of events.

The MCAS is a flight-control law added to the 737 MAX to help the new model handle like its 737NG predecessor, especially at slow airspeeds and high angles of attack (AOA). The MCAS relies on data from one of the MAX’s two AOA vanes, with the source changing after each flight. When the MCAS senses the aircraft’s nose is too high, it applies automatic nose-down horizontal stabilizer trim.

The JT610 investigation is focused on inaccurate AOA sensor data that told the MCAS the 737-8’s nose was 20 deg. higher than it was, triggering a tug-of-war between the aircraft’s flight-control computer and the crew, ending with the aircraft diving into the Java Sea. While the MCAS’s architecture and how well pilots were prepared to react to its failure are of keen interest, the Indonesia National Transportation Safety Committee (NTSC) preliminary report, released in November, offers little insight on why the AOA values did not agree. After the accident, regulators queried operators and scoured databases looking for reports of MAX flight-control anomalies. But nothing turned up.

FAA Acting Administrator Dan Elwell, addressing a U.S. Senate subcommittee during a March 27 hearing, said that 57,000 MAX flights by North American carriers turned up nothing pointing to a systemic problem. “There was not a single case in North America of an MCAS malfunction,” he said.

Elwell also cited 24 reports filed in the NASA-maintained, voluntary, anonymous Aviation Safety Reporting System database. None described MCAS-related malfunctions.

The European Aviation Safety Agency (EASA) went through a similar search in JT610’s aftermath. “In our database, we did not see any evidence of any similar type of incident,” EASA Executive Director Patrick Ky told the European Parliament’s Transport and Tourism Committee March 18.

The absence of other MCAS system failures combined with added context from the JT610 accident suggests that while the MAX software needed improvement, it was only partly to blame for the Lion Air accident.

American carriers disagreed, with the left one reporting a higher value than the right. The MCAS activated, and the pilot countered with trim inputs via a column-mounted switch. This back-and-forth cycle continued until the end of the flight. The crew did not activate the cutout switches.

Initial reports from the ET302 investigation point to a scenario similar to JT610. What is not clear is why.

The software update being finalized by Boeing will prevent the updated MCAS from activating in case of erroneous data from AOA sensors as well as from activating multiple times for each elevated AOA input. It also gives pilots ultimate elevator authority by limiting the degree of automatic nose-down stabilizer. Pilots will also get new training and updated flight manuals. The upgrade is part of what regulators will require to remove MAX operations bans put in place after the ET302 accident.
The technical faults that apparently stuck out during the Lion Air crash on Oct. 29, 2018, were boil downs in the MCAS’s architecture related to the aircraft diving into the Java Sea. While the MCAS’s architecture was not new, the flight data recorder data from JT610 clearly shows the AOA sensor disagreement and how well pilots were prepared to react to its failure are of keen interest. The interim report on the March 10 disaster’s chain of events.

Pilots ultimate elevator authority by the MCAS of Flight-data recorder data from JT610 accident suggests that failures combined with added context of an MCAS malfunction,” he said. Elwell also cited 24 reports filed on why the AOA values did not agree. The JT610 investigation is focused on improving the maneuvering characteristics augmentation system’s (MCAS) reliability and limiting its automatic nose-down horizon-stabilizer trim.

One of the aircraft’s AOA sensors was different from JT610’s crash. The 8s crashed within five months. The absence of other MCAS system anomalies. But nothing turned up. None described a single case in North America by Boeing will prevent the updated software that helps the MAX system changes do not alter system requirements. Fairfield, Iowa, on March 11th, the Oct. 29, 2018, crash of Lion Air Flight 610 (JT610), to conclude that 57,000 MAX fights by North American airlines have been grounded. FAA Acting Administrator Dan Elwell, addressing a U.S. Senate subcommittee March 18.

The technical faults during four flights over three days before JT610’s accident were noted. Airspeed sensor disagreements between the pilot’s and first officer’s instruments. Among them: AOA, altitude and static air data sensors. While the MAX software needed improvement, it was only partly to blame for the disaster’s chain of events. The interim report on the March 10 accident did not address the MCAS’s role in the incident. So far, little is known about what set off an electronic report about the pilots’ instruments.

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NEW TECHNOLOGY FOR SCHEDULING AND RECORDKEEPING are all the rage. The ability to coordinate maintenance requirements and track components through mutually acceptable software programs is great. Unfortunately, these capabilities depend upon human input that can introduce errors.

On the other hand, there is technology that allows remote viewing of an article, engine or aircraft with the same (and often even better) visibility than in-person, on-premises, yet it is not being fully embraced. In April 2018, the FAA released draft guidance for comment on “video-witnessing” testing or inspections in design. In August 2018, the industry responded with a draft advisory circular for consideration that expanded the concept of remote viewing to operation and maintenance activities. Since then, the agency has promised to release guidance for design and production activities and has admitted there is nothing that prevents its use in maintenance, even without guidance.

Even though the industry can enhance and expand its capability to perform inspections and to supervise maintenance activities with remote-connectivity technology, the fear of misuse and abuse continues to dominate its adoption. This is despite the facts that the technology can:

- Enhance visibility with multiple-camera configurations and lighting;
- Save travel time and money;
- Improve the productivity of inspectors and supervisors;
- Offer instant access to multiple experts and expertise; and
- Create more efficiency in day-to-day operations.

The use of remote technology needs to be embraced rather than relegated to the back burner due to problems that exist with or without its use. The issues with performing inspections, supervision and oversight are the same—saying you did when you didn’t or performing the work badly or in a slipshod manner—whether the activities are done in-person, on-premises or remotely.

It is time for the maintenance industry to use these tried and true techniques in a bold manner to enhance:

- Maintenance control’s ability to view issues and ensure appropriate solutions during line maintenance activities;
- The ability to perform required inspection item inspections;
- The capability of on-premises technicians in troubleshooting and corrective actions through contact with experts or expertise; and
- Safety.

To learn more about the successful effort to update the agency’s guidance for remote connectivity, visit arsa.org/remote-connectivity.

Sarah MacLeod is managing member of Obadal, Filler, MacLeod & Klein and a founder and executive director of the Aeronautical Repair Station Association. She has advocated for individuals and companies on international aviation safety law, policy and compliance issues for 30 years.
Hawaiian Airlines

Jim Landers, senior vice president of technical operations at Hawaiian Airlines, talks to James Pozzi about the airline’s new maintenance hangar in Honolulu and the carrier’s plans for its technical services.

What are some of the key elements of Hawaiian’s maintenance strategy?

Now in our 90th year of operation, and as a leader in on-time performance among North American carriers for the past 15 years, we value and guard the reputation of safe and reliable service entrusted to us. We focus on “doing it right the first time and by the book every time.” At Hawaiian Airlines’ current scale, we strive to strike the right balance between in-house and outsourced work. For our outsourced work, we seek value and flexibility.

What does Hawaiian look for when choosing an MRO partner?

Prior to selecting an MRO partner, we consider several factors, including: What is their reputation for delivering quality at a fair cost? What is their geographical location and scheduled turnaround time? Also, what is their reputation for schedule flexibility and willingness to accommodate inevitable schedule changes?

What are Hawaiian’s maintenance capabilities?

We recently took occupancy of a new hangar at Honolulu’s Daniel K. Inouye International Airport (HNL), which features new equipment and the latest in safety systems, making us more efficient in servicing our growing fleet. Today, we perform the full scope of maintenance (from line servicing to heavy maintenance checks, including 12-year and 60,000-cycle) on our 20 Boeing 717s. Hawaiian also performs the full scope of maintenance on our 13 new Airbus A321neos flying between the U.S. West Coast and Hawaii. We are taking delivery of five more A321neos through next year. With less than two years in service, our requirements for this fleet have been so far limited to line maintenance tasks. For our 24 Airbus A330 long-haul aircraft, we can complete all line maintenance requirements up to an A check. We also recently received our FAA Part 145 certification, enabling the growth of our own technical services revenue stream.

Many airlines like to mix outsourced maintenance with in-house services. How much of its maintenance does Hawaiian outsource?

Like most of our industry partners, we outsource our engine and most of our component maintenance. Additionally, based on our limited scheduled frequency to many of our destinations, we contract line maintenance services. We outsource all heavy maintenance on our A330 widebody fleet, as we do not have a facility optimized for the industrial capacity required for many of those tasks. Approximately 60% of our total maintenance budget is outsourced.

Hawaiian Airlines Fact File

HISTORY: Founded in 1929.


MRO FACILITIES: One maintenance hangar in Honolulu handles most maintenance needs.

MAINTENANCE PARTNERS:
Aviation Technical Services, MRO Holdings, Qantas Engineering, Delta Tech Ops, Ascent Aviation Services, Singapore Airlines Engineering Co., International Aerospace Coatings (IAC), Dean Baldwin Painting and AAR.

Boeing 767 was a venerable workhorse for Hawaiian Airlines for most of the past two decades. As this aircraft left our network, our maintenance capacity shifted to take on our new A321neos, and we increased our in-house level of effort for overnight maintenance on our A330s. As we look toward the arrival of the 787, our team is already working with Boeing to gain insight into the technology that drives a different approach to maintenance on this aircraft. From the big data that the aircraft delivers to inform preventative maintenance decisions to the all-composite structure reducing the incidence of corrosion, we are very much looking forward to welcoming Hawaiian Airlines is undergoing a big refresh of its fleet. The Boeing 767 has left the fleet while the Boeing 787-9 is expected in two years’ time. How has this fleet turnaround affected the maintenance operation?

With any fleet transition, there are both opportunities and challenges. The Hawaiian Airlines PHOTOS

INSIDE MRO APRIL 2019 MR015
the 787 and the opportunity to become experts with this fleet type. And of course, we are pleased to reap the cost-saving benefit of the heavy maintenance honeymoon common with any fleet transition.

Deliveries of the 787-9 will begin in 2021, marking the induction of a brand-new aircraft into the fleet.

What are your plans in terms of training maintenance teams for the aircraft’s arrival?

We’ll start training our highly skilled technicians using technical training provided by the OEM. This will allow us to prepare our staff accordingly for the aircraft’s arrival and ensure maintenance requirements are met based on systemwide induction schedules and operational logistics.

What are some other key challenges facing your MRO operation?

While we can meet our staffing requirements, we are constantly recruiting, as demand for skilled maintenance technicians remains high as airlines have expanded globally. Later this year, we will begin performing “customer” MRO maintenance on our “Ohana by Hawaiian” fleet of ATR-42s used for passenger service between Honolulu, Moloka’i, Lana’i and West Maui, and ATR-72s used for all-cargo flights between Honolulu, Lihue on Kaua‘i and Hilo on the island of Hawaii.

Which technologies in Hawaiian excited about for its MRO operation?

We are currently beta-testing new technology with TRAX Mobility, which will streamline access to resources our technicians need, including technical documentation, OEM manuals, capabilities for sign-off and aircraft release. We are also exploring predictive maintenance tools and GPS tracking for ground support equipment. These resources all play a significant role in our U.S. industry-leading on-time performance measures and technician productivity.

The average technician age in North America is around the mid-40s. What is the airline’s experience of hiring technical talent? Has this proved challenging, and what methods does it use?

We are fortunate to be able to select from a pool of people who want to work in the beautiful islands of Hawaii. We can pick the very best talent, and they stay with us for a long time. Over our 90 years, we have built a huge amount of institutional knowledge. That is invaluable because of the unique challenges of flying to, from and among the islands. We also partner with Honolulu Community College’s Aeronautics Maintenance and Technology Program to recruit local talent via an apprenticeship program set up with the support of the International Association of Machinists and Aerospace Workers.
We Mean That.

Time is money, and when your landing gear overhaul takes longer than it should you end up eating it. You shouldn’t have to put up with that!

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gopaa.com/737-TAT
Building a results-generating airline predictive maintenance analytics system is much like constructing a spider web.

It starts as a loose but connected pattern that fills in with a tighter weave as the architect continues to add elements. Soon, the silken threads form closer patterns and the web’s density increases, capturing tangible results—food for the spider and actionable data for an aircraft operator.

The aviation industry has produced a preponderance of data for years but often has not done a good job of weaving it together to form patterns and connect the dots. Information—from pilot reports to maintenance logs to the aircraft communications addressing and reporting system (ACARS)—and other data long remained siloed in separate parts of the web. Now the threads are joining to capture patterns—via algorithms, analysts and machine learning.

While there is much to do to further link data sources together, big data analytics are producing increased aircraft availability, faster turnaround times, fewer maintenance delays and cost savings.

Aircraft generate plenty of data—and the newer the aircraft, the more there is. But even older-generation aircraft and engines generate data from key systems that can be gathered, analyzed and used to drive maintenance programs.

**Predicting Failure**

Delta TechOps works with OEMs for analytics but also uses an internal team of 18 people to monitor various sources of data to predict when a component is getting close to failure—from older Boeing 757s to its latest Airbus A350. “We’ve learned that just about every component or system has a signature footprint,” which could be electrical, current or resistance-related, or a frequency in which it operates, says Gary Hammes, Delta TechOps vice president for engineering and quality assurance, planning and logistics.

To help monitor certain components, the MRO has added electrical, mechanical or sound-generating sensors to certain parts to watch for those slight changes. It also basically created an Airbus A320 flying testbed by adding, in conjunction with Airbus, “as many sensors as possible, to learn as much as possible,” says Hammes.

These efforts combined have prevented 3,000 cancellations or delays in the Past two years, says Hammes. Of equal importance: Pending failure predictions have been correct 95% of the time, based on shop tests, meaning TechOps is not simply replacing equipment for no reason.

Delta, which is incorporating Airbus’ Skywise platform into its day-to-day business to track and analyze operations and performance data on its A320 and A330 fleets, also seeks to “build some key joint venture agreements or partnerships with sensor technology companies as well as Airbus and/
or Boeing—or both—to continue to drive long-term predictive technologies that will ultimately result in a new way to generate maintenance programs for aircraft,” says Harnes.

In contrast, FlightWatching, a Toulouse-based company launched six years ago, was created to “get the best out of existing fleets without any aircraft modification, by tapping existing data sources,” says co-founder and CEO Jean-Philippe Beaujard. Chief among them: ARINC communication protocols and ACARS, the real-time air-to-ground communication infrastructure used by hundreds of airlines.

The startup specializes in digital analytics, visualization and predictive maintenance. “The FlightWatching software platform is enhancing the usage of this old ACARS protocol by making it very easy to use: What sounded so complex in the ACARS A620 standard now becomes extremely simple,” he says.

The company, purchased by Revima earlier this year, has been monitoring Airbus A300s for more than five years and using its onboard avionics system to “monitor many different ATA chapters useful for maintenance, including hydraulic, engines, auxiliary power units and flight controls,” says Beaujard.

DATA SILOS

Insights can come from pairing different data sources together, but first you have to gather the information—and do it well. “Data quality is the key issue in predictive analytics,” says Jan Stoovesand, Lufthansa Technik senior director for analytics and data solutions. “The old wisdom from the recording studio ‘garbage in, garbage out,’ is true here as well.” The situation gets more challenging when data comes from different sources.

American Airlines’ legacy infrastructure means “the environments that house the sensor data are different from those that have the operational data” such as delays, cancellations and deferred maintenance items, “which are different from the environments that contain our workload scheduling data or our manuals,” says Stacy Morrissey, managing director of fleet engineering. To rectify this, American has made a concerted effort over the years to store operational data in one place. This creates “one source of the ‘truth’ in our data that is accessible to many,” says Morrissey. “For other data that just doesn’t make sense to move or store in that data warehouse, we leverage tools that allow us to blend and visualize the data so that it appears seamlessly integrated to the end users,” she adds.

While the airline has seen a number of benefits since it started its data analytics journey, Morrissey says American is moving beyond predictive maintenance and delay-prevention “to help troubleshoot chronic issues, identify trends across the fleet and make better operational decisions.”

The work extends to improving the maintenance process. “We use text mining to reduce the amount of time analysts spend manually reviewing data, as well to identify repeat or chronic items on aircraft to aid in troubleshooting,” says Morrissey. By combining data from various sources, the airline has been able to develop indicators of future component-level failures and empower its “maintenance control and planning teams to make better, real-time decisions,” she says.

Lufthansa Technik’s Stoovesand agrees and points out the empowerment piece does not just come from a tool. “The positive outcomes at the end are generated by our ability to master the whole data-processing and fulfillment chain, (i.e., data gathering, cleansing and quality) followed by the actual analytics and, most important, the ability to turn a prediction into an actionable task—directly triggered in the fulfillment system, as in our customer’s organization,” he says. “To achieve this, we had to find a suitable set of tools for the different tasks within this processing chain and integrate these tools for a smooth operation on a 24/7 basis.”

Aviatar, the open platform Lufthansa Technik created, includes an “analytics stack” used by engineers, data scientists and developers to help find these outcomes.

One example is predicting integrated drive generator (IDG) failure modes. “[By] constantly analyzing certain sensor readings, we were able to not only predict failures way in advance but we were also able to suggest simple maintenance tasks such as an oil exchange” to prevent the component’s removal, Stoovesand says.

Etihad Airways Engineering says big data and predictive maintenance are major areas of focus for the group. It uses satcom, VHF, quick-access recorder data, aircraft condition monitoring system (ACMS) fault data, flight schedules, maintenance logs and shop-visit data to glean insights. So far it has relied on OEM monitoring tools to limit unscheduled maintenance and dispatch delays. However, it “is in the process of developing an in-house platform, while in parallel collaborating with major OEMs in regard to predictive maintenance tools for specific components,” says a representative.
Like Delta, EasyJet also is using Skywise—but for its entire fleet. It signed a five-year predictive maintenance partnership program in March 2018 with Airbus to forecast aircraft technical faults before they occur. By using the Airbus platform, EasyJet engineers proactively replace parts before they fail. Delays from technical issues have declined from 10 per 1,000 flights in 2010 to just more than three per 1,000 flights today on the airline’s newest aircraft. Not surprisingly, EasyJet’s goal is to get that number to zero.

One way the airline plans to get there is by installing Collins Aerospace’s flight operations and maintenance exchange (FOMAX), which EasyJet says can collect 60 times more data than existing systems, on its fleet by this summer. After the installation, EasyJet expects to collect 800 GB of data from up to 24,000 parameters each year.

AirAsia also is using Skywise for predictive maintenance to reduce service disruptions, and it has its own digital transformation team reporting directly to CEO Tony Fernandes, says Nantha Kumar, head of group aircraft engineering. The group also has an internal team looking at using blockchain to reduce aircraft-on-ground downtime.

**CORE ANALYTICS**

As a major supplier of both components and communications services with significant content on most large-aircraft platforms, Collins is arguably as well-positioned as any company to satisfy operators’ appetite for actionable data. The company’s Ascentia prognostics and health-monitoring offering, launched in 2018, uses three core data-analysis methods to drive reliability improvement: physics-based insights, statistical analysis and machine learning.

“Aircraft systems are complex, and our deep product expertise enables us to lead with the physics behind our equipment and, in many cases, how the equipment interacts with other systems on the aircraft,” says Collins Associate Director for Digital Programs Shiv Trisal. “This allows more focused, smart-data approaches to assess equipment performance and health. These deep methods are also complemented by data science approaches such as machine learning and statistical analysis to maximize results. It’s not just the quantity of data, but the quality and application of the data.”

Ascentia is platform-agnostic. The current focus is on Boeing 787s and 777s as well as Airbus A320s and A380s—each of which contain significant Collins content. Created through last year’s merger of Rockwell Collins and United Technologies’ UTC Aerospace units—both major players on their own—Collins Aerospace has deep expertise in designing components with sensors, transmitting data to and from aircraft and analyzing it. Ascentia’s early returns show Collins is delivering. Aggregated performance data shared by the company include a 30% reduction in delays and cancellations, and a 20% dip in unscheduled maintenance for fleets covered by the service.

In most cases, the wins come issue by issue. Collins’ predictive models were able to identify deterioration on one 787 cabin air compressor outlet check valve and alert the operator, providing it with a proactive maintenance recommendation. An inspection confirmed the issue, and an operational interruption was avoided.

IDG-wear data from one operator’s twin-engine fleet detected uneven wear between the left- and right-side IDGs, leading the carrier to modify taxi procedures. An IDG temperature difference on another operator’s twinjet was traced to the fuel recirculation system, avoiding unnecessary maintenance. “While predictive models are one part of the overall equation, the other is better customer support,” says Trisal. “We can place dedicated data analytics expertise on-site, embedded with our customer’s operations. We make specific recommendations on when to remove equipment ahead of a failure. This has led to real and actionable results.”

Collins relies on data available via main avionics buses, using its IntelliSight aircraft interface device. While it could add more sensors, “there is plenty of data that hasn’t been fully mined yet,” Trisal says.

FlightWatching’s monitoring system is designed to reduce maintenance costs by detecting wear and erosion early.

**VIBRATION AND ENGINE DEBRIS**

Customers of Calgary-based flight-data streaming specialist Flyht use the company’s Automated Flight Information Reporting System (AFIRS) hardware and FlyhtHealth software service to monitor airframe and engine data and reduce unpleasant maintenance-related surprises. The most common tasks: real-time engine vibration and exceedance monitoring, says Gino Davoli, Flyht’s customer support manager.

The engineering manager from one operator that has used Flyht’s services for 11 years shared some specifics with Inside MRO. “Using the AFIRS trend data has helped us to identify engine degradation over the years, thus enabling us to schedule engine changes before it becomes an on-wing issue,” says the engineering manager, whose fleet includes multiple models of Boeing widebody aircraft powered by either GE or Pratt & Whitney engines. “We have had several engines over the years where we have had N1 [fan speed] exceedances that have alerted us to perform a fan blade lube or even fan balance prior to it becoming an issue,” he adds.

Flyht’s triggered alerts instantly provide data snippets that include chunks of time just before and after the flagged event. A basic setup monitors about a dozen parameters on
Inside MRO

An inspection confirmed the issue, and an operational intervention providing it with a proactive maintenance recommendation.

A basic setup monitors about a dozen parameters on unscheduled maintenance for feet covered by the service. A 30% reduction in delays and cancellations, and a 20% dip in flight execution.

Ascentia’s early returns show Collins is delivering. UTC Aerospace units—both major players on their own—of which contain significant Collins content. Created through last year’s merger of Rockwell Collins and United Technologies’ communications services with significant content on most large-aircraft platforms, Collins is arguably as well-focused, smart-data approaches to assess equipment performance and health. These deep methods are also complemented by data science approaches such as machine learning and statistical analysis and machine learning.

As a major supplier of both components and communications services with significant content on most large-aircraft platforms, EasyJet engineers proactively replace parts before they fail. Delays from technical issues have declined from 10% of flights today on the airline’s newest aircraft. Not surprisingly, they fail. Delays from technical issues have declined from 10% of flights today on the airline’s newest aircraft. Not surprisingly, they fail. Delays from technical issues have declined from 10% of flights today on the airline’s newest aircraft. Not surprisingly, they fail. Delays from technical issues have declined from 10% of flights today on the airline’s newest aircraft. Not surprisingly, they fail. Delays from technical issues have declined from 10% of flights today on the airline’s newest aircraft. Not surprisingly, they fail. Delays from technical issues have declined from 10% of flights today on the airline’s newest aircraft. Not surprisingly, they fail. 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each engine, including common indicators such as engine gas temperature margins as well as N1 and N2, or shaft speed, percentages. Instant alerts provide 21 sec. of data, including 10-sec. snapshots just before and after the triggering event.

Customers also use Flyht’s services to monitor OOOIs, short for “out, off, on, in,” or when an aircraft pushes back, takes off, touches down and arrives at its destination gate.

“We have 14 flavors of outs,” Davoli says. “Some of our operators use gate-to-gate [for out and in], some want ‘out’ to be when the door closes. We can customize activity for the customer.”

Automated OOOI data-delivery into many common software systems that Flyht supports appeals to both flight operations and maintenance. “[Airline] operations will sign up and select OOOIs, while maintenance is using OOOI data in another system to monitor their parts-wear times and other key metrics,” says Davoli. “When maintenance figures out we can deliver [OOOI data] automatically, they want it, too.”

Flyht’s AFIRS is in use with about 90 airlines, including more than 20 in China, where a satcom device that connects aircraft and operations centers within 4 min. will soon be mandatory. AFIRS uses proprietary software to gather and send data to the ground in real time. It is processed and delivered to the operator using its UpTime server network. Besides health monitoring, the setup supports real-time aircraft tracking and flight-record data streaming that meets new International Civil Aviation Organization Annex 6 standards. The AFIRS unit also serves as a quick-access recorder.

While connectivity is Flyht’s calling card, the company sees significant opportunity in expanding its real-time monitoring services. It has developed a highly customized event-alert profile for one Bombardier CRJ operator that provides alerts on more than 80 parameters, ranging from engine-related trends such as fuel and oil consumption to passenger-door anomaly messages.

“We start with an out-of-the-box package, then things can be added,” says Davoli. “The operator can select which parameters they want, and have pushed. It’s a lot of data, but they can see what’s going on with each aircraft. Over time, they begin to spot trends.”

Ottawa-based Gastops is helping operators spot trends in another crucial area: detecting wear in engines and other mechanical components before failures occur. A long-time sensor supplier—its oil-debris detector is standard on Pratt & Whitney’s F119 and its PW1000G geared-turbofan lines— the company also can retrofit in-service engines and provide analysis. One of its newer products is ChipCheck, a portable fluid-sample analyzer that instantly identifies debris in engine oil that can signal major failures before they occur.

“Inspection of particles in oil is typically subjective,” says David Lefebvre, Gastops senior accounts manager and engineer. “Chipcheck identifies the particle size, count and what the alloy is made of. It takes away the subjectivity.”

Such accuracy is typically available only through a lab analysis—and even then, certainty is not guaranteed.

Lefebvre recalls a time when a customer found a single particle on an engine’s magnetic chip detector. ChipCheck identified the bit as 52100 material common to bearings.

“Typically, such a failure mode would result in many particles being generated, thus leading to an immediate grounding of the aircraft and teardown of the engine,” he says.

Determining whether the material was 52100—thus pointing to an imminent bearing failure or something more innocuous—was critical. Dispatching the engine would be too risky, while an unnecessary teardown would be costly.

The customer needed a second opinion and sent the sample to a lab. Two days later, the lab said it could not classify the material. As a last resort, the sample was sent to the engine manufacturer, which confirmed what Chipcheck reported: The material was 52100. The engine was torn down, revealing that a critical component that shed the debris was failing.

Another airline operating a GE-powered widebody on a transatlantic flight received an engine-debris warning. The crew diverted to Paris-Charles de Gaulle Airport. The airline consulted with GE, which knew a ChipCheck customer had a unit at the airport. Within an hour, the verdict was in: The engine was not about to fail, and the flight could safely continue. “Without a ChipCheck on-site, this operator would have been forced to send the debris off to a laboratory and wait several days for the results,” Lefebvre says.

While instant, accurate analysis is useful, the system’s longer-term value is monitoring engine condition over time. ChipCheck can store samples by serial number, meaning operators can perform periodic tests and track changes over time, essentially developing an in-house predictive maintenance analytics program for any engine platform. Among the product’s converts: the U.S. Air Force, which has ordered 75 ChipCheck units to help support its GE F110 engine fleet.

The combination of new equipment with everything needed to feed a data analytics program plus retrofit services that can tap into data sources on older models means most operators can leverage predictive maintenance data. The results are getting so predictable that MSG-3 could be obsolete within 10 years, says Delta’s Hammes. He foresees that the fuselage and structure will stay on hard maintenance times, but the components and systems will switch to on-condition, driven by predictive maintenance and machine learning.
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Sustainment Shift

Competition drives the U.S. Air Force to rethink industry’s sustainment-driven model

Steve Trimble Washington

What would it take for aerospace manufacturers to hand over their sustainment business to the U.S. Air Force? Will Roper, the Air Force’s assistant secretary of acquisition, technology and logistics, has made it a new priority to find out.

A closed-door meeting scheduled for late April—Air Force Acquisition Industry Days—will give the Air Force’s OEMs their first chance to weigh in on the idea.

“I put a date on the calendar: 26th of April,” Roper says. “It’s open-door. It’s for industry to come back in and talk about how we shift them from sustainment into development.”

It is likely to be a provocative discussion. If anything, aerospace industrial strategy is putting even more financial value on the sustainment phase of products, when an OEM’s treasured rights to the intellectual property of the software, design and embedded innovations in major platforms guarantees decades of competition-free work at relatively high profit margins. The model has become a bedrock of the modern aerospace industry, with the returns on sustainment helping companies reinvest in lower-margin activities such as research and development on new platforms and manufacturing technology.

But the practice has become a matter of concern within the Air Force. With adversaries such as China innovating rapidly with a model that largely ignores intellectual property rights, the Air Force’s top acquisition official feels a new urgency to redesign the procurement of advanced weapons. As the acquisition strategy for the next decade’s most significant new programs—the Next-Generation Air Dominance (NGAD) system and Advanced Battle Management System—comes together inside the Pentagon, Roper wants to inject a new level of flexibility and speed into the bureaucracy and industry that must invent the next generation of military weapons.

In the process, the Air Force leadership seems willing to entertain the most provocative proposals, such as breaking the existing industry structure and forcing contractors to concentrate less on sustainment revenues to drive their balance sheets.

Despite such heady rhetoric, Roper also suggests he is willing to be pragmatic. If contractors are not ready to simply walk away from the sustainment business, he is willing to discuss how much money it would take to make it worth it to them.

“I’m not naive. I know that 70% of our life-cycle dollars are in sustainment. I know the steady cash flow that a life-cycle contractor gets from the sustainment contract is very important to their business model. We wouldn’t be naive to think that we could just ask them to politely hand it back to us and go back to development,” Roper told a group of Wall Street analysts at the McAleese/Credit Suisse Defense Programs conference in March.
Instead of dictating terms to industry, Roper has asked industry for answers. “What incentive structure would compel you to try to let the Air Force do more of its sustainment? I don’t know if it’s that we have to license sustainment from them,” he said. “I don’t know if it’s a royalty. I don’t know what it is, but we’re going to have to replace the cash flow that would normally be there.”

Roper’s incentive-based approach still may not work, however. For some contractors, the sustainment phase is too valuable, economically and strategically, to relinquish to the Air Force at any price. “With this vision that this guy has, you’re breaking some really fundamental precepts of the aerospace industry,” says Kevin Michaels, managing director of AeroDynamic Advisory and author of the new book, AeroDynamic: Inside the High-Stakes Global Jetliner Ecosystem.

Some companies such as Boeing have doubled down on the sustainment business to drive profit growth, he notes. The founding of Boeing Global Services in 2017, in fact, came with a goal to triple aftermarket revenues. So Boeing’s $14 billion sustainment and services business in 2016 would become a $50 billion colossus by 2025. Boeing appears to have no strategic interest in backing off from that strategy.

Even if Boeing or its competitors agreed to heed Roper’s invitation, such a move could reverse the same incentives the Air Force and other aerospace industry customers now rely on for key programs, Michaels says.

The promise of the financial rewards over a long sustainment phase drives companies to introduce expensive new innovations, counting on cash flow in the aftermarket phase to close the business case for the upfront investment during the design and development stages. Michaels cites Boeing’s $9.2 billion bid for the T-X contract as an example: The Air Force originally budgeted $19 billion to buy 351 aircraft and about 40 simulators, but Boeing offered the service $10 billion less to deliver up to 475 aircraft and more than 120 simulators.

Breaking that model is a risk that Roper seems willing to consider. In making his case at the McAleese event, Roper described another, intangible benefit of his preferred model. “We’ve got to make the shift to get the industry back into development. And that means finding a way to pivot from where we are today to a place that really incentivizes it—to hand us the reins of sustainment and get back into cutting-edge design,” Roper said. “What is driving a lot of engineers into aerospace is building new things. What a shame that many engineers only have one airplane on their resume. Are we going to win, are we going to compete that way? No way.”

Competition is Roper’s main concern. It echoes the theme of the National Defense Strategy unveiled by the Pentagon in 2018, which calls for resetting the military’s focus on preparing for war with China and Russia over the next decade. The objective is not to instigate a military conflict but...
to prevent one by demonstrating technological dominance. As the acquisition program for the Air Force’s next tactical aircraft, NGAD is the aerial centerpiece of the new strategy. Some have likened NGAD’s classified objective as fielding a “sixth-generation fighter” in the 2030s. But Roper has adopted a skeptical view of such an approach, saying that any attempt to predict the threat environment in 2030 is doomed by technological surprise.

“Is artificial intelligence going to come out not out of left field but out of center field and completely be the juggernaut that people think? Maybe,” Roper said. “We have to be ready for that. But there are other things we don't tend to think about in defense, like synthetic biology. What about ubiquitous sensing—not being able to hide because there are so many sensors out there? There are lots of wild cards. A whole deck of them. We don't know what hand we're going to be dealt.”

Instead, he prefers to craft an acquisition strategy that delivers a steady stream of air dominance capabilities every few years. The goal of this “capability pipeline,” Roper said, is to force adversaries such as China to react to the U.S. military, rather than the opposite.

“If our adversaries knew that we could produce a new option to go into some level of production and do that on an every-four-year basis . . . [they’d] be reacting to us. [They’d] be having to think of where we're going,” Roper said.

But that approach could depend on reorienting the defense industry’s largest OEMs to focus on design, development and production, he added.

“I'm pretty confident that if we had a more responsive, reactive acquisition system that's constantly pushing out new things, we'd be in a much better posture to deal with whatever that wild card is than presuming we could predict it,” Roper said. “I want our defense industry base to get back to where design is happening all the time and where engineers have 10 aircraft or 10 satellites on their resumes.”

As the stream of next-generation aircraft is delivered, the Air Force’s goal is make the sustainment and modernization phase competitive. Rather than allowing the OEM to control the intellectual property throughout the life cycle of an aircraft, the Air Force would make contracts for upgrades and repairs part of a bidding process. In Roper’s view, this approach also would incentivize the industry to use open-architecture software.

“If we can find that incentive structure, maybe building an open system wouldn't be so difficult anymore,” Roper said. “Because I know when we ask for open [architecture] that there's not a good business case.”

The industry’s reaction to the Air Force’s vision for future sustainment will come out at the closed-door event at the end of April. For now, Roper is optimistic that such a strategy could be embraced. “Hopefully, April 26 will be a good day of great ideas that will start a pivot for the brave companies that come by,” he said.
Delta’s Renewal

Delta TechOps is in growth mode—from a capabilities and revenue standpoint

Lee Ann Shay Atlanta

“W e’re just getting going,” said Delta Air Lines’ top executive at the grand opening of the company’s new 150,000-lb.-thrust test cell in February. CEO Ed Bastian’s message is a nod to several of Delta’s initiatives—from the new test cell, the world’s largest, to its airline fleet renewal to investments in Delta TechOps intended to take it to $1 billion in annual revenue in a few years. It is about the transformation underway at Delta as it adds next-gen aircraft and engines to its own fleet—while leveraging that to add next-gen capabilities to its MRO division to take it into the future.

The $100 million test cell investment is a “vote of confidence in Delta TechOps,” doubling its previous 68,000-lb.-thrust capability maximum, and is built to accommodate engines not even designed yet, says Bastian. As a point of reference, the highest-thrust commercial engine, the GE90, which powers Delta’s Boeing 777-200LR fleet, produces 115,000 lb. thrust.

In addition to the test cell, in August 2018, Delta cut the ribbon for a 127,000-ft.² engine shop—about the size of 2.5 football fields—that will accommodate the new Rolls-Royce XWB and Trent 7000 that power the airline’s fleet of Airbus A350s and A330-900neos. It inducted the first engine, a Trent 1000 from Virgin Atlantic, in October.

This engine shop and the 150,000-lb.-thrust test cell played an important role in Delta expanding into next-gen engine MRO capabilities and gaining 30-year contracts from Rolls-Royce and Pratt & Whitney for their latest engines in the Americas.

Delta’s new engine shop is the size of 2.5 football fields.

In late 2018, Delta become a Rolls-Royce authorized maintenance center for the Trent 1000, which is one of the engines powering the Boeing 787 and provides 53,000-75,000 lb. thrust; the Trent 7000, which powers the Airbus A330neo and delivers 68,000-72,000 lb. thrust; and the Trent XWB that powers the A350 and produces 75,000-97,000 lb. thrust. It also services the BR715 under the agreement.

Delta TechOps will also support Pratt & Whitney’s geared turbofan (GTF) engine family as part of the OEM’s MRO network and expects to repair or overhaul more than 5,000 GTFs. Delta Air Lines selected the PW1500G and PW1100G to power its Airbus A220s and its A321neos on order.

Another key piece of Delta’s engine aftermarket investments is its hot-section engine repair shop that will enable it to perform those repairs in-house—including coatings and brazeings—which saves time and money, say its executives. It started with PW2000 capability first and is adding CFM56 capability next.

This all feeds into Delta TechOps’ goal of $1 billion in annual revenue “in the very near term,” says Jack Arehart, Delta TechOps president of MRO Services. In 2018, that figure was $700 million, and this year it is $800 million. Besides the additional revenue from its new engine shop and test cell, Arehart says TechOps is also increasing its repair capabilities for Airbus components.

“For years, we’ve been able to do about 70% of Boeing components in-house, and we’re moving close to 50% of the components on Airbus, and we’ll keep growing that,” he says.

Delta TechOps is in growth mode—from a capabilities and revenue standpoint.

AviationWeek.com/mro
Global MRO

Some of the key aftermarket trends throughout the world under the microscope

James Pozzi London

NORTH AMERICA

- Airline MROs are adding capacity. Delta TechOps opened a new 150,000-lb.-thrust test cell for the Rolls-Royce Trent 1000 engine in Atlanta—the world’s largest facility of this type. United Airlines and Southwest Airlines are planning to open new hangars in Los Angeles and Houston, respectively, for their maintenance operations.
- MROs are on the hunt for experienced workers, and wages for certain roles are rising. Avionics technicians are in high demand, as are mechanics experienced with electrical and software systems.
- MROs and OEMs are attracted to the U.S. outsourcing market, with many airlines still preferring to outsource. In the summer of 2018, FAA Form 41 data revealed that the top 10 U.S. passenger airlines increased outsourced maintenance spending 1%, to 48% of all MRO spending in 2017.
- With FAA’s ADS-B equipage deadline of Jan. 1, 2020, MROs are adding modifications services.
- The North America aftermarket, encompassing the U.S., Canada and Mexico, is set to generate $187.6 billion in MRO spending in 2019-28.

AFRICA

- Some of the continent’s most prominent airlines are struggling. Cash-strapped low-cost carrier Fastjet has extended some of its loan agreements to later in 2019, while regional airline SA Express received 1.1 billion Rand ($96 million) in government support to remain in operation.
- According to Nick Fadugba, general secretary of the African Airlines Association, areas in need of attention include spare parts provisioning, materials management, component maintenance, refurbishment and conversion of aircraft cabin interiors. In some countries, even wheel and brake overhaul and repair capabilities remain a challenge.
- Analysts believe there is room for better cooperation between MROs in Africa, which could lead to the emergence of MRO centers of excellence in specific areas to avoid wasteful duplication.

LATIN AMERICA

- The expanding middle class is driving airline growth, and MRO growth should follow.
- Many carriers think onboard internet connectivity is becoming necessary to compete.
- The Mexican government’s decision to cancel the new (but partly built) Mexico City International Airport has left airlines and MROs serving the metropolis in limbo. The new airport was intended to become a major hub for the continent.
- Airlines and MROs—from Aeroman in El Salvador to Copa Airlines in Panama—have set up maintenance schools producing hundreds of new mechanics. Others closely collaborate with local technical schools and universities to develop talent.

Across the globe, both independent MRO providers and those affiliated with airlines are expanding their capabilities and offerings. Although the fastest expansion is occurring in the emerging markets of the Asia-Pacific region and Latin America, mature markets of North America and Europe still account for the largest share of MRO spending globally. In all regions, new technologies—including predictive analytics, AI and blockchain—promise to reduce costs while enabling improved maintenance options for airlines. Here is a summary of the worldwide trends.
**EUROPE**

- MRO consolidation is occurring due to a combination of acquisitions and liquidations. In the past few months, Magnetic MRO acquired Dutch line maintenance provider Direct Maintenance, while the U.K.’s Monarch Aircraft Engineering went out of business.
- Capacity constraints on engines old and new are still challenging the engine repair segment, but repair specialists are targeting greater efficiencies in the management of their shops to address the issue.
- Regulatory agencies are making contingency plans for the U.K.’s possible exit from the European Union, although it is not clear yet how much tougher any Brexit—hard, soft or delayed—will make cross-border regulatory collaboration.
- Joint ventures in Eastern Europe, with favorable access to skilled labor and lower costs, are continuing to be established by MROs such as Lufthansa Technik.
- Airbus canceled the A380 program in January, but heavy checks are predicted to be steady over the next decade. Despite some of the megatransports being offloaded by carriers, many industry analysts do not foresee a strong secondary A380 market developing.

**ASIA-PACIFIC**

- Several airlines or airline-affiliated MROs are looking at expanding their in-house maintenance capabilities or facilities, including AirAsia, Malaysian Airlines and Gameco. Independent MROs, including GMF AeroAsia and Sapura Technics, are also expanding.
- There is great market potential for inflight connectivity on aircraft fleets in the Asia-Pacific region, with connectivity specialist Inmarsat estimating penetration of only 20% in the region.
- Repair services for new engine types are beginning. In early 2019, Pratt & Whitney added MRO capability for its geared turbofan PW100G-JM at its Eagle Services Asia facility in Singapore.
- Use of drones for aircraft inspections in hangars is expanding.

**MIDDLE EAST**

- MRO investment continues to pour into Saudi Arabia and the United Arab Emirates, with the recent moderation of oil prices contributing to delayed retirements of older, less efficient aircraft, increasing maintenance demand.
- With several high-profile airline bankruptcies in Europe in recent years, MROs in the UAE are increasingly looking to the continent to source technical talent. However, in the long-term, training people in-house is still the preferred option, with Etihad and Emirates setting up their own Part 147 training schools.
- Broader component repair capabilities and logistics support has continued building up in Dubai, as seen in recent times with foreign companies like UTAS and Lufthansa Technik Dubai.
- New technologies such as blockchain continue to pique interest from MROs in the Middle East and elsewhere.
- Despite difficulties for lessors setting up their main hubs in Dubai, hampering any ambitions they have of rivalling Ireland and Singapore, the Gulf city is likely to see its status as a leasing location grow in the coming years.

**CHINA**

- One major challenge for Chinese airlines lies in procuring quality components on time from suppliers, says Yongdong Hu, head of Satair sales and support in China. Reasons for this include low stocks or long lead times, geographic distances, different time zones, complicated logistics and communication with foreign suppliers.
- Industry analysts note that MRO infrastructure development in mainland China has not been able to keep up with recent growth.
- China’s ambitious play in the aviation leasing segment is expected to continue over the next two decades, but challenges around expertise remain.
- The Civil Aviation Administration of China (CAAC) is seeking to improve airworthiness certification capacity and develop a high-quality certification system. The regulator has outlined improvements in project management, working modes, personnel training, legal and regulatory frameworks, system layout and incentive mechanisms.

**INDIA**

- The Indian government, which estimates that around 90% of MRO for Indian airlines is outsourced to other countries, has set an ambitious goal of reversing that, having 90% of the work being carried out in India.
- However, some industry figures believe India’s current tax system—considered less favorable for the MRO industry than that of other countries, is counterproductive in achieving that target.
- According to Aviation Week’s MRO and Fleet Forecast data, India will see the world’s highest aircraft fleet growth. The forecast projects a compound annual growth rate of 10.4% until 2028, with aftermarket demand of $23.8 billion over the same period.
Malaysian Moves
Malaysia’s big players target new MRO opportunities

Some of Malaysia’s major airlines and maintenance providers are looking to expand their MRO capabilities, which could support government aims to fast-track the development of the country’s aerospace industry.

Malaysia Airlines is considering relaunching itself into the third-party heavy maintenance market, while Sepang Aircraft Engineering is also studying whether to expand facilities and its scope of work. Meanwhile, low-cost carrier giant AirAsia is planning to make its first foray into heavy maintenance in either Malaysia or Thailand. The three companies discussed their strategies on the sidelines of Aviation Week’s MRO Southeast Asia conference on March 6-7.

The Malaysian government has established a goal for the country to become the top aerospace nation in Southeast Asia by 2030 and has developed and refined its Malaysia Aerospace Industry Blueprint to help achieve that objective.

One of the plan’s aims is for the local MRO industry to capture 5% of the global market share by 2030 and for local companies to account for a 3.5% share of the engineering and design services market. Other goals pertain to aerospace parts and component manufacturing, and systems integration.

Like other Asian countries, Malaysia sees itself well-positioned to take advantage of projected demand growth. About 40% of commercial aircraft deliveries are expected to go to Asia-Pacific airlines over the next two decades, and the commercial fleet in Malaysia is forecast to double in size by 2030. The country has the third-largest fleet in Southeast Asia and is projected to have the second-largest — behind Indonesia — by 2023, according to Frost & Sullivan research.

The national objectives fit well with the goals of Malaysia Airlines’ engineering and maintenance division, which aspires to become one of the biggest MROs in the region. To achieve this, however, it will need to expand beyond maintaining the airline group’s 112 aircraft and start offering third-party MRO services.

While its time frame and the specific services it plans to offer are unclear, Malaysia Airlines has a long-held goal to return to the third-party MRO market. The airline previously did perform heavy maintenance for other carriers, but this stopped when Malaysia Airlines embarked on a major restructuring process in 2014.

The restructuring saw the parent company relaunch as Malaysia Airlines Berhad (MAB). The engineering division closed its facilities at Kuala Lumpur’s older Sultan Abdul Aziz Shah Airport, instead consolidating its operations in two hangars at Kuala Lumpur International Airport (KLIA). There were also large-scale workforce reductions that affected the engineering unit. Since then, MAB’s focus has been on maintaining its own fleet.

However, the company has several factors in its favor when it decides to reenter the third-party market. MAB has excess hangar capacity and a skilled and well-qualified workforce, says Eke Nazri Rahim, head of the airline’s engineering and maintenance division. “With minimum investment, we could embark on third-party work,” he told attendees during the MRO Southeast Asia conference.

Another advantage is that the carrier is one of a few with the capability for Airbus A380 heavy maintenance. MAB opted to handle its own A380 work with a dedicated line at its KLIA facility. It has completed heavy checks on four of its six A380s, with a fifth underway, says Nazri. The two KLIA hangars also house Boeing 737 and A380 lines.

As part of the company’s broader restructuring efforts, MAB Engineering launched its own transformation plan to make it a high-performing organization. Over the last couple of years it has increased its productivity, streamlined processes and made itself more competitive, says Nazri.

Nazri admits “the journey ahead [will be] tough” because the aftermarket sector is very competitive. However, he notes the engineering division has made substantial investments over the past two years and has achieved significant goals.

MAB went live with the AMOS maintenance software system in December, which gives it better day-to-day control of its operations, drives efficiency and lays the groundwork for it to pursue a “big data” strategy. The company also invested in a wheels and brakes shop and expanded its cabin interiors work.

Nazri says Malaysia Airlines’ engineering group hopes to regain its European Aviation Safety Agency (EASA) Part 145 maintenance certification later this year or early 2020. He considers this a prerequisite for starting third-party MRO services.
Malaysia’s big players target new manufacturing, and systems integration, as aerospace parts and component manufacturers. Other goals pertain to local companies to account for a 3.5% share of the engineering and design services market. Other goals pertain to the MRO industry to capture 5% of the global market share by 2030 and for the Malaysian government to establish a goal for the country to become the top aerospace nation on March 6-7.

The Malaysian government has established a goal for the country’s aerospace industry. The three companies discussed their strategies on the sidelines of Aviation Week Americas’ Regional Outlook on Manufacturing and Engineering on March 6-7.

The country has the third-largest fleet in Asia, and the commercial fleet in Malaysia is forecast to double in size by 2030. Malaysia Airlines is considering studying whether to expand facilities in Sepang, Aircraft Engineering is also relaunching itself into the third-party heavy maintenance market, while the biggest MROs in the region. To achieve this, however, it will need to have the second-largest—behind Indonesia—by 2023, according to Frost & Sullivan. Malaysia Airlines has a long-held goal to return to the third-party MRO market. To lay the groundwork for it to pursue a strategy, which aspires to become one of the biggest MROs in the region. The airline previously did perform maintenance in either Malaysia or Thailand. While its timeframe and the specific opportunities are unclear, it now sees itself well-positioned to take advantage of projected demand growth.

One of the plan’s aims is for the local enterprise to achieve that objective. On April 1, 2020, Malaysia Airlines invested in a wheels and brakes shop and maintenance providers are looking to expand their MRO capabilities, which could support governing process in 2014. Malaysia Airlines’ engineering group hopes to regain its strength, which aspires to become one of the top three MROs in Asia by 2023. The engineering division closed its facilities at Kuala Lumpur International Airport (KLIA) in December, 2017, and the engineering and maintenance division moved to Kuala Lumpur’s older Sultan Abdul Aziz Shah Airport, instead consolidating its operations at Kuala Lumpur International Airport (KLIA). MAB opted to handle its own A380 maintenance, repair and overhaul (MRO) services. About 40% of commercial aircraft deliveries are expected to go to Asia-Pacific, and Malaysia sees itself well-positioned to take advantage of this growing demand. MAB’s parent company, Malaysia Airlines Berhad (MAB), has made substantial investments over the past two years and has achieved increased productivity, streamlined processes and made itself more competitive. Over the last couple of years it has increased its productivity, streamlined processes and made itself more competitive. MAB has invested in a wheels and brakes shop and maintenance providers are looking to expand their MRO capabilities, which could support governing process in 2014. Malaysia Airlines’ engineering group hopes to regain its strength, which aspires to become one of the top three MROs in Asia by 2023. MAB’s parent company, Malaysia Airlines Berhad (MAB), has made substantial investments over the past two years and has achieved increased productivity, streamlined processes and made itself more competitive. Over the last couple of years it has increased its productivity, streamlined processes and made itself more competitive.
However, the outlook for MAB Engineering is clouded by uncertainties surrounding the future of the parent company. So far, MAB’s restructuring and recovery plan has not returned it to profit, and the country’s leaders are showing increasing signs of frustration with its progress. MAB is government-owned, through state-backed fund Khazanah. The carrier is preparing a revised recovery plan that will be presented soon, and there have been suggestions the government may consider other alternatives such as selling or shutting down the airline.

Selling off an attractive asset like the engineering operation may also be considered. Other major aerospace companies have previously expressed a desire to establish MRO joint ventures with MAB, so there could be potential buyer interest.

Malaysian MRO provider Sepang Aircraft Engineering (SAE) is also based at KLIA. It has become one of Southeast Asia’s key support facilities for the region’s many low-cost carriers (LCC) operating Airbus aircraft, and it is considering expanding its capabilities to cover new aircraft and types of work.

Currently, the only airframe heavy maintenance work performed by SAE is on narrowbody aircraft. Its largest customer is AirAsia, but other major customers include LCCs Scoot, IndiGo and Jetstar Asia. SAE is now 100% owned by Airbus, and it is in the process of establishing itself as an Airbus center of excellence for A320 work in Asia.

SAE has two hangars at KLIA. One hangar has four narrowbody lines or potentially could have capacity for two widebodies, says SAE Vice President for Commercial To Chow Leah. The second hangar has two narrowbody lines, and SAE also has a dedicated paint hangar. The MRO is studying whether a third hangar could be needed in the long term, although To stresses there is no plan for this yet.

The company could potentially expand into widebody heavy maintenance, says To. SAE is already certified to work on A330s, which is the fleet type operated by AirAsia X. While it does not do C checks or scheduled maintenance on widebodies, SAE does support its customers with some widebody repair work such as composite repair and is conducting modification work on Airbus A380 doors.

SAE’s narrowbody work scope includes airframe heavy maintenance up to 12-year C checks, pilot seat repair, passenger seat refurbishment, aircraft lease-return work, nondestructive testing, composite repair and structural repair. It is an Airbus-approved radome repair facility for all Airbus types in the region. The company is considering going into component repair using its existing hangar facilities, To says.

KLIA is a beneficial location for an MRO base, says To. In addition to its favorable geographical position, it has a broad range of international flights and good cargo handling infrastructure. The airport has three runways and no curfew.

SAE’s work intake has been healthy in 2019, and it is anticipated to remain...
strong for the next few years, To says. However, it still has capacity for new customers.

Meanwhile, AirAsia is assessing whether to set up a heavy maintenance operation to accommodate its fleet growth plans, and if so, where such a facility would be located. It is seriously considering basing it in Malaysia or Thailand.

While the LCC is yet to make a decision, it does want to handle some of its own base maintenance needs in the future, says Nantha Kumar, AirAsia’s head of group aircraft engineering.

AirAsia currently outsources all of its heavy maintenance to a range of providers such as SAE. Kumar stresses that AirAsia will continue to work with these providers, as the carrier will have an increasing MRO requirement that can be addressed with both insourced and outsourced work. It is still too early to say how the additional work would be divided between existing suppliers and AirAsia, says Kumar. SAE’s To notes that this development has been announced only recently, and the company will review its implications.

There is no specific time line for AirAsia deciding about the heavy maintenance facility, although the group’s senior leadership envisages beginning operations within two years of making a decision, Kumar says. AirAsia will review whether “it makes business sense for us to invest” in an MRO facility.

Any such operation would work for AirAsia and its various overseas affiliates as well as widebody operator AirAsia X. The scope would potentially include airframe work up to C checks, wheels and brakes and composite repair, but not engine work or components. While AirAsia would primarily focus on its own fleet, there may be opportunities for third-party work in the long term, says Kumar.

The new facility would likely start with one hangar and at least two or three lines, Kumar says. The carrier would consider establishing a partnership or joint venture with an existing MRO provider.

AirAsia is interested in becoming one of the MRO providers in a new aerospace development in U-Tapao, Thailand, and group CEO Tony Fernandes last year said AirAsia wanted to open a facility there. However, there is still much uncertainty about how the Thai government selection process will work and what incentives may be offered.

This will be one of the factors in determining the timing of AirAsia’s decision about whether to proceed with heavy maintenance and where it will be located, Kumar says. Once more details about U-Tapao are known, AirAsia can conduct a review and determine if the business case makes sense.

If the carrier decides to establish an MRO base in Malaysia instead, it would be located either in Kuala Lumpur or in another part of the country. AirAsia’s main hub is at KLIA, and its major MRO provider SAE is also based there. However, various Malaysian state governments have been engaging with AirAsia to try to secure the MRO facility for their airports.
South Korea’s New Players
Startups, aircraft orders boost country’s LCCs

Adrian Schofield Seoul and Auckland

South Korea’s low-cost carrier (LCC) sector is primed for a fresh wave of growth, with the government approving new entrants and some existing LCCs planning major fleet expansions.

The looming increase in competition will complicate what is an already heavily contested LCC market. The new players will present challenges for full-service legacy carriers Korean Air and Asiana Airlines, and also for the six-largest incumbent LCCs in South Korea.

As in other markets, LCCs in South Korea believe there is still potential for growth, as they can stimulate new demand as well as capture traffic from foreign and domestic competitors. However, it appears the South Korean LCC sector is gathering enough critical mass that it could be ripe for some consolidation in the near future.

The existing LCC players include Jin Air, owned by Korean Air, and Air Busan and Air Seoul, both owned by Asiana. Jeju Air is an independent operator, and the others are Eastar Jet and T’Way Air. These six have a combined fleet of about 140 aircraft. They account for 46.2% of international and domestic capacity for all South Korea-based carriers, according to data from the CAPA Center for Aviation, an Aviation Week Network Service (see chart).

South Korea’s ministry of land, infrastructure and transport (MOLIT) on March 5 granted approval for three new LCCs to enter service. MOLIT was considering four passenger LCCs and one cargo carrier in the latest round of airline license applications. The successful carriers were Aero K, Air Premia and Fly Gangwon. The unsuccessful applicants were Air Philip and a cargo LCC that was to be operated by Guardians Airline.

The South Korean government has been reluctant to allow new startups in recent years due to concerns about congestion and excess competition. Two of the airlines—Aero K and Fly Gangwon—applied in 2017 but were rejected. They reapplied in November, after the government reviewed its criteria and accepted new proposals.

MOLIT examined the applicants’ business plans and financial backing to determine their viability. The ministry stressed that the additional LCCs will create jobs, reduce fares and boost some regional airports. Having been granted business licenses by MOLIT, the three airlines can now begin the process of obtaining air operators’ certificates (AOC). They are required to begin service within two years.

Aero K will be based in Cheongju, a city near the center of South Korea. Although Cheongju is served by other airlines, none is currently based there. The airline hopes to gain its AOC in time to launch service by the end of this year; the airline’s representative director, Mike Kang, told Aviation Week recently. He said Aero K intends to begin with three Airbus A320s, adding more leased aircraft in 2020. The airline has a total of eight firm orders for Airbus A320s. Initial destinations are expected to be in Japan, China and Vietnam.

Air Premia will be based at Seoul Incheon International Airport. The carrier intends to serve mid-to-long-range routes using Boeing 787-9s. Air Premia says it is targeting operational launch in September 2020, with its first long-haul route in 2021. The initial long-haul destinations could include Los Angeles or San Jose, California, with Honolulu and Vancouver also high on its priority list.

The carrier plans to launch with three 787-9s and then add up to two aircraft a year. This would allow Air Premia’s fleet to reach 10 aircraft within five years, the carrier says. It intends to configure its 787-9s with two classes: economy and premium economy.

Fly Gangwon will be based in Yangyang, in the northeast region of South Korea. It will operate Boeing 737-800s, and will initially target routes to China, Japan and the Philippines, according to MOLIT.

Of the incumbent LCCs, Jeju has the most ambitious growth aspirations. The carrier ordered 40 737-8s in 2017, with options for another 10. They are due for delivery in 2022-26, but some may be exchanged for 737-10s.

In placing this order, Jeju acknowledged that the short-haul LCC market is already congested. The carrier says there are limited new market opportunities within range of its current fleet of 737-800s, but it notes it can fly 650 nm farther with the 737-8s it has ordered. Jeju has indicated it could potentially use these aircraft to target Singapore, Bali and Indonesia, as well as other destinations in Thailand, Malaysia and Indonesia.

South Korea Airline Market Share

<table>
<thead>
<tr>
<th>Airline</th>
<th>Seat Capacity</th>
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<tbody>
<tr>
<td>Air Seoul</td>
<td>26%</td>
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<tr>
<td>Eastar Jet</td>
<td>8%</td>
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<tr>
<td>Air Busan</td>
<td>13%</td>
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<tr>
<td>T’Way Air</td>
<td>20%</td>
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<tr>
<td>Jin Air</td>
<td>12%</td>
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<tr>
<td>Jeju Air</td>
<td>16%</td>
</tr>
<tr>
<td>Korean Air</td>
<td>32%</td>
</tr>
<tr>
<td>Asiana Airlines</td>
<td>21%</td>
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Source: CAPA

Seat capacity for the week of March 18, South Korean carriers only.

The successful carriers were Aero K, Air Premia and Fly Gangwon. The unsuccessful applicants were Air Philip and a cargo LCC that was to be operated by Guardians Airline.

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Eastar Jet is also basing its growth plans on the 737 MAX. It operates two 737-8s as well as 19 737NGs, and has four more -8s on order. However, like other carriers it has had to ground its MAX aircraft while accident investigations continue.

Jin Air is South Korea’s second-largest LCC by capacity after Jeju. The carrier’s fleet is primarily based on 21 737-800s, but it also operates four 777-200ERs. It has grown its fleet with 737s and 777s transferred from parent Korean Air.

Jin Air’s short-term growth has been halted due to restrictions imposed by the Korean government, though. These stem from revelations that a former Jin Air board member was a U.S. citizen, which is not allowed under South Korean regulations. The board member in question was Cho Hyun-min, who is the daughter of Korean Air Chairman Cho Yang-ho.

MOLIT held hearings to consider what action to take against Jin Air, which could have included revoking its license. However, the ministry decided instead to prevent the airline from registering new routes or aircraft for an undetermined period of time. Jin Air committed to strengthening its corporate culture and making improvements in other areas.

Korean Air says these restrictions remain in place, although the airline notes that Jin Air has “already fulfilled the ministry’s recommendations to improve leadership culture and management process.” The ministry is expected to decide whether to remove the constraints after evaluating the airline. Jin Air will not confirm its fleet plans until after the growth restrictions have been removed, the airline says.

Korean Air has 737 MAX and A321neo narrowbodies on order, which will be used to replace aging 737NGs, and these are due to begin arriving this year. However, it is too early to tell if any of these will go to Jin Air, according to the parent airline.

The leading M&A advisor to business owners within the aerospace aftermarket

Our Recent Aftermarket Transactions

<table>
<thead>
<tr>
<th>Company</th>
<th>Description</th>
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<tbody>
<tr>
<td>STS Aviation Group</td>
<td>Equity Investment from Greenbriar Equity Group LLC</td>
</tr>
<tr>
<td>PrimeFlight</td>
<td>Has been acquired by The Carlyle Group</td>
</tr>
<tr>
<td>DAS</td>
<td>Has been acquired by WestStar Aviation</td>
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<tr>
<td>A Portfolio Company of GenCap America</td>
<td>Has been acquired by Holder Family Investments</td>
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Retirements of large commercial aircraft slowed dramatically in 2018, leaving fewer units parked in desert holding stations and triggering both positive side effects and issues of concern, financial analysts observe in recent reports.

On the plus side, manufacturers who have emphasized aftermarket work in their business portfolios continue to enjoy an updraft, the analysts note. On the other hand, with airlines retaining aircraft longer than before, the potential for new-order deferrals could rise this year.

Jefferies counts 64 Boeing 757s among the parked fleet, including these with Delta livery parked in Marana, Arizona, in 2016.

At the end of January 2019, there were 1,186 parked aircraft, about 5.5% of the total fleet, according to Jefferies. “This is down from 6.7% a year ago, and well below the average for the parked stock for the past 20 years,” they said.

While 1,186 may sound like a lot of unused aircraft, that number is deceiving for a few reasons. For one, 16% of the parked fleet is lessor-owned, up from 9% a decade ago, according to Jefferies.

Another important factor is that “the majority of the parked fleet is unlikely to be brought back into service,” they suggest. The parked fleet is 69% narrowbody and 31% widebody. This accounts for 5% and 8% of the active fleet for narrowbody and widebody aircraft, Jefferies says.

“One of the reasons for minimal availability of narrowbody aircraft may be timing on the [ramp-up] of the [Boeing] 737 MAX and [Airbus] A320neo, as airlines may extend leases for a short while as their aircraft are delivered,” Jefferies explains.

Of the parked fleet, Jefferies counts 250 Boeing 737 classics, 158 McDonnell Douglas MD-80s, 64 Boeing 757s and 66 Airbus A340s. Only 501 aircraft from the parked fleet are in-production models, including 166 widebodies. What is more, Jefferies counted 67 Boeing 777s.

As to why airlines are keeping more of their older airliners, results of a UBS survey issued Jan. 30 said it was due to above-average commercial air passenger traffic growth, which is not expected to drop off significantly.

“Retirement planning is generally unchanged,” UBS notes, citing survey results in which 59% of airline executives asked said they did not plan to accelerate retirement of older aircraft over the next 6-12 months, about the same percentage of respondents in a survey last August. “While oil prices modestly climbed through the first nine months of 2018, strong traffic helped keep planes in the fleet, and the year-end fall in oil prices is also likely contributing to the lack of change,” UBS points out.

Jefferies analysts say retirements will average 2.3% over the next five years.

However, one knock-on effect worth watching this year is a potential change in airline thinking about the deferral of deliveries. According to the UBS survey, 51% of respondents are looking to defer deliveries of ordered aircraft, up from 34% in the August survey.

While manufacturers certainly would prefer not to see an unusual degree of deferrals arise, they may be satiated by better aftermarket sales that stem from supporting all the older aircraft still flying. The projected aerospace OEM and defense aftermarket growth is 4-6%, according to VRP.

“Age continues to rise for narrowbody, widebody and regional jets, while for turboprops it is declining,” says Stuart Hatcher, chief operating officer at independent aviation advisor IBA. “Demand for parts to maintain this aging fleet will grow, particularly engines which remain in very high demand. Operators will find more cost-effective solutions to maintain their fleets and refrain from taking on the operational risk and higher ownership costs of new technology.”

Others concur: “We do expect retirements to increase, but as long as fuel remains low, and traffic holds up, we believe the use of mature assets will hold up, which is a positive for aftermarket growth,” Canaccord Genuity analysts said Jan. 1.
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Dassault Aviation’s acquisition of two major maintenance networks in business aviation signals a strategic shift to capture more of the revenue its Falcons generate over their service lives. A business aircraft may be in service for 25-30 years. While sales of new business aircraft remain slow, growth prospects for maintenance, repair and overhaul activities appear much more attractive. The expected income may fuel research and development in the context of fierce competition with Bombardier and Gulfstream.

MRO services for turbine-powered business aircraft will total $14 billion in 2025, thanks to average annual growth of 2%, according to New York-based consultancy Oliver Wyman. That is faster than the expected annual 1.4% growth of the global fleet. MRO activities are so regulated that forecasts are generally much more solid than those for new-aircraft sales.

To secure revenues, Dassault—like other airframers—offers a “pay-as-you-fly” program, which the Paris-based company has branded Falcon Care. Such worry-free arrangements are proving popular with customers. The airframer takes a comfortable profit margin, notes Jerome Bouchard, aerospace partner at Oliver Wyman.

Not only does MRO bring an increased turnover with high margins, it also provides valuable data. Learning how the customer uses his or her aircraft could help salespeople make a more attractive offer for a new Falcon. Bringing Falcon aircraft maintenance into a company-owned network helps to control quality and “directly manage the customer relationship over the entire maintenance life cycle of our aircraft,” says Dassault Chairman and CEO Eric Trappier.

Company engineers are likely feeling confident about customer support. After almost two decades, Dassault’s support services are recognized as among the best in the industry.

The company announced its takeover of ExecuJet’s worldwide maintenance activities (from Luxaviation) in January. In February, it acquired TAG Aviation’s European maintenance activities, which expands the share of Falcon maintenance controlled by Dassault. The existing company network has sites in Europe (including Russia), the U.S. and, to a lesser extent, Africa and South America. The recent acquisitions extend the company’s footprint to the Middle East and Asia-Pacific and boost European and African coverage.

Increased revenue from expanded MRO services may help Dassault maintain R&D spending at a high level after years of slow sales (a record-low 41 deliveries was posted last year).

For decades, the company has striven to stay at the forefront of business-aviation technology. Its FalconEye combined-vision system is the first head-up display to blend synthetic terrain-imaging with actual thermal and low-light camera images for enhanced situational awareness. Development of the large-cabin, 5,500-nm-range Falcon 6X, set for entry into service in 2022, is in full swing. And a step change is planned in its use of big data analytics. The Falcon 6X will offer a much more powerful means of collecting and processing data, with real-time transmission to the ground multiplied by 1,000. “Big data is key to offering new services,” says Trappier.

The airframer is simultaneously gearing up for the launch of a new design. No details are available, but Dassault’s recent research work—in aerodynamics, composite materials and fuel cells—suggests significant technology advances. Such projects require hefty funding. Instead of seeing R&D expenditure as having to be amortized on a given number of aircraft sales, the calculation may now also factor in after-sales revenue.

ExecuJet and TAG’s brands will eventually be replaced with the Dassault name, says Trappier. Aircraft from other manufacturers will still be serviced, he notes. TAG specializes in the Dassault and Bombardier product lines.
Inside MRO38

Source: Dassault Aviation

Thierry Dubois

Paris

focus on after-sales revenue

Aftermarket Updraft

based company has branded Falcon you-fly” program, which the Paris-

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unmatched product knowledge and peace of mind. With as much as 50% higher residual value*, it’s easy to see how our TRUEngine program helps to protect your overall investment.

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The continued forecast growth in air cargo traffic is spiking interest in both narrowbody and widebody main-deck freighters, with retired passenger jets prime candidates for cargo conversions. In the medium freighter segment, the focus appears to be on the Boeing 767.

“With an increasing number of 767-300ERs being phased out of passenger service, a strong supply of feedstock for cargo conversions is becoming available,” says Ken Herbert, managing director of Canaccord Genuity in San Francisco. “In fact, the air cargo carriers have emerged as the largest market for retired passenger 767s, starting with the overall resurgence of air freight shipments in 2017.”

He cites the 767-300ER as the leading candidate for freighter conversion in the medium class, given both its regional and international range capability. “The 767-300ER occupies a very special niche in the air freighter market because it fits nicely between large freighters, such as the 747-400 and 777-300F, and the narrowbody 737 Classic and 737 NG—many of which are also being converted to freighters,” he says.

Herbert reports that since the 767-300ER remains in production as a freighter, and now a military tanker, the converted older models will continue to benefit from an active and competitive supply chain and good parts availability.

Stephen Fortune, principal of Fortune Aviation Services, a commercial aircraft consultancy, reports that in both 2017 and 2018, 24 passenger 767s were reconfigured as cargo carriers—up from 14 767s in 2016. “Based on market demand, I would estimate another 12-15 767 conversions for 2019,” says Fortune, citing data from Ascend.

As a medium-size freighter, the 767 competes with the Airbus A330-200 and -300 and, to a lesser extent, the A300-600. “Today, the 767-300ER, specifically, is becoming the regional widebody market leader, with over 100 aircraft in service and almost 400 remaining in passenger service, which are potential conversion candidates,” notes Fortune.

Asked if the new-production 767-300ER freighters are serious competitors with the converted models, Fortune concedes that there has, in fact, been a substantial increase in demand for the newly built freighters over the past five years—largely driven by FedEx and UPS.

“FedEx is largely responsible for keeping the 767-300 freighter production line going,” he says. “Although there is still considerable feedstock of passenger 767s, new freighters offer greater reliability and, of course, the maintenance honeymoon. Companies like FedEx and UPS, which offer a premium service, prefer the reliability of new aircraft and are willing to pay for it.” In June 2018, Boeing announced an order for 24 freighters from FedEx, including 12 767s and 12 777s.

At the same time, Fortune raises one cautionary note with respect to freighter conversions. “There is a severe shortage of ‘green time’ CF6-80C2 engines. When you look at the 767 conversion market and other programs, that’s the biggest headache right now.”

Scott Brensike, GE Aviation’s CF6 product line general manager, acknowledges that the supply of used serviceable material (USM) for the CF6-80C2 is being affected by both high demand and delayed retirement of older fleets.

“The strong demand for CF6-powered aircraft has led to a somewhat paradoxical situation: The longer the engines stay in service, the fewer used engine parts are available. Used serviceable material contributes to mature fleet cost savings; but USM availability, including life-limited parts, is dependent to a certain degree on engine retirements,” he explains.

For cargo carriers looking for comparatively inexpensive aircraft, however, the used-767 market continues to boom. Rich Corrado, chief operating officer of Wilmington, Ohio-based Air Transport Services Group (ATSG), reports that a converted 767 freighter averages about $28 million—on the ramp—compared to a new-production model at two to three times that cost. “On the operational side, a new freighter provides better fuel burn because you’re getting new engines. Plus there’s the maintenance holiday,” he says. “But even with a converted 767, you’re looking at an aircraft that averages about 98.5% dispatch reliability.”

Corrado says ATSG is the world’s largest lessor of converted 767 freighters, with 68 in its portfolio as of year-end 2018. These included 34 767-300s and 34 767-200s. Through ATSG’s leasing subsidiary, Cargo Aircraft Management, 58 are dry-leased to external customers globally, while the remainder
are leased to ATSG’s wholly owned air cargo carriers, specifically ABX Air and Air Transport International. Corrado notes that 67 of those aircraft were converted to freighters by Israel Aerospace Industries’ Bedek Aviation Group, under its 767-300 BDSF program, with the remaining models converted by a company he says is no longer in that business. Another five former passenger 767-300s were being converted by Bedek at the end of 2018 for delivery this year.

ATSG continues to expand its 767 freighter fleet, announcing last December its intent to acquire 20 767-300s being retired by American Airlines. Delivery of those aircraft by Bedek in a cargo configuration will occur in 2019-21.

ATSG’s expanded 767 freighter fleet is largely attributable to Amazon’s growth; 20 are leased from the ATSG fleet by the retail distribution giant under an aircraft plus crew, maintenance and insurance (ACMI) contract, plus a separate agreement covering flying services. Amazon has committed to another five aircraft this year and five more in 2020.

The procurement process used by ATSG for the 767-300 involves multifaceted due diligence, starting with a preference for purchase of an entire fleet from a single operator where possible.

“The aircraft’s pedigree—its maintenance history—is very important. Many aviation authorities want to see as few owners as possible, because there is generally greater stability in terms of maintenance,” he explains. “In addition to the number of operators, where it was flown and how it was flown, we want to be sure that the airframe is upgradable to its highest available maximum takeoff weight, as well as the green time remaining on the engine and the level of sophistication with the avionics. All of this determines what we think the aircraft is worth and what we are willing to pay for it.”

While Corrado agrees with other industry observers who estimate the 767-300 feedstock at a couple of hundred, that does not mean they will all become available for freighter conversions tomorrow.

“One of the reasons for the available 767 feedstock was production delays with the Boeing 787. That kept the 767-300 in service a lot longer, and because of this, the airlines continued to maintain them well,” he remarks. “The real question is how much longer the airlines will hold onto them.”

Kin Chong, executive vice president of the business coordination division of Evergreen Aviation Technologies (EGAT) in Taiwan, is optimistic that used 767s will continue flowing through the cargo conversion pipeline.

“As more replacement airframes such as Boeing 787s and Airbus A350s are delivered to airlines currently operating 767-300ER passenger jets, used 767s more than a decade old will increasingly be released into the secondary market to become feedstock for conversions,” he says.

Chong reports that integrated freight operators, airlines with independent cargo operational units and leasing companies are “the observed buyers” of widebody conversions. To date, EGAT has performed seven 767 conversions at its hangar near Taipei under the 767 Boeing Converted Freighter (BCF) supplemental type certificate (STC).

“The 767 converted freighter is the best widebody airframe and most adept to meet the current market demands, especially in the Asia-Pacific region,” says Chong. “Demand is being driven by burgeoning intraregional e-commerce growth, an increasing appetite for imported perishables and high-value, time-sensitive-to-market consumer products due to a mushrooming middle class.”

Boeing chose not to talk about specific regional market opportunities for the 767 BCF program, citing the ongoing investigation into the crash of an Atlas Air 767 converted freighter near Houston in February.

For MROs with widebody airframe expertise, freighter 767 conversions could continue to assure a revenue stream.

“For the year ahead, we anticipate approximately 100 767 maintenance visits, of which 80% will be freighters,” says Greg Colgan, CEO of MRO Holdings, which performs 767 maintenance and modifications at its Flightstar facility in Jacksonville, Florida. “We anticipate an increase of 767 volume at Flightstar, and as a result we are evaluating capacity [for that aircraft] at our sister facilities—Aeroman in El Salvador and TechOps Mexico.” The company is well into its own market study on the 767 and sees increasing demand for shop capacity as the fleet transitions from passenger to freighter.

**FREIGHTER OUTLOOK**

The Boeing World Air Cargo Forecast for 2018-37 estimates 2,650 freighters will be delivered over the next 20 years, of which 63% will be freighter conversions. Taking aircraft retirements into account, the forecast predicts a total freighter fleet by 2037 of 3,260, with the medium-size group totaling 1,150, nearly double its size of 620 in 2017, when the total freighter fleet numbered 1,870. 

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### New and Converted Freighters Forecast, 2018-37

<table>
<thead>
<tr>
<th>Year</th>
<th>Current/Retained Fleet</th>
<th>New Freighters</th>
<th>Converted Freighters</th>
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<tr>
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<td>980</td>
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<td>2037</td>
<td>1,870</td>
<td>2,500</td>
<td>3,260</td>
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*Source: Boeing World Air Cargo Forecast 2018-37*
**CF6 Redux**

Low fuel costs and high cargo volumes are driving MRO for the GE CF6 engine

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

As high-volume shippers continue to snap up cargo pallet space on widebody freighters, MRO demand for the engines powering those aircraft is significant. That is particularly true of GE Aviation's CF6 family, a leader in widebody propulsion, with more than 10,000 engines produced through year-end 2018 since the CF6-6 entered service on the McDonnell Douglas DC-10 in 1971.

More than 3,600 units are in service, including 1,135 CF6-80C2s and 295 CF6-80E1s, which are in current production, along with the CF6-80CK1F, which powers the Kawasaki C-2 military transport, according to Scott Brensike, GE Aviation's general manager for the CF6 product line. Taking the CF6 family as a whole, some 90% are on commercial airliners. “As a result, the in-service fleet size is increasing year over year,” Brensike says.

To illustrate, he says that GE shipped 42 CF6-80C2s in 2018, along with 14 CF6-80E1s and four CF6-80CK1Fs. “We have increased production for the past two years and project 20% yearly growth in demand through 2021, when we could be producing over 100 engines,” Brensike says. “The utilization rate and MRO market for these engines will continue to be very strong, with retirements of older aircraft countered by demand for good, mature widebody passenger and freighter aircraft, and feedstock for passenger-to-freighter conversions, as well as continuing production for current and potential new applications.”

Cargo, in fact, is what Brensike terms “a great tail wind” for the CF6-80C2, driving production rates upward, along with more freighter conversions of passenger 767s. This will extend engine service lives by 15 or more years, he predicts.

At the same time, the uptick in cargo shipments is enabling the return to service of 747 freighters that were in storage, as well as extending the lives of Airbus A300 and A310 and McDonnell Douglas MD-10 and MD-11 fleets.

“Given that we have CF6-6-powered MD-10s in service with FedEx, which will be 48 years old this year, we expect that the CF6-80 fleet will be flying well past 2050,” Brensike remarks.

Underscoring its commitment to the fleet’s longevity, GE introduced a performance improvement program (PIP) in 2015 for the CF6-80C2 and CF6-80E1. The PIP includes fan, high-pressure turbine (HPT) and high-pressure compressor (HPC) flow path and efficiency improvements, which have enhanced fuel efficiency. “Since 2015, all CF6-80C2 and CF6-80E1 engines have been produced with the PIP improvements, for a total of more than 260 engines,” he says, adding that the hardware used for the CF6-80C2 and CF6-80E1 PIP is retrofittable at overhaul.

Major MRO shops that maintain the CF6 family are seeing similar trends to those cited by the OEM.

Hans-Dieter Reimann, director of engine programs at MTU Maintenance in Germany, says CF6 engines—both the CF6-50 and -80C2 variants—account for more than 80 repair and overhaul shop visits at the MRO’s facility in 2018. For the CF-80C2, in fact, this represented an increase in shop visits of nearly 33% over 2017. “Over the past couple of years, there has been increased demand for MRO on the CF-80C2, due to the rise in freighter capacity demand and the lower retirement rate of aircraft that use this engine type because of lower fuel costs,” he points out.

On a cautionary note, Reimann says that due to high demand for CF6-80C2 maintenance, capacity for that engine type has become very tight worldwide. Because of this, he says, MTU “in-
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tends to add capability and capacity in the near future” for the engine at its Vancouver facility in Canada, to give the MRO greater flexibility for engine inductions. Currently, all of MTU’s CF6-80C2 work is carried out in Hannover, Germany.

More capacity for CF6-80C2 work, Reimann notes, is slated to become available this year as MTU winds down its CF6-50 business after 40 years.

He agrees that air cargo carriers have become an important customer base, now accounting for one-fourth of its CF6-80C2 business. “We expect this share to grow in the future, as the 767 is certainly a cargo workhorse, and newly built freighters are still being delivered,” he points out. “The increase in e-commerce should also have a stabilizing effect on the market.”

Asked about any repair developments at MTU to improve its performance, Reimann says that since the CF6 family is in the latter stage of its life cycle, it already has received modifications over the years and is considered a very reliable engine. “Our R&D work focuses largely on repair development, including processes that are not engine-specific and include, for instance, erosion or thermal barrier coatings,” he explains. “Such high-tech repairs can reduce scrap rates, increase time on wing and bring considerable cost benefits.”

As with MTU, Standard Aero anticipates continued growth with its CF6 MRO business. The Scottsdale, Arizona-headquartered company offers 1,926 repairs on rotating and stationary parts on the CF6-6, -50, -80A, -80C and 80E at its Cincinnati component repair location. However, according to Joe Nolte, vice president for component MRO, most of the repairs “now exist for the CF6-80C2 and the CF6-80E1, at 897 and 314,” respectively.

“Within the repair business, Standard Aero has seen increased repair demand for the CF6 family, driven primarily by the -50, -80C and -80E,” he says. “The majority of the repairs have been in support of the -80C, followed by the -80E and -50. However, demand for repairs on the -80C is 3-4 times that of the -80E, and the -50.” Nolte also points out there is continued interest in CF6-80A component service, although it is small. He says repair demand for the CF6-6 is “minimal.”

In that regard, Nolte explains that projections call for CF6-50 and -80A shop visits to continue to decline, with -80C shop visits remaining flat, and the -80E trending slightly upward over the next few years. In reality, he says, repair demand for all four models has increased over the last 4-5 years. “This isn’t necessarily contradictory, as the material in the market available for repair will increase as engines come out of service,” he stresses. “Repair demand can continue to go up, as that material is consumed in future shop visits.”

Nolte adds that there is no single driver for the growth mode in the CF6 MRO market. “Barring any unusual economic or geopolitical change, the expectation is that the CF6 repair demand will continue to grow over the next 3-5 years,” he says. “Fuel has been cheap and economies stable. Flying older, depreciated assets that are reliable and relatively fuel-efficient makes financial sense. The mix between the models may change, but in total, demand should remain strong, with the -80C being the largest contributor.”

Not everyone has such a bullish view of the CF6-80C2 MRO market. Clemens Caspar Geercken, head of product sales engine services in the Americas for Lufthansa Technik, says the number of inductions of the CF6-80 family into the company’s Hamburg shop this year will remain in the double digits, but on what he calls “more or less the same level as 2018,” he says. “CF6-80 engines are part of a mature fleet which is expected to retire significantly within the next years. For the CF6-80C2, that fleet is expected to decrease from approximately 2,800 in 2019 to 1,600 in 2028,” says Geercken, citing ICF data for 2019. This, he explains, translates into an expected decrease in shop visits over the next 10 years to 300 annually by 2028 from approximately 490 this year. Most are coming from Boeing 747-400 and 767 and MD-11F operators, with a few continuing to come from the A300/A310 community.

“Whether the engine fleet or the demand for engine shop visits will really drop at exactly this pace strongly depends on economic factors like oil prices, economic growth and global political stability,” Geercken stresses. “Of course, we will continue to offer services for mature engines—not just the CF6-80—to find an optimal work scope, optimize residual value and life of the engine, as well as utilization of the engine itself.”

### CF6 Engine Airline Applications

<table>
<thead>
<tr>
<th>MODEL</th>
<th>AIRFRAME</th>
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<tr>
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<tr>
<td>CF6-50</td>
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<td>Airbus A310-300</td>
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<td>Airbus A300-600, A310-300</td>
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<td>McDonnell Douglas MD-11</td>
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<tr>
<td>CF6-80E1</td>
<td>Airbus A330-200, -300</td>
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Source: GE Aviation
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Electric propulsion emerging as a modification market

A new market to modify aircraft from piston and turbine engines to electric power may be emerging as industry explores the potential to reduce energy consumption and direct emissions.

Harbour Air, North America’s largest seaplane airline, has partnered with motor developer MagniX to convert its fleet to electric propulsion. The companies plan to begin by replacing the radial piston engine in one of the airline’s de Havilland Canada DHC-2 Beavers with the startup’s 750-hp electric motor.

United Technologies Corp. (UTC), now the aerospace industry’s largest suppliers plans to convert a Bombardier Dash 8 Q100 regional turboprop into a hybrid-electric propulsion X-plane. UTC is eyeing a commercial market for the system, which is being developed by Collins Aerospace Systems and Pratt & Whitney Canada under the new United Technologies Advanced Projects organization.

Hawaiian commuter airline Mokulele Airlines has signed a letter of intent with U.S. startup Ampaire to potentially convert its Cessna Caravans to electric power. Others that have signed similar agreements are Seattle's Kenmore Air, Tropic Air of Belize, Puerto Rico-based Vieques Air Link, Southern Airways Express of Memphis, Guernsey’s Aurigny and Star Marianas Air, based in the Northern Mariana Islands.

What connects these projects is range, whether it is Harbour Air’s island-hopping flights in the Pacific Northwest or the Dash 8’s short-haul regional services. Long range is not required, and this makes electric propulsion feasible, whether it is the battery-powered Beaver or the hybrid-electric Dash 8.

Vancouver, British Columbia-based Harbour Air operates 12 routes to islands and other locations in the Pacific Northwest. A typical Beaver flight lasts 10-20 min. “We can do that with today’s batteries, let alone with 2022 batteries, which will provide longer range,” says Roei Ganzarski, MagniX CEO.

“Harbour Air understands what we can do today. For Seattle-Vancouver flights they use a Cessna Caravan. We can’t do that with today’s batteries,” he says. “We can’t do 200 mi., but a Beaver flying 65-70 mi. between islands does make sense.”

The “remotored” Beaver is expected to fly by the end of 2019 and will be used as the test aircraft for supplemental type certification (STC) of the conversion. Harbour Air plans to begin commercial service with the electric-powered Beaver by 2022, says Ganzarski, and wants to convert its entire fleet of almost 35 seaplanes, including the larger DHC-3 Otter, DHC-3T Turbine Otter and DHC-6 Twin Otter.

MagniX is developing the 750-hp magni500 motor to replace the popular Pratt & Whitney Canada PT6A turboprop in utility aircraft such as the Caravan and Beechcraft King Air, with short-haul cargo carriers and island-hopping airlines as target markets. “Which came first depended on who had the most foresight,” says Ganzarski. “Harbour Air is leaning forward because it sees the value electrification will bring to its business model.”

Harbour Air operations also led them to electric propulsion, with frequent stops during which batteries can be recharged. “We are aiming for a 1:1 to 1:0.75 ratio—1 hr. flying to 1 hr. or 0.75 hr. charging,” he says. “A 20-min. flight, 20 min. charging, and Harbour Air’s turnaround times are 30 min. to 1 hr. They can do this without changing the aircraft or their business model.”

At 750 hp, the magni500 motor is significantly more powerful than the Pratt & Whitney R-985 radial engine powering the DHC-2, but Ganzarski says operators are already re-engining their Beavers with the more-powerful PT6A. “If they are looking for more power, we can make it clean. And an
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electric motor is not affected by altitude,” he says, noting piston and turbine engines lose power with altitude.

The cost of “remotori ng” an aircraft like the Beaver “should be equivalent to re-engining with a PT6,” says Ganzarski, but the operating cost should be significantly less because of the lower maintenance required by electric motors. “The five-year life-cycle cost should be 70-80% cheaper than today.”

Under the partnership, Harbour Air will help with engineering of the modification and hold the STC to convert its own fleet and those of other operators. The plan is to begin with certification of the Beaver, then move on to the DHC-3 Otter, DHC-3T Turbo Otter and the DHC-6 Twin Otter. MagniX is responsible for all aspects of the electrification, including the charging infrastructure, he says.

MagniX is using a Cessna Caravan airframe for ground testing of the 350-hp electric motor driving a propeller.

Ampaire has modified a Cessna 337 Skymaster to a propulsion testbed for electric-powered regional aircraft. The Skymaster’s push-pull configuration allows the forward piston engine to be retained for safety while flight-testing the electric drivetrain that replaces the rear engine.

Based in Hawthorne, California, the startup has received funding support from Starburst Accelerator and in August 2018 was one of the first 10 companies inducted into the ‘Techstars Energy Accelerator In Partnership With Equinor. This is incubator Techstars’ first Nordic accelerator, and involves Norwegian energy company Equinor and engineering group Kongsberg. Kevin Noertker, Ampaire co-founder and CEO says the company is working with Norway, which wants all short-haul flights to be electric by 2040.

Beginning later this year, Ampaire plans to fly its experimental aircraft on routes flown by Mokulele between Kahului and Hana under a program funded by Hawaii’s Elemental Excelerator, a nonprofit incubator. The six-month trial will look at how to incorporate hybrid-electric aircraft into a fleet. Mokulele hopes to begin electric flights in 2021 after FAA certification of the conversion.

Interested airlines such as Mokulele want to keep their aircraft but convert them to electric power, says Noertker. In the Skymaster testbed, the rear Continental piston engine is replaced by an off-the-shelf electric motor, but Ampaire—like MagniX—is targeting replacing the popular PT6A turboprop that powers aircraft such as the Caravan and Twin Otter.

UTC, meanwhile, is designing the hybrid-electric electric propulsion system for the Dash 8 X-plane with certification and production in mind. Installed in place of P&W’s 2,150-shp (1.6-megawatt) PW121 turboprop—on one side only for safety—the 2-megawatt system comprises a 1-megawatt turbine engine and a 1-megawatt electric motor, both driving the propeller via the same gearbox.

For takeoff and climb, both the turbine engine and electric motor are used. In cruise, only the turbine engine operates. And on descent, the motor operates as a generator and uses excess turbine-engine power to recharge the lithium-ion battery pack installed under the cabin floor.

By downsizing the turbine engine and operating it at its optimum point throughout the flight, UTC expects fuel savings of at least 30% on a 1-hr, 200-250-nm flight. There is a penalty: Operating empty weight increases, and fuel capacity is reduced by about 50%. Range is reduced to 600 nm from a baseline 1,000 nm, but UTC says 99% of 30-50-seat Dash 8 missions are shorter than 500 nm.

Range is the key, but in niche short-haul markets it is beginning to look possible, even likely, that electrification can bring a new lease on life to long-established aircraft types—and a new modification revenue stream for the industry.
Fail Safe

Engine MROs and OEMs are focusing on preventing failures in the field

Paul Seidenman and David J. Spanovich San Francisco

When an engine problem causes an AOG (aircraft-on-ground) situation, the operator faces the cost of rebooking passengers or cargo on other flights while the aircraft sits idle, awaiting repairs.

“Many field repair events, in our experience, can be traced back to the engine’s last shop visit—particularly with the internal components such as high-pressure compressor (HPC) blades, high-pressure turbine (HPT) blades and nozzle guide vanes,” observes Fergal Whelan-Porter, CEO of Aeolus Engine Services, a global engine line services and technical support company in Dublin. “On the CFM56-3, for example, we have seen cases of insufficient workscopes because it is late in its life cycle, and the operator sees a short time horizon.”

To guarantee “good time on-wing,” operators need to perform sufficient performance restoration repairs in the HPC and HPT modules during off-wing maintenance to match life-limited parts’ allowance, Whelan-Porter explains. He also reports that line replaceable units (LRU) such as fan blades, sensors, main engine controls and fuel nozzles are among the more common items prone to failure, often the result of high time on wing and/or faulty installations.

Fortunately, new developments with materials and predictive data technologies are helping to reduce field repair events, which can keep an aircraft out of service for days at a time.

“At Standard Aero, we are just beginning to incorporate digital inspection tooling with a focus on laser measurement inspections of critical airfoil components,” says Brent Ostermann, the MRO’s vice president of engineering, in Winnipeg. “Using digital technology to create an image of a compressor or fan blade reveals an image of its in-service condition compared to that of a brand-new unit, providing a baseline as to when to refurbish the airfoil. And by applying automated blending, we can restore the airfoil back to its designed condition to assure the engine will have excellent performance in the field.”

Automated blending, he explains, uses robotics and computer numerical control (CNC) programming to perform precision machining or blending of airfoils to replicate new conditions following in-service erosion. “It removes the variance of humans performing the same task,” says Ostermann.

Pratt & Whitney also is expanding its digital capabilities with the goal of minimizing unexpected MRO events, according to William Cermignani, the engine OEM’s executive director of Global Services Engineering.

“We are working to make engine maintenance events highly predictive and move the focus from reactive to proactive maintenance,” he says. “The tools we have developed proactively look at these types of events and give us an early warning on potential fleet trends. We expect further growth and integration of our predictive analytics capabilities.”

In that regard, Cermignani reports Pratt & Whitney is using state-of-the-art data acquisition systems, analytics and real-time intelligence through its EngineWise suite of services to monitor the health of its engines in order to predict and prevent engine disruptions before they occur. As an example, he cites the geared turbofan (GTF) engine.

“The GTF incorporates 40% more sensors than the [legacy] V2500 engine and can generate approximately 4 million data points per engine, per flight,” he explains. “That provides significant improvements in maintenance through our EngineWise program to mitigate disruption to our customers.”

Pratt & Whitney, Cermignani points out, also is leveraging data generated by advanced diagnostics and engine management (ADEM) and enhanced flight data acquisition storage and transmission (eFAST) to “reduce operator maintenance burden,” such as borescoping, and connect the trend analytics to remote on-wing and near-wing maintenance, enabling faster and more cost-effective maintenance options.

He says “the expansion of component inspection limits is an effective way” to extend time on wing and reduce engine operating costs. “Our latest initiatives to collect feature-specific component distress data allow us to understand progression rates and effectively extend on-wing limits,” he adds.

Sylvia Stuenkel, director of on-site services at MTU Maintenance in Ger-
many, says the MRO uses an engine trend monitoring system, which culls engine data from flight operations to help prevent engine failures. “We currently work with smaller, more specific data sets directly from operations, rather than large volumes of big data,” she explains. “However, we are working on the integration of continuous engine operational data.”

MTU Maintenance’s engine trend monitoring system data includes remaining on-wing time prediction, based on critical performance parameters such as exhaust gas temperature margins, automatic diagnostics that identify the root cause of any trend shift and a quick fleet analysis tool to review on-wing deterioration per engine serial number and shop visit effects.

“These features improve our ability to proactively manage fleets and recommend courses of action to customers that prolong time on wing and prevent secondary and serious damage from occurring when trend shifts are spotted. This all saves cost and reduces potential for AOGs for customers,” she says.

At the same time, she explains, engine trend monitoring itself is undergoing changes. The “traditional approach” to engine trend monitoring, she says, is to identify long-term trend changes that enable the aircraft to transmit “single snapshot reports” in different flight modes, producing only a small amount of data—about 10 kilobytes per report. “But newer technology developments use continuous data from the whole flight that includes snapshots from each second,” says Stuenkel. “That data is still below 1 gigabyte but are already exceeding the current inflight data transmission capabilities and are therefore [downloading the data] via a wireless groundlink quick access recorder [WQAR] after arrival.”

While data volume will likely continue to increase, Stuenkel notes that it is too expensive to transmit data for the whole flight in real time via the aircraft communications addressing and reporting system (ACARS). “But new technologies might help to reduce the costs to a level that makes real-time transmission a reality,” she remarks.

Stuenkel says data format, transmission capabilities and frequencies for each aircraft are not universal, as products from hardware and software producers and update levels vary. “Amassing the data to feed the databases and create enough data points to establish patterns across engines, regions and operations is also a challenge,” she says.

Alyson Thomas, director of fleet support at GE Aviation, says the engine OEM’s fleet support team continues to build and evolve detection analytics to improve detection rates of anomalies in the snapshot data.

“Customers send engine performance data that is referred to as ‘snapshot data’—discrete data points transmitted in real time during set points of the flight, such as takeoff, climb and cruise,” Thomas explains. “The outputs of these analytics go into ‘customer notification reports,’ in which we make recommendations to the customer regarding preventative inspection or maintenance actions.”

Thierry Chabroux, engine product director for Air France Industries KLM Engineering & Maintenance (AFI KLM E&M) says that since putting its Prognos solution in place in 2017, the MRO has implemented “very powerful analytics” with the current available data. “With even more data tomorrow, it is clear that even stronger analytics will be built,” he predicts.

Prognos is a multipurpose predictive maintenance solution service applicable to all engines as well as auxiliary power units. The system, which transmits data in real time from the aircraft via Wi-Fi or 4G, provides short- and long-term trend monitoring, hosted and controlled by AFI KLM E&M. The goal is to detect an unscheduled maintenance event at least several flights before the operator might get an alert from the OEM. AFI KLM E&M says this yields greater forecasting accuracy, as the service is tailored to the individual airline’s operations and fleet dynamics rather than worldwide fleet models used by the OEMs for data analysis.

But preventing engine failures is not just a matter of interpreting big data. It also comes down to materials and repair methods. “There is a lot of focus now on addressing hot section problems, mainly through the use of better coatings technologies and stronger materials,” says Standard Aero’s Ostermann. “For example, there are more applications of ceramic coatings because they last longer than vapor-phase aluminized coatings.”

Ostermann says Standard Aero is adopting “cold spray,” a repair method using metal powders that are accelerated onto the part using high-velocity inert gas without damaging the part. Standard Aero will start using this technology in the second quarter of this year. “Cold spray maintains the same strength characteristics as welding but without the high heat that leads to distortion of the metal surface,” he explains.

Stuenkel notes that MTU uses a CMAS (calcium-magnesium-aluminum silicates) resistant thermal barrier coating and its ERCosteeco (erosion-resistant coating for HPC airfoils), which reduces scrap rates, improves the durability of hardware and reduces the specific fuel consumption of the engines. “Such repairs are a very cost-effective way to help operators combat high material costs and considerably increase engine on-wing times. These repairs are particularly beneficial to customers flying in harsh environments.”

AFI KLM E&M’s Chabroux cites ceramic matrix composites among the technologies that have improved engine reliability. “They can withstand very high temperatures without any cooling system,” he says. “But it is premature to say how the new technologies will [work out] over time, since we only have very limited hindsight.”
Automotive Inspiration

Aviation suppliers, cabin designers and UAM stakeholders look to automakers for new ideas

Lindsay Bjerregaard Chicago

The lines between transportation industries are starting to blur as aerospace companies more frequently team with automotive specialists to innovate. Within the last few years, the industry has seen pairings between Boeing and automotive seating specialist Adient, Lufthansa Technik and Mercedes-Benz, Liebherr-Aerospace and General Motors (GM) and Airbus and Audi—and the list continues to grow as the urban air mobility (UAM) market begins to take off. It is becoming increasingly clear that crossover between the two industries will be necessary for innovation to proceed.

Electric-powered vertical-takeoff-and-landing (eVTOL) air taxi startup Lilium, which hired renowned car designer Frank Stephenson as its head of product design in 2018, sees the automotive industry as a natural source of inspiration—particularly in terms of meeting high production demand.

“The aerospace industry, and particularly those of us engaged in developing UAM, can learn a lot from the automotive industry,” says a Lilium spokesperson. “Independent studies of the UAM market suggest there will be the need for a significant number of these aircraft, meaning they will need to be produced at volumes more akin to those in the automotive sector.”

Aside from production and supply chain practices, UAM is blurring the lines between aerospace and automotive even further. Innovators such as Elon Musk are exploring both autonomous cars and aircraft, while large tech companies including Google and Uber are dipping their toes into both industries to explore how autonomous vehicles can create new business op-

Lilium is drawing on autonomous technology from the automotive industry for its eVTOL jet.

portunity.

Lilium says that although it plans to operate its aircraft with a pilot at first, the Lilium jet is designed to operate autonomously. A company source says Lilium will be looking to learn lessons about technology for autonomous driving from the automotive industry.

According to Ella Atkins, professor of aerospace engineering at the University of Michigan and founder of the Autonomous Aerospace Systems Laboratory there, both cars and aircraft likely will become increasingly autonomous over time.

“In terms of perception and decision-making, there’s a lot of overlap in that both types of vehicles need to be aware of what’s around them, be in communication with other vehicles and make safe decisions,” says Atkins. “I think a lot of deep learning and decision-making based on other traffic work that is happening in the auto industry—in particular with lidar (light detection and ranging) vision systems and their fusion—is going to move into the skies.”

Atkins says smaller unmanned aircraft systems (UAS) such as the Lilium jet, which will be flying in close proximity to buildings and other UAS, will use these types of technologies to maintain safe clearance and coordinate location of other aircraft independent of sensors. Meanwhile, Atkins says automotive technology development knowhow is also making its way into energy systems for aerospace.

“There’s a ton of crossover because everyone wants higher-energy-density batteries that are fast to charge,” she says. “That gets into materials, operations, monitoring technology, safe handling—all of those things.”

In addition to batteries for UAM vehicles, aerospace companies are looking to automotive specialists to develop energy systems for both commercial and
defense applications. Liebherr Aerospace and Transportation partnered with GM last year to introduce fuel-cell technology into aircraft onboard power-generation systems. In late 2017, Airbus began a collaboration with Williams Advanced Engineering—the engineering and tech arm of Formula One racing company Williams Grand Prix Engineering—to explore potential areas for technical collaboration.

A representative for Airbus says the company is looking to Williams because of its cutting-edge research on structures, batteries and electrical power. Although Airbus is not releasing specific details about the progress of the collaboration, it is looking to leverage innovations within its Zephyr High-Altitude Pseudo-Satellite program that could also apply to commercial aviation in the future.

Airbus also has collaborated with automotive partners on UAM on passenger experience. The company worked with Audi last summer to provide ground transportation to its on-demand helicopter-booking platform Voom, starting in Sao Paulo and Mexico City. If successful, this service could presumably be offered for the OEM’s CityAirbus eVTOL, which made its public debut last month in Ingolstadt, Germany (where Audi is located).

Atkins says other traditionally automotive-focused companies such as Uber, which has partnered with eVTOL makers Bell and EmbraerX, are looking to get in on the ground transportation element of UAM. “Something that puts them in a really good position with respect to UAM is that if you fly people from point to point, likely those planes or VTOL UAM platforms will need secure areas to land, take off and handle passengers. So it is absolutely the case that the only way that’s going to be convenient is if there’s, for example, an Uber car delivering someone to take off and ready to pick someone up when they land,” she says.

**AI AND PASSENGER EXPERIENCE**

Looking to the future, Atkins believes other areas of UAM crossover between aerospace and automotive will be maintenance and human-artificial intelligence interaction.

“If we have a fleet of vehicles that are autonomous, they’re not necessarily going to be parked in their garages at night,” says Atkins. “Maybe some of the vehicles will be parked at 3 a.m., but there will be a lot of common procedures for dispatching and managing maintenance and making sure the right parts are at the right place at the right time. I think a lot of that is going to be common to the different autonomous vehicle industries.”

As for the passenger experience within autonomous vehicles, Atkins says there will be major differences between how the human-AI interface will need to work. “In cars, we all know how to drive, and we all know what the car is going to do because most of us have been riding in cars all our lives. In planes, it’s going to be quite different because we’re used to sitting in the back with a TV in front of our faces, but we’re not used to being in a small vehicle zipping low over cities,” says Atkins. She adds that the industry will need to figure out how to bridge the divide by sorting out how autonomous systems will interact with passengers in aircraft versus the way that is being handled in cars.

With the move toward autonomous vehicles, cabin design within cars may begin drawing more inspiration from aircraft cabin seats in terms of storage, space for eating meals and other leisure activities. However, when it comes to the experience of sitting in an aircraft cabin, aerospace designers have been taking inspiration from the auto industry for years—particularly for business- and first-class seating products.

Boeing’s seating joint venture Adient Aerospace says its premium seating concepts—such as the Ascent business-class seating system it will debut at the Aircraft Interiors Expo this month—draw inspiration from luxury vehicles through design choices such as “well-managed gaps and removing fasteners from the passenger’s line of sight,” creating a feeling of attention-to-detail similar to that experienced in luxury vehicles.

UK-based design house Factorydesign—which has created specialty aircraft cabin interiors for carriers such as British Airways, Etihad Airways, Delta Air Lines and Scandinavian Airlines—has drawn styling cues from automotive in everything from hand-veneered wooden tabletops in business-class lounges to premium aircraft seats with cross-pattern stitching and side bolsters. According to Adam White, partner at Factorydesign, much of the automotive inspiration for aircraft cabin design is to create a feeling of luxury rather than replicating specific design details from cars.

“What we do is take the persona or the character,” says White, pointing to the example of touchpoints passengers interact with such as interface controls to recline and adjust seats, which he says have become increasingly refined in their design. In business class, White says one area where aerospace has drawn ideas from automotive is lighting.

“If you picture cabin and seat lighting as recently as a few years ago, there was really very little other than This Lufthansa Technik and Mercedes-Benz VIP cabin collaboration is inspired by the S-Class luxury sedan.
Inside MRO

Aerospace partners with Audi for ground transportation to and from on-demand UAM service.

...the main cabin lights, the reading lamp and perhaps a sort of ambient light on the bulkhead, whereas in the automotive world, at night you could change the whole color of your cabin, and there was edge lighting around controls," he says. "We’re getting a lot more of that cross-fertilization, where LED technology is increasingly making the whole theater of the seat that you sit in more exciting and more like a Mercedes-Benz S-Class, for instance."

The VIP cabin collaboration between Lufthansa Technik and Mercedes-Benz unveiled in 2018 drew on the S-Class and featured dashboard-inspired black panels and carbon-fiber elements. Lightweight materials such as carbon fiber have an obvious appeal for both the automotive and aviation industries.

"The world of performance cars has been obsessed for decades with creating the strongest, lightest possible product—hence the enormous development they’ve made in composite materials," explains White, adding that the aviation industry has increasingly become sensitive to the weight of products in the cabin. "If you stand back and look at a first-class suite [or] even a lot of the old business-class products, they’re mammoth structures, and there’s a considerable amount of weight in them. It would simply be unthinkable to approach design in that way in a supercar, so there are extremely valuable learnings from the automotive industry, particularly at the high end."

When it comes to the materials themselves, White says designers are restricted within aviation, given the high level of testing required, but the industry is still striving to push the envelope with materials. Adient Aerospace suggests that certain steel alloys used in automotive might offer advantages over conventional applications of aluminum alloys in aerospace. Conversely, the company says some materials offering weight advantages within aerospace provide challenges when scaling to automotive volumes.

Other big differences that must be considered for aircraft-cabin interiors are aerospace’s strict flammability standards and the durability required. In terms of maintenance, “the bar is high in automotive but can be higher in aviation,” an Adient Aerospace spokesperson says. “For example, a typical business-class seat can average 20 cycles between the seated and bed position every day. Most of us don’t adjust our car seats nearly that often.”

Despite these differences, White believes crossover between the two industries will continue to grow along with commercial fleets and the UAM model.

“At the very high end, if you go back a few decades, a supercar really was a very specialist product—whereas now, there’s a surprisingly large number of extremely refined and very fast vehicles that are relatively affordable to a lot of people," says White. “The market has grown significantly, and it can only grow if manufacturing [gets] better. Aviation and automotive have kind of reached a point where the interests are mutually self-serving.”

AERO-AUTO SUPPLY CHAIN HISTORY

Demand for newer, more high-tech and fuel-efficient aircraft continues to grow exponentially, with Aviation Week Network’s Commercial Fleet and MRO Forecast projecting that new-production deliveries will reach 2,100-2,250 each year over the next decade. This annual growth rate of 2.8% presents challenges for aircraft production and the supply chain, which need to keep up to meet projected deliveries.

According to Kevin Michaels, managing director of aerospace consulting firm Aerodynamic Advisory, aerospace has long drawn inspiration from the automotive industry to meet challenges—such as in the early 1990s, when major aircraft OEMs began adopting the Tier 1 supply chain model originated by Toyota, and supply chain executives from auto makers began migrating to companies such as Airbus, Bombardier and Rolls-Royce. Michaels says best practices to meet expectations for on-time delivery, costs and continuous improvement are often at their sharpest in the automotive industry.

“Companies like that are used to operating in a really tough environment, and you can carry those lessons over and apply some of that to aerospace,” he says. “The automotive industry is decades ahead of aerospace in supply chain sophistication. We’re obviously a high-mix/low-volume industry, and the automotive industry is the opposite, but there’s a lot of crossover.”

Companies within the aerospace supply chain such as Liebherr-Aerospace and Adient Aerospace say best practices from automotive’s more mature production model are increasingly attractive for aerospace markets. 
Cybersecurity threats to aircraft, ground and mobile systems are increasing

Alex Derber London

U.S. government researchers in 2017 concluded that “most commercial aircraft currently in use have little to no cyberprotections in place.” A year earlier, the same researchers had taken two days to hack into unspecified systems on a parked Boeing 757 via its radio-frequency communications, while their next project was to examine the vulnerability of Wi-Fi and inflight entertainment (IFE) systems.

The results of that study have yet to be made public, but there are fears that more modern aircraft, where passengers, crew and many aircraft components themselves possess greater internet connectivity than on a 757, will prove even more vulnerable. In 2015, a cybersecurity specialist said he had moved an aircraft inflight via its IFE system, although his claims have been met with huge skepticism and, even in the case of the more rigorous 757 research outlined above, it is unclear whether critical systems were accessed.

Even so, U.S. Homeland Security Department researchers believe it is only “a matter of time” before an aircraft cybersecurity breach occurs, while a 2018 survey of airline IT chiefs by SITA found that cybersecurity was their second-highest investment priority. For airport chief information officers it was No. 1.

Boeing says it is confident about the cybersecurity of its aircraft. “Multiple layers of protection, including software, hardware and network architecture features, are designed to ensure the security of all critical flight systems,” a representative tells Inside MRO, adding: “Boeing’s cybersecurity measures are subjected to rigorous testing, including through the FAA’s certification process, and our airplanes meet or exceed all applicable regulatory requirements.”

One example of those regulations is DO-326, which deals with activities that need to be performed in support of the airworthiness process when the development or modification of aircraft systems and the effects of intentional unauthorized electronic interaction can affect aircraft safety. Companion documents set out various measures to achieve this.

While the potential to access flight control and other critical systems remains uncertain, huge disruption could still be carried out. For example, it has been estimated that the cost of updating one line of avionics code can run to $1 million when one considers the implications of developing, testing and implementing a fix and—crucially—the time an aircraft might have to be out of service to do so. One need only consider the global grounding of the 737 MAX fleet while Boeing upgrades certain software to imagine the havoc that computer viruses might cause.

CONNECTED COMPONENTS
Also worth noting is the interplay between mobile devices and aircraft systems, particularly as flight and cabin crew take advantage of advances in connectivity to assist them. Often they use tablet devices to do this, presenting a risk that malicious software on the tablet could migrate onto aircraft systems. To reduce such risks, airlines need rigorous systems in place to manage their mobile devices and who has access to them.

In theory, a more direct route into those systems potentially exists through connected components that form part of the Internet of Things. One example is the engine man-

MONSTLT/ISTOCKPHOTO
management unit (EMU), which collects, processes and transmits engine data. In the past, this was a one-way stream, but certain EMUs can also receive instructions. Rolls-Royce launched such a device with its Pearl 15 business jet engine and is intending to roll out the technology to other platforms in order to enable functions like remote testing. “Now we can talk back to the engine while it’s on the ground,” Rolls-Royce’s head of product management for digital services, Nick Ward, told Inside MRO recently.

Like Boeing, Rolls-Royce is confident that multiple security layers protect its components from interference, but that is not the case everywhere on an aircraft. SITA estimates that about 12% of aviation cyberattacks target navigation and air traffic control, with GPS proving particularly easy to undermine with cheap jammers and open-source “spoofing” software. The effects already experienced by flight crews include loss of satellite position reception, an inability to report aircraft positions accurately and being forced to perform go-arounds using backup navigation systems.

**DATA SECURITY**

Another layer of threat exists for ground systems. An airline’s passenger data security is beyond the purview of this publication, but OEMs and maintenance companies must be aware also of heightened cybersecurity risks, be they to internet-enabled components or the increasingly valuable data they generate. Keeping client data confidential is one priority, but manufacturers and MRO providers must also guard against intellectual property theft and other malicious actions by rival companies or even nation states.

“Access and authorization to see data, whether from an individual airline or anonymized/aggregated, is either controlled by an identity-management team or through integration with the airline’s ‘single sign-on,’” says Jon Dunsdon, chief technology officer of GE Aviation digital solutions. “GE monitors access to ensure only those employees or contractors authorized to view the data are allowed access.”

Rolls-Royce tells Inside MRO that it recognizes cybersecurity “as one of the principal risks” for the company and outlines several measures it takes to protect its own and its customers’ data, including: an information assurance board to approve cybersecurity architecture and access controls, cybersecurity risk assessment for new projects, security operations centers around the world with teams focusing on cyberissues, proactively searching for weak spots across its IT systems and cooperation with Microsoft to enhance the security of data stored in the cloud.

Lufthansa Technik has access to certain airline data via its Aviatar platform, although only what each customer is willing to share. As well as separating each customer’s data, the MRO provider also uses encryption throughout the Aviatar platform, both for data in storage and in transit. This is the last line of defense if other security measures—such as Aviatar’s firewall and automatic threat detection—fail.

At the same time, it is clear that cyberthreats will continue to evolve and proliferate and that the defenses of today may not suffice tomorrow. Therefore, aviation companies must continue investing in security to stay ahead of the hackers.

**TOP 10 CYBERSECURITY TIPS**

1. **Layer Security.** A firewall is a minor obstacle for determined hackers, so multiple layers of security are needed, including system segregation and ultimately data encryption.
2. **Encrypt All Data.** Data encryption has become increasingly affordable and powerful. It is the last line of defense against hackers, and airlines and other aviation companies accordingly should aim to encrypt all data, whether it be on aircraft, ground systems or mobile devices. Furthermore, control of encryption keys must be secured.
3. **Monitor Suppliers.** Malware can be embedded in systems coming new out of the factory, so the cybersecurity of key suppliers is almost as important as one’s own.
4. **Control Mobile Devices.** Access on company devices must be controlled by a solid mobile device-management system, while companies must be aware that allowing staff to use personal devices at work massively increases security risks.
5. **Search for Weak Spots.** Employ experts to identify IT vulnerabilities before hackers do.
6. **Use AI.** Artificial intelligence can detect probes of data before a successful cyberattack.
7. **Know Your Data.** It is essential to keep tabs on all the data generated and stored by your company, where it is, who owns it, how valuable it is and where and how often it is backed up. You need all of this to set your data-protection priorities.
8. **Secure Cloud Data.** Don’t just delegate security for company data stored in the cloud to the cloud provider. Also ensure security of data while it is being transmitted to and from the cloud. Data can be hacked in transmission as well as in storage.
9. **Maintain Physical Security.** Control who has access to data centers or other critical IT infrastructure and restrict the use of USB drives and other storage devices in such places.
10. **Communicate and Enforce Data Security.** A meticulous data-protection policy is useless unless it is followed by everyone involved with data. Hold managers accountable for compliance in their departments.
Premium Upgrades
North American airlines and MROs take a gradual approach to software modernization

James Pozzi  London

It is widely accepted that airline maintenance divisions and MROs need robust IT systems to work as the backbone of their operations across hangars, offices and warehouses. Despite a plethora of market options in tailored maintenance solutions for customers—many of which are becoming increasingly favored over conventional enterprise resource-planning (ERP) systems—finding the right one is dependent on many factors, ranging from the size of the fleet a company maintains to how many parts it has in its inventory.

Dealing with increased data levels and operating under strict regulatory frameworks means investment in the right MRO software is as important as ever, yet undertaking IT projects in aviation is still fraught with challenges. “MRO applications by their very nature are sophisticated and particularly industry-specific,” says Nadine Etong, director of the MRO product line at the aerospace and defense business unit at ERP specialist IFS, which more than two years ago bought Canada-based Mxi Technologies, vendor of MRO management software Maintenix.

Etong identifies several challenges for companies undertaking IT projects of this nature. “Problems can arise when commercial aviation organizations look to implement solutions for maintenance using traditional all-encompassing enterprise software that is, by its nature, inflexible, difficult to implement and not designed to deal with the unique intricacies and granular requirements of aviation MRO,” she says.

“Secondly, there is often a belief that implementing a modern MRO system must be done in one fell swoop—or ‘the big-bang’ approach,” Etong continues. “Unless properly managed with complete buy-in from the board room down to the users, there are risks of projects running off course.” A phased rollout with clearly defined milestones is a more effective method, she adds.

Some airlines in North America have taken this approach as they look to move past legacy systems and implement newer systems better suited to the changing demands of their modern fleets. Southwest Airlines has used two maintenance software systems: a legacy Wizard system, a version of Maxi-Merlin, along with a Trax system acquired when Southwest took over and integrated the operations of low-cost carrier AirTran Airways in 2010. It has long-held plans to consolidate its maintenance systems into a single product by this year through implementing them across different variants of its Boeing 737-family fleet.

American Airlines, the world’s largest carrier by fleet size, has made major changes to its maintenance IT systems since its 2013 merger with US Airways, and its efforts are ongoing. Pre-merger, American used three primary systems: a legacy transaction processing facility mainframe system, a custom midrange application and a newer SAP system, which was being implemented at the time of the merger.

US Airways, meanwhile, was operating on Sceptre, which ultimately was selected for the integrated airlines. American plans to harmonize all aircraft parts and move the pre-merger American components to Sceptre, followed by fleet migrations.

Sceptre is used by several other large U.S. carriers, too, one of which is Hawaiian Airlines, which uses it specifically for management of its Airbus A330 fleet. It also uses a Trax system for its technical records; the software handles all time-controlled maintenance, aircraft operational data and configuration controls as well as tracking all engineering and inventory needs.

Tracy Hassell, managing director of Tech Ops IT for American Airlines, says systems integration on such a large scale encompassing more than 900 aircraft was a major challenge. “[It involved] harmonizing the large number of aircraft parts across the enterprise and building the necessary bridges to support a phased migration of aircraft to a single solution,” Hassell states.

From the perspective of a parts repair specialist, AJW Group prefers to operate off one core system. It deploys a point solution in the form of Component Control-developed Quantum Control MRO & Logistics Software across its business units, including its AJW Technique components repair business in Montreal, Canada. This integrates personalized MRO data and logistical information for all operational, production and billing purposes. This software supports warehouse, supply chain and customer service management; the sales and marketing of parts and components; and accounting and financial modules.

Han-Ley Tang, chief information officer at AJW Group, says using this enterprise software has enabled the Montreal facility to repair more than 35,000 units a year across 6,000 separate part-number lines. The software also has enabled the parts specialist to develop specific reporting and automation techniques. Upgrades are regular, but never too drastic.

“We upgrade the Quantum Control software at regular intervals as recommended by the software vendor to utilize advanced software functionalities,” Tang says. “Our approach is to keep the software as vanilla as possible, using change requests through to component control for any enhancements.”

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Paperless Lease Transfers Coming

New digital aircraft-record specifications are set for real-world debut in 2019

Sean Broderick Dallas

A years-long effort to simplify aircraft ownership transfers by cutting down on paper and connecting disparate back-end systems is poised to yield its first real-world results, say some of the key people involved in hashing out new electronic aircraft records-transfer standards.

The Aircraft Transfer Records Working Group (ATRWG), a growing collection of industry representatives, has been developing the new standard, ATA Spec 2500, for several years. If all goes well, the first records transfers will take place this year, with lessor GECAS leading the way.

“We’ve spent the last five years getting ready for this,” says Aileen Carroll, GECAS technical records leader. “We’re ready now.”

GECAS is among the dozens of lessors, airlines, manufacturers and software providers that helped develop Spec 2500—an XML standard for exchanging aircraft records and key maintenance data. The standard is being integrated into many widely used maintenance and engineering systems, such as AMOS. Digital records specialists, including Boeing’s AerData Stream and GE’s AirVault, are also on board.

The working group’s initial gathering had about 16 participants, says Rebecca Molder, a senior specialist for engineering processes at American Airlines and the working group’s co-chair. Now more than 80 companies participate, including both large and small airlines from around the world.

The group’s long-term vision: have assets such as aircraft and engines delivered with Spec 2500-compliant records that an operator or lessor can ingest into its system and update as needed. Ownership changes between parties using the standard could then take place without having to exchange boxes of paper records that often must be re-entered into the new owner’s system.

The shift holds the most promise for the leasing community. With nearly half of the world’s air transport fleet owned by lessors, the number of annual transactions—currently about 4,000—is on the rise. Transferring records costs $100,000 or more per transaction, due to everything from required reviews to the cost of physically moving documents between involved parties. ATRWG members believe Spec 2500 will make ownership transfers both easier and cheaper for both operators and lessors.

“The standards will simplify records reviews and drive out costs,” Carroll says. “Moving to electronic records opens up the possibility of remote access as well. If you get to review records earlier, it fosters needed discussions in advance of the transaction.”

Spec 2500 focuses on records linked to an asset’s as-maintained, as-flown status, including airworthiness and service bulletin status, repair and damage records, maintenance status and basic records such as certificate of airworthiness. It is part of a wider effort to digitize aircraft records—something the International Air Transportation Association is pushing for over the next several years. Another standard, ATA Spec 2400, focuses on configuration data. At its core is a standardized file that defines the “allowable configuration” of an aircraft and its components. “This specification defines part-configuration attributes and concepts which integrate engineering product structure with allowable part usage by function position installation through the life of an aircraft,” the spec’s definition explains.

“Electronic records can offer advantages in that presentation of data can be done in various ways which may suit both the lessee during operation and the lessor at transition,” the International Air Transport Association says in its “Guidance Material and Best Practices for Aircraft Leases” document. One of the document’s appendices includes a “typical” list of re-delivery records, which the working group has tailored Spec 2500 to support.

Working-group members have been testing Spec 2500 in isolated trials as part of the development process. But GECAS is poised to put the spec through its first real-world test. The lessor will use the standards to transfer records from its current electronic aircraft record repository provider to its new one, AirVault.

GECAS will not stop there, Carroll says. The company is talking to customers with upcoming transactions in search of early adopters. The expectation is that at least one will step forward this year, and others will soon follow.

“We have made an investment in the future, and we are excited to lead Spec 2500 adoption,” says Gib Bosworth, GE Aviation Digital’s global lessor executive director. “This is a watershed moment; no more talk. We’re going to do it.”

IATA is targeting 2020 for paperless aircraft documentation.
Breathe In
Predictive analytics techniques improve cabin air system reliability
Thierry Dubois Lyon

A cabin air system is more than a standard air conditioner fitted into an aircraft cabin. Its role is to heat and pressurize the cabin while outside air temperature is dozens of degrees Celsius below freezing and air pressure is less than one-fourth of what it is at sea level.

Most of these systems use engine bleed air, which introduces major technical challenges. The three main system providers in commercial aviation—Collins Aerospace, Honeywell and Liebherr Aerospace—are endeavoring to improve their products. They also have to cope with aircraft and engine design evolution, which translates into additional constraints.

Meanwhile, cabin air system maintenance has begun benefiting from big data analytics, which makes it more predictive.

The cabin air system consists of the bleed air system and the environmental control system (ECS), itself made of a refrigeration pack, a cabin pressurization system and a ventilation system. Key components include pneumatic control valves and heat exchangers as well as temperature, pressure and flow sensors, electronic controllers and rotating machinery such as air-cycle machines (cooling turbines and compressors) and fans.

A turbine in the air management system spins at 50,000-70,000 rpm and uses air-bearing technology, thus avoiding the need for grease, says Tom Hart, vice president and general manager for air and thermal systems at Honeywell. Adding to complexity are air quality devices—ozone converters, humidification system and filters.

What are the design drivers of a cabin air system? “It is an integral part of aircraft design,” says Paul D’Orlando, Collins’ business development director for air management systems. Changes in maximum cruise altitude, airspeed, maximum passenger load and engine power availability affect the definition of every major part of the pneumatic system.

Because the air that passengers and crew members breathe is not only a matter of comfort, safety regulations apply. They impose a minimum fresh air flow rate based on the number of occupants. This rate directly impacts the size of major components like air cycle machines, heat exchangers, pneumatic control valves and ducts, says D’Orlando.

In other rules, a maximum is set for the temperature of the bleed air as it travels through different zones in the aircraft. Component insulation is required, to avoid damaging composite structures.

Mechanical and control redundancies are mandatory, in the event of a component failure. This can affect the design through the need for duplicate parts but also requires sizing parts larger than needed. For example, the size of a typical heat exchanger is determined based on an assumption that other components have failed. That means the heat exchanger is oversized during normal operation, D’Orlando notes.

Additional design drivers include the number of passenger areas “where you want to be able to control cabin comfort independently—first class, business class and economy class,” a Liebherr representative points out. At the same time, other areas may have to be provided with air conditioning such as a crew rest compartment or a cargo compartment carrying animals.

All these technologies are evolving with aircraft design. “The latest technologies are mostly linked to the electrification of the aircraft—electrically powered air conditioning, with variable-speed fans and high-power electronics becoming commonplace,” says Liebherr. The Boeing 787 inaugurated a so-called more electric architecture, in which electric systems replaced numerous pneumatic and hydraulic systems. In Collins’ more electric ECS for the 787, the traditional pneumatic bleed air control system

“An environmental control system is the largest non-propulsive power consumer on the aircraft, accounting for 3-7% of engine fuel burn.”

Paul D’Orlando, business development director, Collins Air Management Systems

“An air conditioning pack like this Liebherr system for the Airbus A320 includes a 40,000-rpm turbine.”

Liebherr

“A widebody commercial airliner system can remove as much as 500 lb. of water per hour from the outside air on a humid day operating on the ground.”

Tom Hart, vice president and general manager, Air and Thermal Systems, Honeywell
Predictive analytics techniques improve humidification system and filters. Honeywell. Adding to complexity are avoiding the need for grease, says Tom and uses air-bearing technology, thus system spins at 50,000-70,000 rpm and compressors) and fans.

Air-cycle machines (cooling turbines and flow sensors, electronic control valves as well as temperature, pressure automatic control valves and heat exchange.

Data analytics, which makes it more products. They also have Honeywell and Liebherrers in commercial aviation.

What are the design drivers of a cabin? A turbine in the air management major components like air cycle machines, This rate directly impacts the size of major, electrical power availability affects the definition of every major part of the pneumatic system is the largest non-cabin air system is more than a standard air conditioner fitted in the passenger cabin. Because the air that passengers and crew breathe is re-used. Air conditioning or in-flight refueling is used to heat and pressurize the cabin while outside air temperature is dozens of degrees Celsius below freezing and is constrained by the interfaces established by the airframer, however.

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To design an air generation pack for the Airbus A350, Honeywell had to cope with the hotter and higher-pressure bleed air a new-generation engine creates.

The equipment manufacturer has developed algorithms that factor in parameters such as outside air temperature as well as recent weather, the presence of sand and previous maintenance data. A model is thus built to predict failures and measure system efficiency.

Trials have taken place with "between seven and 10" airlines since 2017, Hart says. "We have seen a 35% cut in delays and cancellations associated with the air management system and no-fault-found events reduced to 2% of the removals." The main enabler is the emerging power of big data analytics—the improvement is made without any additional sensors. "Just by using available data, we can predict failures and [enable] smoother operations for the airline," he adds.

Such models are deemed mature for the Boeing 777 and Airbus A320 and A330. Honeywell is developing more algorithms for the A350 and Boeing 737 MAX. Using such a model, a carrier may be confident, prior to aircraft dispatch, that the system will operate faultlessly. "It also works for aircraft with non-Honeywell systems," says Hart.

Liebherr is betting on predictive maintenance as well. When a system uses outside air, it naturally draws in everything else contained in that air—including water, hail, sand, dust and salt, to name just a few, says the company representative. The more thickly the dirt builds up on the heat exchanger, the less efficient it becomes. To address this issue, Liebherr put together a team of designers, data scientists and specialists from its technical customer service, and cooperated with other companies in aviation and data management. After analyzing the causes of interruptions in operations for 18 months, the team created a "health manager app" for the A380’s central refrigeration unit, an air system that keeps food cool. Using predictive calculations, the specialists managed to reduce wear and the number of key components to be replaced.

Physical maintainability is critical as well. "At Collins, we focus on designing a system that can be easily diagnosed and dispatched by a simple maintenance action (i.e., locking a valve), and we prioritize component arrangement and accessibility based on historic reliability," says D’Orlando. The actual ECS arrangement is often constrained by the interfaces established by the airframer, however.

On the Boeing 787, Collins' environmental control system uses electric motor-driven compressors instead of conventional pneumatic bleed air control.

HONEYWELL
Evolving Electronic Tech Logs

Lindsay Bjerregaard Chicago

1. Turnkey ETL Service

Product: eTechLog8
Specifications: Conduce’s eTechLog8 software completely replaces paper-based aircraft logbooks, providing what the company says is a full turnkey approach for airlines. Subscriptions to the service are based on an airline’s fleet size and cover all software, hardware, secure data hosting, data communications and support. The software provides total offline connectivity, and Conduce says it can also be used to replace other cockpit-based paperwork using its built-in eForms8 application. Since eTechLog8’s launch just over four years ago, the software has been adopted by the Thomas Cook Group, Royal Brunei Airlines and Airbus Transport International. The software is certified for use under several airworthiness authorities, and Conduce expects certification from France, Germany and Brunei within the next three months.

conduce.net/etechlog8/

2. Fully Mobile Log Reporting

Product: PilotLog
Specifications: As part of Trax’s eMobility suite of applications, PilotLog handles log reporting to help pilots monitor their aircraft and record necessary information. PilotLog includes functionality for flight monitoring and data, defect reporting, fuel and de-icing recording, service reporting and more. The application synchronizes with a customer’s existing Trax Maintenance & Engineering or Trax eMRO system so ground crew can prepare for resolution of defects. The company says PilotLog is truly mobile due to its offline capability, which enables automatic synchronization of input data when an aircraft reconnects to Wi-Fi. According to Trax, the application—which has been on the market for one year—is in the implementation phase for multiple customers.

mrolinks.mro-network.com/company/trax-usa-corp

3. Building Blocks for Boeing

Product: Crossmos
Specifications: Crossmos ETL software was developed in 2015 through close cooperation between CrossConsense and a number of airlines, including Swiss International Air Lines, its launch customer in 2016. The software offers dedicated user modes for flight and cabin crew, maintenance, administrators and authorities, as well as a bi-directional interface allowing data to be sent from the software to the back-end system and vice versa. Boeing acquired the intellectual property rights for Crossmos in October and plans to use the software as the foundation of its new Boeing Mobile Logbook. Development teams from CrossConsense are supporting the transition and future product enhancements, including an iOS version of Mobile Logbook that Boeing plans to release in fourth-quarter 2019.

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4. Fewer Maintenance Delays

Product: Ultramain ELB
Specifications: In use for more than a decade, Ultramain ELB is autonomous electronic logbook software that fully replaces paper technical logs, cabin logs, journey logs and damage logs. Using the software’s touch-screen interface, pilots and cabin crew are able to record discrepancies, inflight or on the ground, which are then transmitted in real time to ground-based maintenance personnel and systems. According to Ultramain, this allows for faster repairs and fewer maintenance delays, since maintenance crews can immediately review write-ups and prepare corrective action in advance. Ultramain ELB can be used for all fleet types, and the company says one of its customers recently went paperless by using the software, adding more than 12,000 iPhone and iPad users.

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5. Independent ETL Offering

Product: Skypaq eLog
Specifications: Skypaq eLog software enables airlines to collect technical logbook data and other information about MRO and flight operations such as defects and malfunctions, block times and fuel consumption. The software is independent of any aircraft OEMs, so customers securely own their operational data. Skypaq says its Mobile Backend as a Service (MBaaS) offering lets airlines build their own front end on top of the software’s framework, so Skypaq does the “heavy lifting” of data integration, hosting and 24/7 monitoring while customers’ IT departments can utilize the software’s data to build their own applications. Customers include Norra and Finnair; both recently received software upgrades allowing for direct two-way synchronization of data in real time between Skypaq eLog and Swiss-AS AMOS.

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AM Collaboration

New perspectives can help push adoption

Additive manufacturing (AM) is being used in engines, cabin interiors and airframe structures, but feedback from end users and understanding of their pain points is critical for the technology to advance.

This became clear after a recent conference of airlines, manufacturers and 3D-printing suppliers at the Etihad Airways Engineering Innovation Center for the RedCabin Aircraft Cabin AM summit.

Besides outside the expected benefits of AM—light weight, waste reduction or topology optimization, to name a few—the airlines ask questions such as, “How will this technology help improve the passenger experience?”

These unique views and new ways of thinking about AM help to build a better business case for the technology and provide guidance for promoting its adoption.

The AIRLINE VIEW

“The [aircraft] cabin is the image of the airline. Why is it so inflexible?” asks Bernhard Randerath, vice president of engineering at Etihad Airways Engineering, which says it is the only MRO with Part 21 G & J approval. The Etihad team developed and certified the first approved AM part, a Boeing 777 LCD shroud, in five months. Etihad managed the entire process from material selection and qualification, machine and process qualification and part testing. The 3D-printed part is 20% lighter, 30% cheaper and has an improved turnaround time (TAT) compared to a conventionally manufactured part.

For Etihad, most success in AM is in targeting small-volume, long-TAT or customized parts; the issue lies in certification. To date, Etihad has developed its own standards for certification. Its goal is to print 60% of the aircraft cabin in the next six years, which it cannot do if it must continue writing its own AM certification processes. This highlights the urgent need for clear and consistent industry standards.

Wayne Thomas, AM project manager at Air New Zealand, asks: “What can AM offer the airline industry in the future?” Today, ANZ uses AM for rapid prototyping, part customization and product differentiation.

The value proposition of AM in the cabin for ANZ comes from non-critical parts. Its AM road map looks for parts that affect passenger experience, have no critical safety effect, require limited post-processing and offer assurance that any quality escape would not affect part performance. This maturity-model approach helps build understanding and confidence in the technology, paving the way for growth in AM applications at the airline.

ANZ also sees the value of AM in offering quick replacement for worn or broken cabin parts. The airline aims to use AM to promote decentralized logistics and add AM design and manufacturing instructions to an illustrated parts catalog, too.

The MRO VIEW

Magnetic MRO offered insights into similar AM pain points and challenges, including the lack of suitable AM materials, immaturity in the Part 21 J design process, challenges in post-processing, surface treatment durability in high-wear areas in the cabin and concern about intellectual property (IP) protection. Similar to Etihad, Magnetic MRO focuses on AM for non-structural, cosmetic parts and manages the full AM process in-house.

MROs use AM in tooling and replacement parts in the cabin. The benefit of AM replacement parts lies in a shortened lead time of the overall repair cycle and potentially a shorter scheduled or unscheduled check. But this benefit does not come without challenges, for which Magnetic MRO requests better guidelines and acceptance from regulators and OEMs.

Next STEPS

To translate the pain points into areas for growth these steps should be taken: Standardize AM certification processes; mature material (flammability, selection, certification); establish processes for IP ownership and protection; increase availability of qualified service bureaus; and prepare for a new, rapidly changing supply chain.

Many of these pain points are not new to the AM industry and will take a collaborative effort to resolve. What needs to happen this year or in the near future to maintain momentum?

■ Include airlines and MROs in developing certification standards.

■ Train workers—AM will touch many new people who will need training to cover design, manufacturing and strategy.

■ Reconsider OEM business models to facilitate decentralized logistics.

■ Invite airlines and MROs to join the AM industry to discuss development of AM technology and application.

■ Promote better understanding of MRO by AM industry leaders.

It is critical to welcome new ways of thinking and celebrate successes of new AM adopters while leaning on lessons learned by seasoned AM pioneers. If everyone can work together across industries to solve some of the key issues, there will be rapid maturation across multiple points in the AM industry, enabling quicker and easier adoption at airlines and MROs.
Inside A technology to advance.

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Looking ahead: MRO BEER (Baltics, Eastern Europe & Russia) is happening on May 20-22, 2019, in Vilnius, Lithuania. Secure your place at the region’s largest MRO event to network with local market leaders and regional airlines, and to gain critical insight from expert led discussions on regional aircraft maintenance issues. This event features an integrated conference and showcase featuring 30+ exhibitors to create an unparalleled forum where key intelligence is gathered, real business leads are generated, and partnerships are forged. FL Technics is hosting a tour of their 8,500-sq.m. hangar and workshop facilities at the conclusion of the conference. Use promo code: LINKS20 to obtain 20% discount on registration fees. For more information on participating exhibitors, conference speakers or to register for the event please visit: mrobeer.aviationweek.com.

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VRC Metal Systems

Director of Sales & Marketing

931-240-1197

931-402-9366

info@vrcmetal.com

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Craft and control them in the airspace ... to more complicated AI," says Matt Duquette, a researcher with AFRL’s Aerospace Systems Directorate. “Once the system is in place, you could introduce more and more complex levels of AI to accomplish certain tasks or sub-tasks in a mission.”

Skyborg builds on AFRL programs such as Have Raider and the Automatic Ground Collision Avoidance System (Auto-GCAS), which have shown that “levels of autonomy in high-performance aircraft are not only possible, but they are practical,” Duquette says. “And that is why we are building on this foundation to do more of the mission-level capabilities.”

Under Have Raider, Lockheed Martin in 2017 demonstrated manned/unmanned teaming using an F-16 as a surrogate UCAV. Auto-GCAS is fielded on the F-16 and is being integrated on the F-35 to prevent controlled flight into terrain, and the Air Force views it as a first step on the autonomy roadmap.

Current autonomy algorithms are deterministic, meaning that a particular input always produces the same output. Bringing in AI, and machine learning, will require development of new techniques to ensure that the vehicle always behaves in a safe manner as it learns and adapts. This will be critical to building trust in an AI-driven loyal wingman.

“We want to start flight testing and begin, step-by-step, implementing higher-level, complex autonomy to understand what the issues are and how we build trust to the point where people start to feel comfortable with things like airworthiness and flight-safety approval,” says Maj. Ryan Carr with AFRL’s Aerospace Systems Directorate.

“One of the important parts of our autonomy development is building assurance into the system,” says Duquette. “There are two ways to do that. Either by using formal methods where at design time, as you develop autonomous capabilities, you guarantee certain behaviors. The other, more practical approach is to assess these behaviors as they are running on the aircraft.” This is known as run-time assurance.

“Those are the capabilities we are interested in looking at from an experimentation level, to see what type of assurance we need in the system,” Duquette says. This will include assessing whether the system can run a mix of software with high and low criticality.

“The common use of the term AI is geared more toward machine-learning,” says Tran. “But what remains to be seen is exactly how much of this AI do you really need to accomplish the mission?”

“Machine learning has progressed a lot over the last few years ... and we’re excited by things that are going on in the gaming industry, for example, and we expect that technology to continue to mature fairly rapidly,” says Carr. “What we really need to understand is how you take that and do something; bring it into the real world.”

Sole-Source Deal Beats Brexit Clock

UK BUYS E-7s IN THE AUSTRALIAN WEDGETAIL CONFIGURATION
BRITAIN WILL REDUCE ITS E-3 FLEET TO FOUR FROM SIX

Tony Osborne  London

Britain has committed to buying Boeing’s E-7 airborne early warning (AEW) derivative of the Boeing 737 in a $2 billion pre-Brexit spending surge.

A finalized contract with Boeing announced on March 22 covers the purchase of five aircraft and the conversion work, modifying the 737-700 airframe to the E-7 configuration, to be carried out in-country by Cambridge, England-based Marshall Aerospace.

The deal emerged as Britain continues to consider its future relationship with the European Union, with an inevitable plunge in the value of the pound when the delayed Brexit finally occurs.

Arrival of the first aircraft, planned for 2023, will enable the Royal Air Force (RAF) to pension off its Boeing 707-derived E-3 Sentry fleet.

Commanders had hoped to modernize the E-3s—the youngest Sentry fleet in the world—out to 2035, but financial austerity prompted by the 2008 financial crisis has left the E-3 aircraft and its onboard systems lagging far behind those operated by France, NATO and the U.S. Air Force.

Officials fear the RAF E-3s cannot easily be adapted to rapidly evolving threats. But they believe the E-7 can, since it is a more modern and reliable airframe with significantly reduced personnel requirements and equipped with more modern sensors.

The E-7 is flying in three separate configurations with three different air forces, those of Australia, South Korea and Turkey. Qatari plans to purchase the aircraft have been abandoned.

Britain’s aircraft will be modified to the Australian Wedgetail configuration, which benefits from additional onboard electronic support measures, defensive aids and more advanced software modes and capabilities for the Northrop Grumman-manufactured Multi-Role Electronically Scanned Array (MESA) radar that Washington was willing to release to Canberra but not to South Korea or Turkey. These were developed through the Five Eyes relationship, of which Britain is a part.

Details of a potential order for the E-7 emerged last October, when UK Defense Secretary Gavin Williamson announced the Defense Ministry had entered formal negotiations with Boeing and the Royal Australian Air Force (RAAF) to procure the platform.

The decision was controversial, as it represented yet another sole-source contract for Boeing, which is already slated to deliver P-8 Poseidon maritime patrolers and modernized Apache attack helicopters to the UK.
and fly with it. What we want to focus our attention on in this early period is how we take something that is growing so fast and bring it into the military safely and effectively."

Autonomy and AI will be a challenge not only for development and certification but to the testing community. So as a part of Skyborg, AFRL has partnered with the Air Force’s 412th Test Wing at Edwards AFB, California, to gain early experience using small, fast-moving unmanned air vehicles.

“There is a kind of Air Force culture change that we are trying to implement with the testing community,” says Tran. “For example, say we were to have four XQ-58s with a high level of autonomy and hand them over to the development test (DT) and operational test (OT) community. Right now we don’t have any procedures and processes in place to fly those on our test ranges and have four flying autonomously and collaborating in the air to do any sort of mission.”

AFRL is working with the test wing’s new Emerging Technologies Combined Test Force to start to test the current state of the art in autonomy and AI with small UAVs “and [assess] the ability for them to autonomously team and collaborate in flight,” says Tran.

“By starting small, it’s a lower-risk, lower-cost approach and not only will be able to scale the technology of what we fly, but we’ll also be able to scale the associated processes from a DT and OT perspective and start getting buy-in from the Air Force—not only from the test community but also the operational community—as we go out and fly this technology,” he says.

The CFRI lays out AFRL’s requirements for Skyborg. Critical requirements the system must meet include an open AI software architecture that allows autonomous behaviors to be added, conformance with Open Mission System standards so modular mission hardware can be added, and the ability to meet the certification requirements for U.S. military operation.

“The platform has to be autonomous, defined as “the ability to independently compose and select among different courses of action to accomplish goals”; resilient, with characteristics that increase survivability; and attributable, meaning priced at a point where losing the vehicle to achieve an objective can be tolerated. An attributable vehicle is reusable, but can have a higher probability of failure and lower service life than a conventional aircraft.

Highly desired requirements the system should have include the ability to autonomously take off, avoid other aircraft, terrain, obstacles and weather, and return; separate payload and vehicle architectures to allow for modular adaptability; and mission-planning software that integrates with the Air Force’s next-generation planning tools. A desired requirement that a robust Skyborg system could have is to “operate with personnel who have limited engineering or pilot experience,” says the CFRI.

—With Steve Trimble in Washington

The Wedgetail fleet likely will be based at Waddington, England, home of the UK’s intelligence-gathering platforms near the famous Lincoln Cathedral.

G550-based conformal AEW platform. Officials told parliamentary committees that a Wedgetail order presented the least risk. However, it is unclear whether Britain will benefit from the upgrade road map for Australia’s six Wedgetails. The RAAF is in the process of solidifying plans for a midlife update envisioned to enter service in 2026 (AW&ST March 25-April 4, p. 37).

Williamson says the Wedgetail purchase “strengthens our vital military partnership with Australia,” noting that Canberra is already operating the Lockheed Martin F-35 Joint Strike Fighter and is also purchasing the BAE Systems-developed Type 26 warship.

Australian Defense Minister Christopher Pyne suggests that the British deal would help secure jobs in Australia, notably in Wedgetail support, sustainment and training.

Australia has undertaken work to remove obsolescence from the platform and its systems, and Boeing in Australia has taken special measures to keep the Wedgetail flying. These have included buying plenty of spares while they are still in production, finding more than one supplier for parts, setting up repair capabilities and finding replacements.

Questions remain, however, on the production status of the MESA radar developed in the late 1990s, or even on Boeing’s project development team, although both companies have welcomed the contract. The most recent E-7 delivery was to South Korea in 2012.

The introduction of the Wedgetail adds another strategic platform to the British inventory that cannot be refueled in midair by the RAF’s Voyager tankers, which are not equipped with a refueling boom. However, defense officials say the E-7 meets the endurance requirements of the RAF mission without aerial refueling. If needed, the E-7s will rely on tankers from other nations.

British industry will play a larger role in the E-7’s procurement, at least compared with the paltry 5% workshare from the UK’s purchase of the P-8. Besides the conversion by Marshall Aerospace, the Defense Ministry says there will be opportunities for through-life support and training.

—With Bradley Perrett in Brisbane, Australia
China’s Long March 7 launched several satellites the first time it took flight.

Jen DiMascio Washington

A dozen years after China tested an anti-satellite (ASAT) weapon, both China and Russia are close to fielding missiles that could target U.S. assets in space.


China is also building ground-based anti-satellite missiles to target spacecraft in geostationary orbit and has satellites that can monitor, track and target U.S. forces worldwide, particularly in Asia, according to the Defense Intelligence Agency. It is developing jammers even against protected extremely high-frequency communications. The country is likely to field a ground-based laser that can counter low-orbiting spacecraft by 2020 and may have higher-power systems later in the decade. It is developing on-orbit satellite repair vehicles, which could also harm satellites. Russian capabilities are similarly on the rise, with renewed development of a kinetic anti-satellite missile, a laser ASAT weapon and inspector satellites that could service spacecraft or attack them.

In late March, C4ADS, a nonprofit providing data analysis on security issues, detailed a series of Russian-led spoofing attacks on global navigation satellite system (GNSS) receivers, primarily to cloak the location of high-ranking officials or troop movements (see map, page 43). And India, eager to showcase its space capabilities to neighbors Pakistan and China, knocked one of its own satellites out of low Earth orbit with a missile, creating a debris field.

Far beyond a single Sputnik moment, the collection of data points adds up to what Kenneth Rapuano, assistant secretary of defense for homeland defense and global security, acknowledges is a new space race.

Although the U.S. never stopped investing in space, it is scrambling to reorganize and push its acquisition programs to achieve faster time lines.

President Donald Trump is driving the creation of the Space Force, U.S. Space Command and the Space Development Agency. The U.S. Air Force has sought to remove layers of bureaucracy and overhaul its Space and Missile Systems Center, frequently employing new acquisition authorities. Its commander, Lt. Gen. John Thompson, says his office now resembles “a modern corporation that you might see in Silicon Valley.” And Congress has called for the creation of an Air Force Space Rapid Capabilities Office.

The Trump administration is looking to increase space funding, seeking more than $14 billion in fiscal 2020, 22.8% more than fiscal 2019, according to Velos, a consulting and engineering services company. The goal is to build a more resilient military space program that can withstand threats from jamming and spoofing, laser-dazzling or an
outside organizations such as The Aerospace Corp. are advising the department on how to achieve those goals, learning from the commercial sector to upgrade space capabilities more rapidly.

Steve Isakowitz, The Aerospace Corp. CEO, says it is time to move away from the mindset of an optimal architecture to respond to threats in space. “What’s pretty clear is that it’s not pretty clear;” he says. The Aerospace Corp., the Pentagon and industry are discussing an agile architecture involving flying more often and encouraging industry.

The Aerospace Corp. is also urging the military to take an “enterprise approach” to space. Right now, Isakowitz says, programs are organized distinctly along mission lines such as GPS, strategic communications, missile warning and weather. “We can no longer afford to do that,” he says. The Air Force’s Space and Missile Systems Center is looking at ways to standardize satellite buses, issuing a request for information last month on how to take a Modular Open Systems Approach to building an enterprise bus so that each payload could be adjusted to the mission needs—whether that be protected strategic communication; missile warning; position, navigation and timing (PNT); or nuclear detection.

An enterprise bus approach to satellites may work its way into the Evolved Strategic Satcom program, the next-generation constellation for protected satellite communications after the Advanced Extremely High-Frequency Satellite (AEHF) program, which will be in prototyping phases until 2024.

A common bus makes sense for the government, and it also works well for industry, says Mike Cachiero, vice president for protected communications at Lockheed Martin. “We want to minimize the non-value-added engineering touch labor required,” he says.

Despite those intentions, the Pentagon still plans to spend more than $12 billion through fiscal 2024 on its Next-Generation Overhead Persistent Infrared satellites in geostationary and polar orbits for missile warning, a follow-on constellation to the Space-based Infrared Satellite system (SBIRS). The Space Development Agency is experimenting with a low-Earth-orbiting architecture that would track unpredictable hypersonic missiles in flight and be more resilient.

As the Air Force is building a new generation of GPS IIIF satellites, the Army plans to buy 11 Assured PNT satellites to guard against GPS outages.

If some Pentagon acquisition efforts seem to overlap, that is due in part to the need to address different threats—and it also comes with moving at the speed of change. The military has been criticized in the past for moving slowly when it comes to space, but this administration is “breaking the sound barrier,” Isakowitz says.

Such rapid transformation may bring future difficulties, says Cristina Chaplain, director of contracting and national security acquisitions at the Government Accountability Office.

The Pentagon has learned time and again that space is a difficult place to do business. The cost of Lockheed Martin’s AEHF satellite program, a protected satellite communications system, grew by 117%, and it launched 3.5 years late. The missile-warning SBIRS, also by Lockheed, was delayed nine years and saw its cost increase 265% to nearly $20 billion. The GPS next-generation operational control system to provide secure command-and-control for GPS III satellites made by Raytheon is 68.1% over budget and about five years behind schedule.

As this next series of space programs begins, there are open questions about who will lead space programs that cross between the Missile Defense Agency, the National Reconnaissance Office and military space, Chaplain points out. That uncertainty may invite risk, given the number of new programs being launched—programs that cannot be fixed once on orbit. Plus, the Defense Department lacks technical expertise in space acquisitions. And even though the Pentagon is looking to do more by upgrading software, she notes in her report that the department “has struggled to deliver software-intensive space programs that meet operational requirements within expected time frames.”

Thompson says even though they are moving fast, their goal is to offer lawmakers so much transparency on rapid acquisition programs that Congress will ask them not to go back to traditional acquisition methods. “We don’t want to lose the oversight,” he says.

—With Lee Hudson in Washington

In its Above Us Only Stars study, the nonprofit C4ADS found the navigation systems of 1,311.
Why is there a renewed focus on space, and what types of threats will the U.S. face in the future? The United States of America is the best in the world at space—our allies benefit from it, but our adversaries know it, and they’ve been watching us since the early Gulf wars in the 1990s, where we started using space even more for position, navigation and timing. We started using GPS to guide bombs, we definitely used our military satellite communications for our warfighters on the ground; we even started using our missile warning systems to do early warning for theater ballistic missiles. Our adversaries have been watching us since then . . . and think it’s our Achilles’ heel and are devising ways to come after us. It’s Russia and China, to be very specific, and those countries are developing systems that could disrupt our use of space. There is a continuum they could start using for . . . reversible types of attacks. If you jam a satellite link, you’re not destroying the satellite; cyber could be reversible. Some kinds of lasers are reversible, they’ll just dazzle or disrupt nonpermanently. [There is] co-orbital, meaning other satellites up there disrupting our satellites. Our ground sites could be full-on attacked, and on the far right of this continuum is nuclear detonation in space, which would be very disruptive. Honestly, our intelligence is telling us that our adversaries are working on this entire continuum. Some of the earliest evidence of that was in 2007, when China launched an anti-satellite rocket missile [and] took out their own weather station. They did this as a kind of “demonstration,” but the response from the Air Force and [Pentagon] was that it is a demonstration of a threat—it is serious.

What future capabilities is the U.S. developing to combat these future threats? These systems have been designed to operate in a benign environment for the last 20 years or more and there has been no threat—there are no defenses on our systems. They’ve been freely operating, and we know that we need to change.

In the future, one ground system could see and control everything happening. We have to do something called pivot to SSA, or space situational awareness, as a priority because of the way we understand and track everything that’s going on up there, as opposed to maintaining a catalog of space objects—it’s not a dynamic command and control system right now.

In the future, we’re going to have to be able to ascertain exactly what’s happening in each one of these orbital regimes.

What role will small satellites have in the future with keeping pace with adversaries? The vision and architectures we are looking at call for smaller satellites with 3-5-year design lives, rather than the 10-20-year design life. We have to think about what we are going to do as technology is rapidly changing—we’ve got to capitalize on that.

Our launch capabilities need to be more responsive, and we should never be launching one thing at a time. If we’re going to have smaller satellites, with 3-5-year design lives, you would think we were launching more frequently. We have an affectionate term for it—a freight train to space, where future launches would be stacked with satellites, and if they’re smaller, you can stack more in there and replenish these orbits as needed or as rapidly as possible in case of an attack.

How are space operators being trained differently? When you tell an operator on an ops floor that what they used to think was a satellite anomaly or a glitch . . . could be a nefarious act by Russia or China, they are not saying, ‘Oh, let me look at my tech data.’ No, they’re diving right in trying to understand the capabilities of what Russia or China could be doing to us, what the symptoms look like on our satellites or on the ops floor. We don’t know how to fight in space—we don’t have the tools [and] we don’t have the weapons.

How is the Air Force partnering with other entities on Blackjack? We’re partnering with DARPA, Air Force Space Command and the Space and Systems Missiles Center in Los Angeles to see if they can conduct a demonstration in low Earth orbit (LEO) with smaller satellites and look at some of these missions up here in geosynchronous Earth orbit, bring them down to LEO and try to figure out if it is technologically possible how communication would happen with the ground segment. About 20 satellites will be put into LEO. Possible payloads could be overhead persistent infrared, which is the missile warning mission, radio frequency or persistent, navigation and timing.
there, as opposed to maintaining a catalog of space objects—the way we understand and track everything that’s going on up there. We have to do something called pivot to that we need to change.

These systems have been designed to operate in a benign environment for the last 20 years or more and there has been no threat—there are no defenses to operate in a benign environment for the last 20 years or more. What future threats will the U.S. face in the future?

What future capabilities is the U.S. developing to combat these future threats? The vision and architectures we are looking at call for smaller satellites with 3-5-year design lives, rather than the 10-20-year design life. We have to think about what we are going to do as technology is rapidly changing—are we going to have smaller satellites, with 3-5-year design lives, you should never be launching one thing at a time. If we’re going to have smaller satellites, with 3-5-year design lives, you can stack more in there and replenish these orbits as needed or as rapidly as possible in case of an attack.

Our launch capabilities need to be more responsive, and our adversaries know it, and they’ve been watching us since the early Gulf wars in the [19]90s, where our launch capabilities were some of the earliest evidence of that was in 2007, when China launched an anti-satellite rocket missile [and] took out their own weather station. They did this as a kind of “demonstration,” but the United States did not—don’t have the tools [and] don’t have the weapons. Our adversaries have been watching us since then . . . and think was a satellite anomaly or a glitch . . . could be a nefarious act by Russia or China, they are not saying, ‘Oh, let me look at my tech data.’ No, they’re diving right in trying to understand the capabilities of what Russia or China could be doing to us, what the symptoms look like on our satellites. They’ve learned from these missions up here in geosynchronous Earth orbit, bring payloads could be overhead persistent infrared, which is the Persistent, navigation and timing. We started using GPS to guide bombs, we definitely started using space even more for position, navigation and timing. We started using GPS to guide bombs, we definitely started using space even more for position, navigation and timing.

In the future, we’re going to have to be able to ascertain exactly what’s happening in each one of these orbital regimes. We should never be launching one thing at a time. If we’re going to have smaller satellites, with 3-5-year design lives, you can stack more in there and replenish these orbits as needed or as rapidly as possible in case of an attack.

In the future, one ground system could see and control everything happening. We have to do something called pivot to that we need to change.

Honestly, our intelligence is telling us that our adversaries have been watching us since the early Gulf wars in the [19]90s, where our launch capabilities were some of the earliest evidence of that was in 2007, when China launched an anti-satellite rocket missile [and] took out their own weather station. They did this as a kind of “demonstration,” but the United States did not—don’t have the tools [and] don’t have the weapons. Our adversaries have been watching us since then . . . and think was a satellite anomaly or a glitch . . . could be a nefarious act by Russia or China, they are not saying, ‘Oh, let me look at my tech data.’ No, they’re diving right in trying to understand the capabilities of what Russia or China could be doing to us, what the symptoms look like on our satellites. They’ve learned from these missions up here in geosynchronous Earth orbit, bring payloads could be overhead persistent infrared, which is the Persistent, navigation and timing. We started using GPS to guide bombs, we definitely started using space even more for position, navigation and timing. We started using GPS to guide bombs, we definitely started using space even more for position, navigation and timing.

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industry has been looking for a solid sign that the Pentagon is serious about its Future Vertical Lift (FVL) initiative to develop new rotorcraft to replace its helicopter fleets. The U.S. Army’s fiscal 2020 budget request provides that sign. But at a cost.

The inevitable price to be paid for investing in the future is cuts in the present, to the helicopter programs that must sustain the industry until the new generation of rotorcraft is ready for production.

The Army’s budget request lays out plans to spend more than $4.7 billion over the fiscal 2020-24 Future Years Defense Program (FYDP) on FVL. But to free up some of that funding, the service plans to slow procurement and upgrades of the Boeing AH-64 Apache and Sikorsky UH-60 Black Hawk and cancel the Block II upgrade for regular Army Boeing CH-47F Chinooks.

Most of the FVL funding, $427 million in fiscal 2020 and $2.13 billion of the FYDP, will go toward the Future Attack Reconnaissance Aircraft (FARA) program. FARA is the planned replacement for the AH-64Es that took over the armed scout role after the Bell OH-58D Kiowa Warrior was retired in 2017. Congress added $75 million to the 2019 budget to launch the FARA program.

Another $984 million over the FYDP will go toward the Future Long-Range Assault Aircraft (FLRAA), the planned replacement for the Army’s UH-60s and special forces’ MH-60s as well as the U.S. Marine Corps’ Bell UH-1Y Venoms. Congress added $20 million to the 2019 budget; the Army is seeking an extra $10.3 million, for a total of $32 million, in 2020 to accelerate the FLRAA program.

But the planned cuts to existing programs that would fund these investments are certain to come under attack in Congress. Lawmakers for the Philadelphia district where Boeing produces the Chinook have already fired warning shots over the plan to end CH-47 procurement for the regular Army in 2020. The Army’s statement that half the AH-64 fleet will be replaced by FARA could also generate opposition.

Despite the cuts to other programs, the Army’s FVL leadership portrays the 2020 budget as a victory for the service’s aviation arm. “We are laser-focused on building an aviation force that is optimized for large-scale combat operations against a peer or near-peer competitor, and we did very, very well in this [president’s budget],” says Brig. Gen. Walter Rugen, director of the FVL Cross-Functional Team (CFT).

The $790 million sought in 2020 will go toward multiple “lines of effort” under the FVL CFT. These include FARA, FLRAA, the Future Unmanned Aircraft System (FUAS), air-launched weapons and UAS and the modular open system architecture that will enable these platforms to be upgraded more easily and affordably to remain relevant over their lives.

Funding added by Congress for 2019 will support additional envelope-expansion flight testing by the two Joint Multi-Role (JMR) technology demonstrators—Bell’s V-280 Valor and the Sikorsky/Boeing SB-1 Defiant—paving the way for FLRAA. “That $20 million add by Congress will be coming out on contract soon,” says Rugen.

The V-280 advanced tiltrotor has been flying since Dec. 18, 2017, and has exceeded its 280-kt. target cruise speed. The SB-1 coaxial rigid-rotor compound helicopter finally flew March 21. Despite the delay, Rugen says the Sikorsky/Boeing team has already provided 80% of the data the Army needs, mostly from the ground-based powertrain systems testbed in West Palm Beach, Florida. The SB-1 is targeting a cruise speed of 250 kt.

The analysis of alternatives for FLRAA, underway since the second quarter of 2017, will be released next quarter. The draft capabilities development document (CDD), required for a Milestone A decision to launch the program, is being finalized, and a request
Army plans call for FARA to transition to a formal program of record in fiscal 2024, potentially at a Milestone B decision to launch engineering and manufacturing development. Bidders could include AVX Aircraft, which has teamed with L-3 Technologies, as well as Bell, Boeing and Lockheed Martin’s Sikorsky, the latter with a version of the S-97 Raider high-speed helicopter that is already in flight test.

The Army says FARA will replace all the AH-64s now assigned to heavy attack reconnaissance squadrons, which represent about half of the fleet. These squadrons, in which AH-64Es are teamed with Textron RQ-7B Shadow tactical UAS, were created in 2015 as an interim solution to the budget-driven retirement of the OH-58Ds.

“The Apache is the best attack helicopter in the world, but it’s not the best armed reconnaissance helicopter,” says Rugen. “We need a smaller form factor that can hide in the radar clutter and that has reach.” FARA will have a rotor diameter of no more than 40 ft., compared with the AH-64’s 48 ft., and its range “is going to be a leap ahead” of the Apache’s, he says.

“One of our biggest challenges is going to be to have a survivable, lethal platform that can operate in a megacity,” Rugen says. “Because of the rotor diameter and size, [FARA] is going to be able to operate in megacities.”

The Army has no firm timetable for bringing FARA into the fleet, Army Chief of Staff Gen. Mark Milley told Congress on March 26. “I think it is still a moving target with industry, because we want to see the prototypes.”

The remaining half of the Apache fleet that will not be replaced by FARA are assigned to attack reconnaissance battalions and will continue to perform the attack helicopter’s original mission. “A future attack aircraft that replaces the Apache would be a follow-on program for Future Vertical Lift once FARA and FLRAA are underway and the budget supports it,” the Army says.

“The Apache is going to need to be replaced in the out-years,” Milley told the House Armed Services Committee. “We are looking at an aircraft that . . . essentially goes farther, can see farther, can acquire targets farther and can engage at greater ranges than currently exist.”

Meanwhile, the Army plans to slow procurement of AH-64Es. The budget requests trim procurement to 48 in fiscal 2020, a reduction of five aircraft
from fiscal 2019 plans, and to 210 over the FYDP, a cut of 37 (see table). The budget terminates procurement of new-build AH-64E and buys only re-manufactured aircraft. This will cut $839 million in funding over the FYDP from the profile projected in the 2019 budget request. But the Army has increased its acquisition objective for the AH-64 to 812 aircraft from 690, potentially extending production well into the 2020s.

The Army plans to increase UH-60M procurement in fiscal 2020 to 73 aircraft, up 25 from fiscal 2019. But over the FYDP, the service plans not only to cut UH-60M procurement by 38 aircraft to 177 but also to trim the UH-60Ls upgraded to glass-cockpit UH-60Vs by 23 aircraft, to 159. This will cut $192 million over the FYDP from the profile projected in the 2019 budget request. The Army’s acquisition objective, 1,375 UH-60Ms and 760 UH-60Vs, is unchanged.

It appears the biggest bill-payer for FVL within Army aviation will be the Chinook program. The Army originally planned to upgrade 542 CH-47Fs and 69 MH-47Gs to the Block II standard. Now the service plans to take delivery of the last CH-47F Block I in 2020 and then procure Block II upgrades only for the special-operations Chinooks. If the plan survives Congress, it would make the Block II the last in a long line of upgrades stretching back to the 1960s.

The Army is seeking nine aircraft in fiscal 2020, one more than in 2019, and 34 over the FYDP, a reduction of 24—all to be delivered as MH-47Gs. This will cut $638 million over the FYDP, but the bigger savings would come in the out-years when the regular Army CH-47F Block IIs were due to be produced.

Boeing is under contract to produce three Block II EMD aircraft plus the first eight MH-47G Block IIs for Army Special Operations Command. The first EMD aircraft flew on March 28. The upgrade includes lighter one-piece fuel cells, a redesigned electrical system, a strengthened airframe, uprated transmission and advanced composite rotor blades that increase maximum takeoff weight to 54,000 lb. from 50,000 lb. and restore lifting capacity lost to weight growth over the years.

The justification for canceling CH-47F Block II procurement to free up funding for FVL is that the Block I upgrade has made the Chinook fleet the youngest in the Army, with an average age of less than eight years. “The CH-47F Block I provides an extremely capable heavy-lift capacity, and the Army currently has over 10% more Chinooks than required,” says Army undersecretary Ryan McCarthy.

But the Block I cannot lift some of the Army’s heavier systems such as the up- armored Joint Light Tactical Vehicle and extended-range howitzer, leverage Congress may wield in an effort to restore funding. “Delaying CH-47F Block II production funding would have significant detrimental impacts for fleet readiness, the defense industrial base and taxpayers, and hamper soldiers’ abilities to carry critical payloads,” says Boeing in a statement.

While replacing the Apache and Chinook remain well in the future for FVL, the Army has other near-term priorities under the same cross-functional team. These include air-launched effects, which encompasses both new missiles and UAS designed for deployment from rotorcraft. “You will see a CDD coming out by the end of this year on air-launched effects,” says Rugen.

“We are doing heavy demonstrations, but you are also seeing a commitment from the Army to fund opportunities in air-launched effects,” says Rugen. “We’ll be doing demos two or three times a year on air-launched effects.” Rugen cites an air-launched UAS demonstration at Yuma Proving Ground in Arizona and a “robotic breach” exercise planned for the multinational Joint Warfighting Assessment 2019 in May at Yakima Training Center in Washington.

“One of the air-launched effects is swarming. We had a launch in Yuma last August, and we will do a robotic breach of a complex obstacle in May,” Rugen says. “We’ll launch two air-launched effects from a Black Hawk and have those over the robotic breach. The ground guys are going to be breaching via robot as well.”

The Army is also looking at new weapons for FARA. The XM915 20-mm gun is already under contract with General Dynamics, and a new integrated missile launcher is on contract with SAIC. Army plans include a next-generation air-to-ground missile, loitering multi-role guided missile and modular open-architecture weapon that would come in both rocket-propelled and drop/glade versions.

Within the FUAS line of effort under FVL, the Army has selected two Future Tactical UAS (FTUAS) designs for operational evaluation as replacements for the RQ-7B Shadow. Martin UAV, teamed with Northrop Grumman, will provide its Bat tailsitter vertical-takeoff-and-landing (VTOL) UAS, while Textron Systems will provide the Aerosonde HQ hybrid-quadrotor VTOL UAS.

“We wanted to get after solving some of the Shadow’s problems with acoustics and runway dependency,” says Rugen. “It takes too much to air transport [the Shadow system]. We want to put everything in one Chinook. With the downselect, we’re hoping to solve that. We’re going to put [FTUAS] into soldiers’ hands in [fiscal 2020], and they are going to fly it and tell us if they love it or not.”

Under FUAS, the Army is also conducting demonstrations for the Advanced UAS, which would operate alongside FARA and FLRAA. “On Advanced UAS, we are doing some demonstrations at China Lake [NAWS in California] on platforms that the Army owns to see how we do against our pacing threats.” Additionally, FARA is intended to be optionally manned and able to act as an unmanned “loyal wingman” to other FARA and FLRAA rotorcraft when penetrating contested airspace.

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**Boosting FVL: Where the Army Aviation Cuts Fall**

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**AVIATION WEEK & SPACE TECHNOLOGY/APRIL 8-21, 2019**
**U.S. Army Embraces Virtual Reality Helicopter Training**

**ARMY NEEDS TO TRAIN 1,300 PILOTS A YEAR FROM 2021**

**U.S. AIR FORCE EXPERIMENTS WITH VR HAVE SLASHED TRAINING TIMES BY TWO-THIRDS**

**Tony Osborne**

The U.S. Army is planning to experiment with virtual reality (VR) simulators in a bid to bolster the basic helicopter-flying skills of its students long before they take the controls of an actual rotorcraft.

Commanders are hoping the technology can speed the throughput of the Army aviation training machine at a time when the new era of state-on-state competition is escalating the need for pilots as the service gears up to train 1,300 new pilots a year from 2021.

At the same time, the Army is grappling with pilot retention issues as the number of personnel leaving for the private sector or retiring nears record highs.

The service is hoping VR technology can help streamline training and is looking to begin trials with it as early as April.

“Stepping into an actual aircraft with your first instructor, you probably only remember 10% of what he told you. . . . Now imagine if you were absorbing 70%,” Maj. Gen. William Gayler, the commander of the U.S. Army’s Aviation Center of Excellence at Fort Rucker, Alabama, said at the International Military Helicopter Conference in London in February.

One test of the technology featured an Army trainee who had not yet entered flight school learning how to hover a helicopter in just 45 min., Gayler recounts. “It is a powerful capability,” he says.

Using VR for military flight training was the brainchild of the Air Force, which began its own Pilot Training Next program using VR in April 2018. According to reports, of the 20 pilot students in the inaugural class, 18 earned their wings in just four months. Normally, pilot training takes about a year.

Cost is a major advantage of the system, because the VR setups use off-the-shelf gaming computers and headsets that cost a fraction of the millions of dollars spent on high-fidelity simulators.

Gayler now wants to install 30 of the VR devices at Fort Rucker and is looking at spending $7.3 million on an artificial intelligence system that could ultimately provide a cognitive capability that would act as the instructor. The Army also wants to provide more tactile control feedback to the students.

Once installed, three groups of students will be established—one control and two test groups—and Army instructors will then attempt to find the right blend of VR training needed before the students transition to the real thing.

“This is not a goal to take flight hours away, but to produce a better product,” Gayler points out. “If we get better velocity [speed of training throughput], then that’s great. And if we save flight hours on an advanced aircraft, then we have paid for a simulator.

“It makes sense to try it,” he adds. The move reflects the Army’s wish to refresh its aviator training after more than a decade of preparing pilots for counterinsurgencies in Afghanistan and Iraq and better preparing them for potential state-on-state conflicts.

Its Aviation Warfighting Initiative is adjusting how to train for certain tasks and is demanding a refresh of skills for low-level flying after years of flying at height to avoid small-arms fire, as well as better understanding electronic warfare and air defense systems.

Gayler says that in recent years the training program had become far too focused on learning acronyms and unnecessary technical detail.

“What I care about is that you can fight; we are completely changing to focus on warfighting,” he stresses.

Introduction of the Eurocopter UH-72 Lakota as the Army’s primary training aircraft has helped, notes Gayler. The aircraft’s systems have made it easier for young aviators to bring the aircraft to takeoff and hover.

Indeed in some respects, “we have learned that it is too easy for them to do,” says Gayler.

Army analysis of pilots trained on the Lakota compared with those training on the older analog TH-67 Creek—a derivative of Bell’s Model 206 JetRanger—revealed that the “TH-67 pilots were pretty good pilots but were not so good at learning systems management, while the Lakota students were good at systems management but could not fly that well,” Gayler says. Pilots learning to fly on the
Ex-U.S. Army CH-47s and UH-60s Converted for Firefighting

> COULSON-UNICAL JOINT VENTURE IS MODERNIZING THE AIRCRAFT

> COULSON IS ADAPTING ITS WATER-DELIVERY SYSTEM FOR ROTOCRAFT

Tony Osborne Atlanta and London

Ex-U.S. Army Black Hawks and Chinooks are finding new roles as high-technology aerial firefighters.

Coulson-Unical, a joint venture of Canadian operator Coulson Group and California-based Unical, believes its approach to modernizing the ex-military rotorcraft with an advanced tank delivery system and upgraded avionics could give it an edge in securing firefighting contracts in the U.S., Australia and elsewhere. Best known for the firefighting conversion of Lockheed C-130 Hercules and, more recently, ex-Southwest Airlines Boeing 737-700s, Coulson is adapting its Retardant Aerial Delivery System (RADS) used on those fixed-wing types as a roll-on/roll-off unit for the Unical-owned helicopters.

Unical has one of the largest fleets of ex-military UH-60A Black Hawks and CH-47D Chinooks, with fleets of 35 and 12, respectively. Under the new joint venture, announced at Heli-Expo in Atlanta in early March, Unical revealed it will begin modifying the helicopters as part of a phased modernization program, to ready them for the 2019 and 2020 fire seasons.

It is one of a growing number of operators buying surplus Black Hawks and refurbishing them for commercial use. New-build Black Hawks are also being purchased by fire departments: The Los Angeles County Fire Department, California Department of Forestry and Fire Protection and the San Diego Fire-Rescue Department have all purchased the type in the last 12 months. This prompted Sikorsky to secure a restricted type certificate from the FAA for its S-70M derivative of the UH-60M.

Each of the Coulson-Unical Black Hawks and Chinooks will undergo a “full reset,” says David Graham, general manager of Unical’s maintenance, repair and overhaul organization. Once fully modified, the Black Hawks, to be known as CU-60s, will carry a 1,000-gal. tank fitted into the cabin, while the Chinook (which will become the CU-47) will feature a 3,000-gal. tank that can be fitted into the cargo hold via the rear ramp. On both, the water will be collected in-flight using a retractable snorkel.

To deliver it, Unical will cut open the lower fuselage to allow release of water from the RADS tank. Although openings will be cut in the lower fuselage to allow release of water from the RADS tank, Unical believes the aircraft will still be able to perform the utility mission using its underslung load cargo hooks.

Coulson-Unical joint venture is modernizing the aircraft, to ready them for the 2019 and 2020 fire seasons. It is one of a growing number of operators buying surplus Black Hawks and refurbishing them for commercial use.

Other tanks used on the Chinook drop through the helicopter’s hellhole (the opening in the floor used by the crew to monitor underslung loads), but that is a “small area to get this water volume through,” says Ceccanti. The computer-controlled tank can release water at different rates or simply drop the water at the same time, a capability that can be used to knock trees down if they are causing a hazard to firefighters on the ground, notes Ceccanti.

As well as being able to manipulate the load and fill capacity of the tank using a touch-screen display, the tank is linked to the aircraft’s navigation system and records the pickup and drop locations of the water.

Pickup locations are particularly crucial, notes Ceccanti, as they allow contractors such as the U.S. Forest Service to replace the water taken from farms. “In the past, you would have had one pilot flying and the other noting down all the lats and longs [coordinates], . . . Now we can just do a data dump,” says Ceccanti.

Development and FAA certification from ruining the fruit. “By dropping the water through the belly [for the firefighting role], we know we can control the rate of drop and get the coverage required by the authorities,” says Mel Ceccanti, Coulson director of rotary-wing flight operations.

Although openings will be cut in the lower fuselage to allow release of water from the RADS tank, Unical believes the aircraft will still be able to perform the utility mission using its underslung load cargo hooks.
of the RADS tanks for both helicopters will be completed toward year-end.

The multiphase avionics update will first introduce a GPS, additional radios and flight-tracking monitoring systems required to allow the aircraft to support Forest Service commitments. After that, the joint venture wants to install a Garmin avionics suite into both helicopter types with flat-panel displays and engine instrumentation to standardize the navigation as well as communication systems. This will enable the Coulson-Unical pilots to be dual-qualified on both the Black Hawk and Chinook.

“If we can make the actual art of flying the aircraft as similar as possible, then we only need to worry about the throttles and the switchology in the different aircraft,” explains Ceccanti.

Under the joint venture, Unical owns the helicopters and Coulson will operate and maintain them when on firefighting duties. They will return to California for maintenance and modification. The joint venture has yet to decide whether all the helicopters will be modified to the CU-60 and CU-47 standard, but domestic and international demand for firefighting helicopters is far from extinguished.

“Firefighting is no longer a seasonal job,” says Ceccanti. “The U.S. fire season is now 12 months long, and that means aircraft are being kept on contract for longer. . . . It is a tug of war, and it impacts on contracts on the other side of the world.”

Increasingly, firefighting operators are turning to heavy-lift operators flying outsized airlifters to take the helicopters to other parts of the world. A four-week break putting the aircraft on a ship is no longer an option.

Coulson-Unical plans to have one UH-60 and one CH-47 equipped with firefighting buckets ready for the 2019 fire season but will ready two UH-60s and four CH-47s for the 2020 season, all of which will be RADS-equipped.

Unlike many water tank configurations for the Black Hawk, the RADS tank is fitted inside the cabin rather than underneath the fuselage.
A n industry-backed challenge to develop a safe and quiet personal flying device, the $2 million GoFly Prize, has announced five winners of its prototyping phase, paving the way for the flyoff early in 2020. Each of the Phase 2 winners receives $50,000 to advance their electric vertical-takeoff-and-landing (eVTOL) design toward the finals.

“We were looking for safety and innovation, and that is what we saw from the winners,” says Gwen Lighter, CEO and founder of GoFly. “There was great technical competence, innovation and video evidence of flying prototypes.”

The five winning Phase 2 teams are: Aeroxo, with the ducted-fan ERA Avia bike; DragonAir Aviation, with the multicopter Airboard 2.0; Silverwing Personal Flight, with the ducted-fan S1; Texas A&M Harmony, with the coaxial-rotor Aria; and Trek Aerospace, with the ducted-fan Flykart2. The Aeroxo team is based in Latvia and Russia, and Silverwing in the Netherlands. The other three winning teams are in the U.S.

GoFly is looking for an easy-to-fly device that is no larger than 8.5 ft. in any dimension and can safely carry a single person weighing at least 200 lb. for at least 20 min, averaging a speed of at least 30 kt. over a 6-nm course. The vehicle must be able to take off and land within a 30-ft.-dia. cylinder with 12-ft.-high virtual walls, generating a noise level of no more than 87 dBA at a distance of 50 ft.

“In this phase, we were trying to identify and reward teams that will be able to show up at the flyoff with an aircraft that can do the mission—something that has potential, that shows they have thought about what happens after the competition,” says Sky Sartorius, GoFly technical manager. “It is not about who is most likely to win. It is about who is able to show up, not the best aircraft.”

Boeing is the main sponsor of the GoFly Prize. A $1 million grand prize will be awarded to the team with the best overall flyoff score, with $250,000 prizes for the quietest and smallest entries and a $100,000 award, sponsored by Pratt & Whitney, for “disruptive advancement of the state of the art.”

Of the 40 teams that registered for the prototype phase of the challenge, GoFly received submissions from 31. Selection of the five winners does not prevent other teams from entering the final phase, and GoFly will issue invitations to the flyoff event to those that met the Phase 2 submission requirements.

Phase 2 submissions went through two rounds of judging. “All teams were assessed on all aspects by multiple judges,” says Lighter. “The top teams went into a second round with new judges. By the time the winning teams were selected, they had been reviewed by 16 different judges.”

Aeroxo's Airbike is a motorcycle-like design with 16 ducted rotors arranged in groups of four that tilt between vertical and horizontal flight and are mounted on the ends of fore and aft wings. Silverwing's S1 is also a motorcycle-style design but is a tailsitter eVTOL with two large ducted fans aft of the passenger shell. A foreplane and an aft wing enclosed within the ducts provide lift in forward flight.

For the three winning teams located in the U.S., the design approaches and motivations for participating in the GoFly Prize are quite different.

Trek Aerospace's Flykart2 has a single seat flanked by 10 ducted rotors. Founded in 1996, Folsom, California-based Trek has long experience with ducted propellers, consulting for and supplying other companies. These include startup XTI Aircraft, which is developing the TriFan 600 hybrid-electric ducted-fan VTOL busi-
ness aircraft. “We are building up their concept vehicle,” says Trek President Rob Bulaga.

“A couple of years ago, we built a small personal aircraft, the Flykart1, to showcase our technology. It already met most of the requirements, and GoFly was a chance to show off ducted props to a bigger audience,” he says. “GoFly helped us focus on more detailed requirements such as the reliability needed to carry a person. We went from eight to 10 ducts so it can lose a rotor and keep flying.”

Unmanned test flights of Flykart2 began in February, but Bulaga says the vehicle landed heavily when he chopped the throttle too quickly, breaking one of its gears. Strength and shock absorption have been added to the gear and the airframe modified to reduce flexing. “It will be back in the air in 2-3 weeks,” he says.

Ducted props offer three benefits, Bulaga notes: twice the thrust of an open propeller for the same power, half the noise, and safety on the ground. The Flykart2 will fly for 40 min. on off-the-shelf batteries with about 10 kWh of capacity. Bulaga sees applications with first responders, the military and cargo delivery, but he says, “I’d like to see it offered as a kit that can be assembled in a weekend for under $50,000.”

In the egg-shaped Aria designed by Texas A&M University’s Harmony team, the occupant stands atop a coaxial rotor system. The team is led by Moble Benedict, assistant professor and founder of the university’s Advanced Vertical Flight Laboratory. “I started the lab with the mission to develop the next generation of VTOL concepts. When I heard about GoFly, I said that’s right up our alley.”

The team started with a clean sheet. “We tried to leverage our rotorcraft expertise to come up with a solution for GoFly versus just taking a multirotor,” says Farid Saemi, electric propulsion lead. “It had to be really compact, very quiet and fly 20 mi. That’s hard to do with a multirotor,” says Benedict.

The 8.5-ft. footprint was the biggest driver and resulted in the choice of a coaxial rotor system using cyclic pitch for flight control. “The secret sauce is in the blades,” says Benedict. “We spent most of our time on blade design and an optimization study to minimize noise without compromising efficiency.”

The team has built a full-scale six-deg.-of-freedom simulation of the Aria and flown a one-third-scale model to validate its modeling. “We are progressing toward the full-scale design,” says Benedict. The team plans to work with Texas A&M Corpus Christi’s Lone Star unmanned aircraft system center of excellence to test the full-scale vehicle ahead of the flyoff under its FAA certificate of authorization.

DragonAir’s Airboard is a multirotor platform on which the occupant stands, controlling the vehicle by leaning their body. The first version was built by lead engineer Jeff Elkins and flown by Mariah Cain, project manager and a competitor in hydroflight, a sport in which water-jet propulsion is used to sustain flight and body movement is used for control.

Having missed the initial deadline for GoFly, the team entered the competition when it was reopened for Phase 2. “We had just enough time to turn it into a corporation and file a submission,” she says.

DragonAir then began redesigning the initial, low-budget device into a prototype that fit GoFly’s rules. “It had to get smaller, but with the same amount of lift, carry 200 lb.
versus me at 150 lb., and fly for 30 min,” says Cain. The final design is smaller, with bigger batteries and four coaxial rotors. “We built one drivetrain, tested it to prove we can get the numbers we said, and extrapolated,” she says.

The prototype is expected to fly by the beginning of June. The DragonAir team has been self-funded so far. “The $50,000 prize is huge for us. Now we are going after sponsors and interested investors,” says Cain, who sees applications as a heavy-lift drone as well as a personal flying vehicle. “The GoFly platform has enabled us to create what we have always wanted to do.”

Disruption prize sponsor Pratt & Whitney praises the diversity of the teams. “The way the program is structured is nicely done in terms of leveraging diversity of thought across the teams,” says Geoff Hunt, senior vice president of engineering. “We see academic, international and entrepreneurial approaches. The diversity of thought in the competition so far is encouraging.”

Pratt sees sponsoring GoFly as a way to appeal to talent looking for innovation and disruption in their employer. “It’s a way to get closer to people who are thinking differently,” Hunt says. The company is looking to see if teams can continue to be disruptive and break with traditional development approaches as they tackle the challenge of developing vehicles for the flyoff, he says.

The GoFly Prize was launched in September 2017, Lighter believing technology had advanced to where personal flight was feasible. “What we are seeing is this convergence of breakthrough technologies that for the first time gives us the ability to make these fliers,” she says.

Since the competition was launched, several startups have unveiled ultralight eVTOLs—such as the Kitty Hawk Flyer, Opener BlackFly and Lift Aircraft Hexa—but Lighter believes GoFly’s threshold criteria for size, noise, safety and performance remain difficult to meet. “Those thresholds make these personal fliers truly unique,” she says.

“Our goal is to make people fly. The technology is applicable not only to GoFly but to the aerospace industry in general,” Lighter says. “The teams have displayed both ingenuity and technical prowess, and they will get better as they test and modify. We have a full year left to the final flyoff. GoFly’s job is to help all the teams keep improving.”

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Leonardo Helicopters is working with international medical associations to study the technologies required for future emergency medical services (EMS) helicopters. The air ambulance has transformed health care systems, saving lives by speeding up the transit of emergency patients to hospitals and reaching them in places too remote or difficult to access by road.

But air ambulance service also has its limitations. In most civilian EMS operations, use of helicopters is about speed, getting doctors to the scene of an incident as fast as possible, stabilizing the patient on-site and then flying them back to the hospital. Little or no treatment is usually provided while the patient is in flight.

Rotary-wing flight is not exactly conducive to treatment, as there is lots of vibration, noise makes it hard to communicate, and the small size of cabins in some helicopters can make it difficult to work on the patient, especially when bulky medical equipment is on board.

Leonardo believes advanced technologies could allow major medical procedures to be performed in-flight, adding time to the so-called Golden Hour; the period after a traumatic incident when prompt medical treatment can prevent death.

Over the last two years, Leonardo has been working with Sisart— the Italian Society of Anesthesia, Analgesia, Resuscitation and Intensive Care— on guidelines for helicopter EMS (HEMS) operations. The company is also working with AAROI-EMAC, an Italian association of resuscitation and emergency medical anesthetists to develop courses for HEMS doctors and nurses. This is also of interest to several operators and associations in Australia, Europe and the U.S.

In addition to working on its Future HEMS concepts, the company is also developing its Helicopter Rescue and Operational System (HEROS) training facility, which will support both rescue and medical training courses.

“The earlier you can provide life-saving care to the patient, the more chance you have of reducing permanent damage to the patients and saving lives,” says Massimo Quocchini, the company’s head of HEMS marketing.

Technology is already changing the ability of helicopters to fly and navigate in all types of weather, notes Quocchini. “If the hospital is open all the time, then the helicopter should be available all the time too,” he says.

Enhanced vision systems, night-vision goggle compatibility and helicopter terrain-awareness warning systems are increasingly becoming standard rotary-wing equipment to support safer all-weather operation, particularly at night. Leonardo is also developing a 3D-version of its Obstacle Proximity Ladar System (OPLS), which provides aural and visual warnings of obstacles near the blades of the helicopter, enabling landings in more confined spaces. Developments in performance-based navigation also have improved the capabilities of helicopters, but when crews need to pinpoint the exact location of an injured patient, one way to do that may involve tracking the location of a person’s cellphone. The company is working to develop a full deicing system for its AW169 intermediate-light twin-engine helicopter to meet a Rega Swiss Air Ambulance requirement, too.

Leonardo is also in the process of certifying its AW119Kx helicopter for single-engine instrument flight rules to meet the needs of the U.S. Navy’s helicopter trainer. Such a capability will also likely be desired in the U.S. for EMS missions.

Smother flight could become possible with the company’s work on active main rotor blades and electric tail rotors.

The market for EMS helicopters is evolving, with operators taking on increasingly larger aircraft. While most EMS helicopters in the U.S. are small single-engine types, specialist medical centers have purchased larger models, including the Airbus H155 twin-engine medium helicopter.

Another factor driving the move toward larger types is the fact that patients are becoming both taller and heavier. Critical to turning the EMS into a flying hospital will be the interior layout of the aircraft, notes Quocchini. On some air ambulance helicopters, patients are pushed up against a door. “Doctors want to be able to provide basic surgical intervention in flight,” says Quocchini. Such interventions, he says, could involve anything from stitching up wounds to stop bleeding to intubation (as in a tracheotomy) and carrying out heart massages.

With the right configuration, it may also be possible to provide so-called ECMO treatments in-flight, a process of oxygenating the blood when the heart and lungs are not functioning well, he says.

Leonardo is already studying the use of an onboard wireless internet router to link medical devices onboard without the need to trail wires around the cabin.

Emanuele Bufano, HEMS technology specialist at Leonardo, says a direct real-time link to the hospital will also be critical so that patient data can be monitored not only in the air but also by the doctors who will receive the patient on the ground. Such a link would allow specialist doctors to provide advice to medical personnel in the aircraft as well.

Another idea being studied is the use of helmet-mounted displays so doctors have patient data accessible in front of them throughout the flight. The company has tested stretchers with anti-vibration systems to improve comfort for patients with spinal injuries. There are also proposals to see if computed tomography scanner technology can be miniaturized or adapted for use on an EMS helicopter.
UTC’s Electric Transformation

- Project 804 will fly a hybrid-electric Dash 8 X-plane in 2022
- The Grid will test 1-megawatt, 1-kilovolt electrical system

Graham Warwick New York

United Technologies Corp. (UTC) is undergoing its biggest transformation since it was formed, as United Aircraft, by the breakup of Boeing and Pratt & Whitney in 1934. As it prepares to be reborn in 2020 as a focused, $50 billion aerospace supplier, UTC is taking a hard look at its role in enabling the future of aviation.

As a first tangible step, UTC has created a Skunk Works-like organization, United Technologies Advanced Projects (UTAP), to take on disruptive ideas that bring its business units together. The first of these, Project 804, involves modifying a Bombardier Dash 8 Q100 regional turboprop into a 2-megawatt hybrid-electric propulsion X-plane that will fly in 2022.

At the same time, UTC’s Collins Aerospace—formed in November 2018 by the merger of UTC Aerospace Systems and newly acquired Rockwell Collins—has unveiled a $50 million investment in a multimegawatt aircraft electrification and electric propulsion laboratory in Rockford, Illinois. Called The Grid, the lab’s first task will be to support development of Project 804.

UTC plans to spin off its Carrier and Otis businesses in 2020, emerging as an integrated aerospace supplier comprising Collins Aerospace and Pratt & Whitney. “This is an important time in the company’s history,” says Paul Eremenko, UTC chief technology officer. “With the standup of Collins and the spinoff of the businesses, we are reshaping the company into something fundamentally new. And an important part of that is having a ‘Skunk Works’ organization to more rapidly mature bundles of technology.”

The legacy UTC, as a holding company, had no mechanism to do things that required the integration of multiple product lines. “So as we began this transformation toward becoming a more focused, more integrated aerospace company, we started architecting some of these mechanisms for how we do things that are outside of existing business verticals,” says Eremenko.

UTAP is one of those. Set up to operate at the speed of a startup, UTAP will take on projects that meet one of two criteria. “It has to be the kind of thing you can’t do in a business unit for one of two reasons: either because it requires multiple business units to work together, or it’s too disruptive in nature to the existing product portfolio or the existing way of doing things,” he says. “Hybrid-electric propulsion meets both of the criteria.”

Project 804 is the first to be launched by UTAP because “the most pressing, most obvious need is for UTC to lead in the electrification of propulsion,” Eremenko says. The project’s name comes from the straight-line distance in miles between the two units involved: Pratt & Whitney Canada (P&WC) in Longueuil, Quebec, and Collins in Rockford. United Technologies Research Center is also participating.

Aircraft electrification is one of

A Dash 8 hybrid-electric X-plane is UTC’s first venture into propulsion electrification.

The first task for The Grid lab at Collins Aerospace will be to help develop the hybrid-electric system.
four strategic technology focus areas for the new UTC. The others are autonomy, connected aircraft and the connected ecosystem around the aircraft, and advanced design and manufacturing. All four build on existing strengths within UTC. For aircraft electrification, those comprise turbine engines at Pratt and electrical systems at Collins, where they developed the Boeing 787 power system.

The hybrid-electric propulsion project brings the two business units together and provides a startup-like environment in which to develop a demonstrator at convincing scale. “UTAP can move at the speed of a startup, but do it at the heart of the business,” Eremenko says.

“One of the constraints on UTAP is that we don’t want the demonstrators to run for longer than about 2-3 years and in that time they have to produce something that is productizable,” he says. “That means it has retired all the major risks. It doesn’t mean that it can be turned into a product overnight. UTAP doesn’t make products. But it also doesn’t just make technology prototypes.”

Under Project 804, a Dash 8 will be reengined—on one side only for safety—with a 2-megawatt parallel-hybrid propulsion system that comprises a 1-megawatt gas turbine and 1-megawatt electric motor. The flight demonstrator will act as both a “technology pull” and an integration platform for UTC.

“One megawatt on the electrical side is hard enough to pull technology versus the 250-500 kW we have today. But 1 megawatt is doable in a couple of years in a certifiable way,” says Eremenko. “What 804 does differently is it creates something that can be produced and makes sense for regional airlines.”

The 39-passenger Dash 8 Q100 is powered by P&W’s PW121 turbo-prop, rated at 2,150 shp (1.6 megawatts) for takeoff. In the hybrid system, this is replaced by a new 1-megawatt turbine engine under development by P&W. This turbine, or “thermal,” engine drives a gearbox that powers the propeller.

“With a 1-megawatt electric system we can downsize the thermal engine and get a significant efficiency improvement. The economic case closes and we can productionize it in a relatively small number of years. This is a technology and a product demonstration,” Eremenko says. “It delivers something that has looked at the major regulatory risks, the market opportunity, the business model and retired the top risk in each of those areas.”

A key part of Project 804 is the safety of the hybrid-electric propulsion system. “We’re looking carefully at the safety if this or that component fails and are thinking through how the electrical system would be certified. And to the extent that certification bias does exist, we want to work with the regulators to help develop it.” UTAP will not certify the system, but by the time Project 804 is finished, certification will not be high-risk, he believes.

Project 804 not only opens up the possibility of a hybrid-electric product for the regional market in the near term, it also lays the foundation for other avenues of aircraft electrification. “A key role for UTAP is to provide a technology pull. We wanted to develop 1-megawatt, 1-kilovolt-class electrical components, so we explored the set of possible concepts we could fly and identified this one as having a potential commercial off-ramp,” says Eremenko.

“It was an opportunistic play, and if it works, we will certainly explore this regional market. But we also get this technology pull so that we master this megawatt-class category of components, and we can move on from that,” he says. “It’s a hedge because I think it is not clear which way the industry is going to go in the longer term. But the fundamental technology base we are developing is applicable to pretty much any one of those futures.”

Pratt has said that megawatt-level power is an enabler for different types of propulsion electrification, from boosting a turboprop by bolting a motor to its shaft, powering a tail thruster for drag-reducing boundary layer ingestion or driving multiple smaller fans for distributed propulsion. “Megawatt [scale] opens up all those possible architectures,” says Eremenko.

Collins was already moving to multi-megawatt electrical systems before the project was launched. “What 804 is doing is driving a time line and an
impetus to do it quickly, and providing a concrete set of system-level set of requirements,” says Eremenko. “It was clear from the perspective of our Power & Controls business that we need to improve power density and move up power levels. Project 804 provides an additional pull: an early application of actually integrating the components onto an aircraft and flying.”

Part of a larger; $150 million investment Collins expects to make in electric systems over the next three years. The Grid builds on $3 billion the company says it has spent over the past decade advancing more electric architectures for aircraft. The 25,000-ft.² lab incorporates lessons from the Airplane Power Systems Integration Facility, where the 787’s 1.5-megawatt electric system was tested.

“Some key investments we had made a little more than 15 years ago got us ready for the first phase of aircraft electrification, like the 787 and military platforms that use high-voltage DC and electro-hydrostatic flight controls like the [Lockheed Martin] F-35,” says Tim White, head of Collins’ Power & Controls division. “What was key during that phase was early investment we had made in lab capability.”

The Power & Controls business was formed before Collins Aerospace was created in November, bringing together the electric power, thermal management and engine controls groups “because we see those discipline areas as being critical to the next phase of aircraft electrification . . . as we look at electric propulsion integrating those electrical and thermal aspects with the engine controls,” White says.

“We wanted this lab to be modular and scalable to test multi-megawatt capability, extremely high voltages and be able to test and validate not only the power and loads but integrate them and inject faults,” says White. “It’s important that we can be flexible and able to test various sources of power, whether it’s aircraft generators or battery systems, and couple those with high-demand users of that power, whether it is an electrically driven environmental control system or a motor with simulated loads for electric propulsion.”

The 1-megawatt motor for Project 804 will be the aerospace industry’s most power-dense and efficient, Collins says. “Just as important, we have to think about the control and protection of that amount of power as it gets integrated into an air vehicle at altitude,” White says. “The way we have designed the lab will allow us to collect data and inject faults into the electrical network, and design the algorithms and distribution system to be able to detect a fault condition and repair it, to make sure we’re not putting a significant amount of power into a short circuit.”

Construction of The Grid will begin by laying in the power generation capability at the megawatt level, which White says involves making the right connections between the local utilities and the lab. “Then we have the machinery component which is consuming that power, the rotative capability such as dynamometers, and then the power supplies that allow us to vary the voltage,” he says.

“After we put in those foundational elements that allow us to disburse the power from the utilities, the infrastructure to distribute that within the building, and the power supplies that can set the voltages at the kilovolt level, [then we can] start component-level testing,” he says. Collins will then build out the lab with multiple channels, duplicating the initial setup so it can test systems with four or more channels. “We will have the full modular capability and multiple channels that we envision in 2021,” White says.

Skepticism abounds over electric propulsion, but White believes UTAP is aiming at the right spot with Project 804. “The industry expectation is that every new generation of propulsion will provide a double-digit performance improvement,” he says. “In the propulsion class that 804 is focused on, the math alone for the level of improvement with a hybrid-electric architecture would say it is worth pursuing.”

UTAP and Project 804 are just some of the company’s strategic changes. “We’re a different UTC,” says Eremenko. “We want to help the industry and our customers, including our military customers, think through the future and help shape that future as a partner, not just a supplier.”

## Engine-makers Step Up Hybrid-electric Work To Meet UAM Demand

### INITIAL HYBRID-ELECTRIC SYSTEMS STRADDLE 100-800 KW

### PROTOTYPE TESTS BASED ON ARRIEL, HTS900 AND M250 TURBOshafts

**Guy Norris Atlanta and Los Angeles**

Many of the vehicle concepts under study for the coming wave of urban air mobility (UAM) are the size of today’s small helicopters, so it is perhaps no surprise that major propulsion players in the current vertical-lift market are laying out plans to compete for this next big opportunity.

With larger size comes the need for more power and, with battery technology still lagging, these future propulsion systems are focused on gas turbine-based hybrid-electric concepts rather than all-electric designs. The strategy enables the established engine-makers to leverage their turboshaft experience and, at the same time, helps lay the foundation for what most of them view as the inevitable longer-term transition to all-electric architectures when improved battery or fuel-cell technology becomes available.

With its large presence in the helicopter market, Safran has become one of the leading proponents of hybrid-electric propulsion. The French manufacturer’s partnership in 2018 with Bell on the Nexus electric vertical-takeoff-and-landing (eVTOL) vehicle has propelled it to the forefront of industry efforts and helped spark a broader hybrid-electric development strategy that now encompasses three main propulsion systems covering the 100-kW, 300-kW and 600-kW power ranges.

“We intend to develop a versatile product that we can propose to any player in the market,” says Jean-Baptiste Jarin, vice president of Safran’s Hybrid Propulsion System program. “Today we expect to start our range of
offering with a 100-kW system, while for the Nexus it will be 600 kW. Then we will have something in between at around 300 kW, and maybe later on a 1-megawatt machine. But for now, we have three in the pipeline."

The smallest system is aimed at cargo drones carrying payloads of approximately 200 lb, while the 300-kW system targets smaller eVTOLs. “We ‘almost’ have customers for all three propulsion systems, and a year from now we will be able to say more. We either are in the final proposals stage or have already signed agreements,” says Jarin.

The company, which began ground runs of a 100-kW proof-of-concept hybrid-electric distributed propulsion system demonstrator in mid-2018 at its Pau-Pyrénées test site in France, also recently unveiled the first of a newly developed ENGINeUS family of electric motors of up to 500 kW. Safran is also providing a modified version of its Ardiden 3 turboshaft to provide electrical power on the Boeing-backed Zunum 12-seat ZA10 hybrid-powered aircraft.

For the Nexus demonstrator, Safran will provide a turbogenerator made up of the core of an Arriel turboshaft and a generator. DC electricity will be transferred to motors in each of the vehicle’s six ducts via a redundant power distribution network. The system will work in conjunction with a high-power, high-energy battery storage system that provides a redundant and dissimilar source of power to the propulsion system. Initial flight tests of the Nexus demonstrator are anticipated by the first quarter of 2021.

While the fast pace of the Bell program dictates the use of a core derived from an existing turboshaft, Safran is starting parallel development of a series of new cores purpose-designed for the turboelectric family. “We expect to run the first new core for the larger applications in about 18 months,” says Jarin. “To meet Bell’s timescale of a 2025 entry into service, we need the engine to be certified by 2024 and run it by 2022. So we must have the first engine to test before that.”

All-new cores are required because Safran believes UAM power systems will operate on a fundamentally different cycle than current turboshafts. “Today for helicopter engines our design objectives are based on weight/power density, fuel burn, emissions and direct operating cost (DOC). But for turboelectric engines the No. 1 criteria by far is DOC, with fuel burn and weight after power density. So we will be somewhere between existing turboshafts and APUs [auxiliary power units],” says Jarin.

“In an eVTOL, the turbogenerator will run like an APU. You won’t have the pilot increasing or decreasing the power, and so on. It will run constantly, and batteries will manage the transients and peak flows,” he says. “That is why we believe hybrid makes sense for electric propulsion, because we can optimize the turbogen and also optimize the battery. Today you can either configure the battery for peak demand or energy density, so we can have less power density because we have the [gas turbine] fuel, but we also have the battery to cover for peak demand.”

Optimizing the core to run like an APU will entail designing it with rugged components for durability and longer component lifetimes. Although this may result in a marginal weight impact, Jarin says the lower operating costs will be worth it. “We want to have a DOC that is half the cost or [less] compared to today’s helicopters. That is what we have to do,” he says.

Honeywell is also targeting the UAM market and is conducting initial ground tests of a hybrid-electric turbogenerator system that combines its 1,100-shp HTS900 turboshaft with a pair of 200-kW generators. “The baseline HTS900 is sold today for helicopter applications, and we are able to generate up to 400 kW of power through this engine. The only thing we’re looking to do to get this engine into service by 2023-25 is put on a new gearbox and new controller. We are also investing money to take weight and cost out,” says Bryan Wood, senior director of hybrid-electric and electric propulsion programs at Honeywell.

Like Safran, Honeywell believes the turboelectric option provides a bridge...
hundreds of millions of dollars to build vertiports and install charging stations, but today 30% of Uber rides go to and from airports,” he says. “In that case, if you need to refuel your vehicle, you could have every third, fourth or fifth flight go to the airport where there is already a fueling infrastructure in place. It would save [the capital expenditure] investment. Those are some of the benefits we see.” For initial vehicles, the power system would be designed to operate for around 10 flights of 10-25 mi. back-to-back between refueling.

Ground tests of a nonflightworthy turbogenerator system are slated through 2020. “We are planning to do a full-scale hybrid-electric demonstration sometime in the mid-2020 to early-2021 period. This will be done in-house first, and then with an original equipment manufacturer immediately afterward as well,” says Wood. The oil-cooled, 600-volt DC generators are 92-95% efficient, “and we are trying to get that up,” he says. “We can also scale this up to 300 kW if we need to, and it will be augmented by batteries that will provide 200-600 kW extra, depending on the phase of flight.”

Target weight for the installation at entry into service is 800-900 lb. “This includes the actual turbogenerator, the generator control units, the generators and the gearbox, but does not include the batteries or motor controllers and motors,” explains Wood. Honeywell is studying potential partner-ships for the motor development as well as the option of keeping the work in-house. “We have also formed three different battery partnerships to this point, although we can’t disclose them yet,” he adds. “We are really looking to come to the market with the full package.”

In March, Rolls-Royce also revealed it is developing a hybrid-electric propulsion system based on its widely used Model 250 helicopter turboshaft. Targeted at experimental flights in 2021, the program began at Rolls’ Indianapolis facility in early 2018. “[By the end of the year,] we were able to create a hybrid-electric propulsion system and demonstrate three modes of operation—series hybrid, parallel hybrid and turbo-electric,” says Sara Poxon, head of operations for Rolls-Royce Electrical.

“We have been able to test all three modes of operation. Initial ground tests were completed in the fourth quarter of 2018, and the plan for this year is to work toward a flight-ready solution. We covered the 500-800-kW total power range, which is a sweet spot for eVTOL concepts,” she says. Ground tests undertaken so far include simulated takeoff, cruise, landing and taxing. “[The tests have] confirmed the system’s suitability for a range of transport platforms, including aircraft with a range of up to 1,000 mi. and weighing up to 2,000 kg [4,400 lb.],” says Rolls.

In series hybrid mode, the engine operates as a turbogenerator that charges the onboard battery system and does not contribute to thrust directly. In parallel hybrid configuration, thrust is supplied by a combination of the engine and electrical system, while other aircraft power needs are met by the battery. In turbo-electric mode the battery system is redundant.

The approach to developing the M250-based hybrid-electric propulsion system is part of “a strategy to move away electrically from ground and rig demos to make sure everything we do is more aligned to a certification-capable application,” says Eddie Orr, head of capability at Rolls-Royce Electrical. “So we are moving quickly to flight test, not just rig demos, and making it production-oriented from the start, including looking at certification requirements,” he says.

This approach has enabled the team to rapidly gain experience in areas such as battery-pack integration and power control as well as a better understanding of design requirements for thermal management and mitigating battery thermal runaways. The ground-test rig includes an M250 engine attached to a generator. “This creates power that goes to electric motors, which then power the propulsors, so it is the whole system,” says Poxon. “You also have energy storage as a backup, which you can use during takeoff and hover. During cruise you just use the gas turbine as a series hybrid.”

“The next step is to see how we can take it further,” says Orr. “Whether we do it on a ground-based rig or another option depends on what challenges we want to overcome.”
Rolls-Royce Unveils Comprehensive Electric Power Plan

EMBEDDED STARTER GENERATOR TESTS TARGET NEAR-TERM MORE ELECTRIC NEEDS

E-FAN X WILL BE THE WORLD’S MOST POWERFUL FLYING ELECTRICAL GENERATOR

Guy Norris Derby, England, and Los Angeles

Like many of the world’s aerospace gas-turbine makers, Rolls-Royce is coming to terms with the emerging electric power revolution in civil and military aviation. As it embarks on several parallel new propulsion technology ventures, the company is revealing key details of its 21st-century strategic development game plan.

“We are at a pivotal point in history,” says Sara Foxon, head of operations for Rolls-Royce Electrical, a group recently formed within the company to oversee a new industrial strategy to take advantage of what she describes as an “inescapable trend.”

With up to a billion electric cars predicted to be on the road by 2040 and technology pushed primarily by the automotive industry to greater power densities in electrical machines, power electronics and energy storage systems, “we are reaching the point where they become viable for aerospace; we are starting to see and acknowledge that,” says Foxon.

Yet for all this, while embracing the future, the strategy remains rooted in the company’s existing industrial strengths in gas-turbine technology. “We don’t expect it to happen overnight,” she says. “Over the next 5, 10 and 15 years, we expect the majority of our core capability to still be in the gas-turbine remit, and that is why we continue to revitalize existing capabilities.”

Alongside continued optimization of gas turbines and closer engine-airframe integration on future aircraft, two other key factors played a part in Rolls’ decision to make electrification one of its key areas of product innovation. These are an awareness that electrification is spawning a new generation of agile competitors with deep pockets, and the realization that long-term sustainability of aviation could become unattainable as advances in jet design threaten to plateau in the coming decades.

“We are starting to reach a peak on our technology curve, and there is a recognition that we can’t just continue to make improvements in materials and material technologies,” Foxon says, referencing internationally agreed International Cooperation in Aviation Research (ICArE) goals for emissions reductions set for 2050. “There has to be a radical change in both aircraft or engine design, and electrification becomes an enabling technology to allow for this.”

As it sharpens its electrification focus, the company is maintaining its existing capability and expertise in areas such as permanent-magnet thrusters and electrical products from parts of its recently divested commercial and marine businesses. “Most notably, we have a design group based in Trondheim, Norway, called SmartMotor, that we have retained as part of the sale to Kongsberg, and they are now renamed Rolls-Royce Electrical Norway. We also have Power Systems, which has done work on hybrid trains, microgrids and submarines. So we have a wealth of experience in hybrid-electric across our businesses, and we are making sure we synergize some of these technologies,” Foxon says.

Commercial Aircraft Electrical Capability Growth Forecast

Although electrical capability is rapidly increasing, Rolls believes it will pace future advances.
The development strategy also reflects the two ways electrification technology is expected to fundamentally affect aviation; either through an incremental, evolutionary approach such as the development of more electric aircraft or a disruptive, revolutionary approach such as electric propulsion.

One such incremental program is the ongoing E2SG project in Rolls’ Bristol, England, facility where an Adour military engine has been tested with an embedded electrical start-generator. “We’ve taken the experience from our SmartMotor team to draw power from the high-pressure [HP] and low-pressure [LP] shafts, so it is a dual-spool power off take electrical system,” says Eddie Orr, head of capability at Rolls-Royce Electrical.

“It has been very successful, and has brought together a combination of electrical, mechanical, thermal management and marine engineers.”

The work builds on developments in 2017, when the engine was started and switched to electrical-generation mode with an embedded HP starter generator. “This year, we’ll be putting the generator on the LP shaft,” Orr says. “We’ve continued with the HP starter-generator and introduced energy storage into that system. We’ve gone through subsystem checks, and it is now being integrated with the engine on the test rig.” Further testing is planned for this year, he adds.

The work on E2SG is being fed into the UK Team Tempest sixth-generation combat aircraft project. “[It] is also something we can feed into large civil engines as well, and we are looking to see how we can better manage surge margin for example,” Orr notes.

“So rather than open bleed valves, you can reduce the amount of work on the compressor by taking less electrical power off it. But the platform still needs the same amount of electrical power. So therefore you take it from the HP shaft.”

“On the disruptive side, that is where we are looking more closely at electric propulsion,” Poxon says, concurring with wider industry studies suggesting that initial applications are more likely to be viable at smaller scales. “At what point does the technology become mature enough [to start using] it in markets such as small regional aircraft? As you move to the larger payloads, speeds and ranges, that is where we see hybrid-electric and more electric components. Whereas with smaller payloads, speed and range, we see all-electric as being more viable. In terms of a time line, this is probably over the next five years all the way to 25 or 35 years-plus.”

Rolls believes that future single-aisle airliners may require radically different battery chemistries than current configurations and much higher voltage to deliver tens of megawatts. Compared to the Boeing 787, the world’s first more electric airliner, which has 150 Wh/kg in energy storage, Rolls says a smaller hybrid-powered airliner in the 2030s will require up to 1,000 Wh/kg. Power electronics, which on the 787 are rated at 5 kW/kg, will need to handle four times that level in the future. The two motor/generator sets in the 787, which produce up to 3 kW/kg, will need to be replaced by a system able to generate 20 kW/kg.

Hybrid-electric propulsion for regional commercial aircraft is being evaluated through the E-Fan X demonstrator program with Airbus and Siemens. Designed to be flight-tested on a highly modified Bae 146/Avro RJ, the completed demonstrator will be the “world’s most powerful flying generator,” says Poxon. “We are delivering a 2.5-megawatt generator as well as power electronics, and these are attached to an AE2100 engine that sits within the fuselage and generates electricity.”

Configured with silicon carbide power modules and permanent magnets, the 3,000-volt AC system will power a motor-driven fan that replaces one of the testbed’s original four Honeywell LF507 turbofans. The fan will be taken from an AE3007 engine. Although the E-Fan X at the platform level will therefore be a parallel hybrid, which means propulsion is a combination of the gas turbines and electric power, the main purpose of the experiment is to evaluate it as a series hybrid in which propulsion is electric with additional energy storage.

The generator is a combined effort, says Orr. “The electrical design team in Derby is working with the Rolls-Royce Norway team. They are supported from the U.S. and getting electronics support from Singapore,” he adds. Although the majority of the program is being undertaken as part of the European Clean Sky 2 research program, “There are aspects we do independent of that and so get learning back into our programs,” Orr notes. Rolls is providing the powerplant, generator and fan; Airbus is providing energy storage and distribution, while Siemens is supplying the motor and drive electronics.

Orr stresses that any final configuration will differ from the E-Fan X, which is expected to fly in late 2020. “The concept could become a series hybrid or a boundary-layer-ingestion design, for example,” he says. “What we are doing is showing the capability of getting that large, high-voltage
Rolls expects to learn valuable lessons from the ACCEL program about the integration and packaging of lithium-ion battery cells and modules, as well as a better understanding of the thermal analysis of center cells and under what circumstances they might overheat. It will also learn about battery management and whether particular composite materials might help control the thermal environment.

Knowledge from ACCEL will dovetail with other small-scale electric and hybrid-electric initiatives aimed at the personal air vehicle and fledgling urban air mobility markets. For the latter, Rolls-Royce’s Indianapolis group is ground testing a hybrid-electric system based on the company’s Model 250 (M250) turboshaft.

The program began in early 2018, and by the end of that year “we were able to create a hybrid-electric propulsion system and demonstrate three modes of operation—series hybrid, parallel hybrid and turbo-electric,” says Poxon. “We’ve been able to test all three modes of operation. Initial ground tests were completed in the fourth quarter of 2018, and the plan for this year is to work toward a flight-ready solution. We covered the 500-800-kW total power range, which is a sweet spot for eVTOLs,” she adds.

To help focus studies on the technical feasibility and development challenges of electrical propulsion, Rolls has also designed its own notional eVTOL. “It’s the first time, I believe, Rolls-Royce has come up with a concept like this at an aircraft level, and this has a propulsion-system based on an M250 hybrid-propulsion configuration,” says Poxon.

The five-seat, series-hybrid design incorporates rotors and tilting wings, and would also be done in collaboration with established airframe-makers and other aerospace companies. “If this new market appears, the big players want to make sure it is as safe as what we have today,” he adds.

Rolls-Royce is also working with luxury car company Aston Martin, Cranfield Aerospace Solutions and Cranfield University on a hybrid-electric three-seat vehicle for urban and intercity air travel. Called the Volante Vision Concept, the vehicle would include an M250-based power system and is provisionally targeted to enter service in the mid-2020s.

“It is a concept only, but assuming you get through all the integration challenges, then aerodynamically we believe it could fly,” says Orr. “We have the right power level, the right energy storage, so the power-to-weight ratio is fine. And it is the same with our own concept. There are challenges in terms of certification [and in] how it is set up today because we don’t have electrification as the main propulsion system. But as an industry, we are working with regulators and certification authorities to overcome these hurdles. They are not showstoppers.”

A Rolls-Royce M250 forms the heart of the company’s hybrid-electric, five-seat, eVTOL study concept.
From Air Taxis to Commercial Aircraft, Airbus A³ Is Developing the Autonomy

Graham Warwick Washington

Airbus’ Silicon Valley innovation center, A³, has launched a program to develop certifiable autonomy systems that can be applied across the manufacturer’s product lines, from self-piloted urban air taxis to single-pilot large commercial aircraft.

The Wayfinder project has been spun out of A³’s Vahana demonstration of an autonomous electric vertical-takeoff-and-landing vehicle for urban air mobility (UAM). Vahana is focused on autonomy, and the Wayfinder team developed the single-seat vehicle’s multisensor sense-and-avoid system. Vahana has been under development since 2016 and has so far completed 50 unmanned test flights.

“It became clear that the sense-and-avoid system could have greater impact across the Airbus organization, especially with respect to commercial aircraft,” says Arne Stoschek, Wayfinder project executive. “Our primary focus is on developing a common set of software and hardware that we can apply in a scalable way across a range of aircraft.”

Having developed the sense-and-avoid system for the Vahana demonstrator, Wayfinder is now working to deliver autonomy capabilities for UAM vehicles in the productization phase within Airbus. The team also is part of a large Airbus research and development effort on single-pilot operations of large commercial aircraft, says Stoschek. This includes the Autonomous Taxi, Takeoff and Landing (ATTOL) project at Airbus.

The need for self-piloting capability is driven by the projected shortage of pilots to meet forecast growth in the large commercial aircraft market as well as potential additional demand from the UAM market. “Going from 200,000 [commercial] pilots to 600,000 will be very difficult,” he says. But if UAM vehicles are piloted, “we are an order of magnitude away from the number of pilots that would be needed for large-scale operations,” he notes.

In a self-piloted aircraft such as the Vahana, the autonomy system has to make all the decisions that a human pilot would. “It has to understand its environment and make decisions as competently as a pilot,” Stoschek says. “The key challenge is how the system reacts to unforeseen events. That’s the big jump from automated to autonomous.”

Humans are good at reacting to unforeseen events, provided they are properly trained. “The computer is good at repetitive tasks. So how do we create new [autonomous] behaviors that will be very robust to unforeseen events?” he asks. The answer lies in machine learning and the ability of the system to learn from data.

Wayfinder is developing software, based on computer vision and machine learning, that enables the aircraft to perceive the environment around it. The team is using techniques developed for image processing and self-driving cars and expanding them to meet the requirements for autonomous aircraft. The project also is developing decision-making software that enables the aircraft to navigate autonomously within the environment it senses.

To feed and run the complex software, Wayfinder is developing hardware including new types of sensors and powerful computers that meet the size, weight and power constraints of aircraft. “We are partnering with the leaders in autonomous vehicle sensors and computing to mold their products to fit our needs,” says Stoschek.

Wayfinder is using a data-driven development approach. “The pilot goes through rigorous training and learns to fly. They learn from their mistakes, but when they retire that experience is lost,” he says. “The data-driven development approach aggregates the experience from hundreds or thousands of pilots and puts it into a context the autonomy can learn from.”

A system that can learn poses a problem for certification, as its behavior is nondeterministic—a given input may not always produce the same output. In Wayfinder’s approach, the aggregated data is used to train a model. “We verify the model is safe, then we port it to the aircraft,” Stoschek says. “Once on the aircraft, it behaves in a deterministic way. It stays as it is and does not change unless we update it.”

Pilot experience data will be collected during aircraft operations. “Being a manufacturer provides the opportunity to install systems on vehicles and learn the environment of the vehicle and the actions of the pilot,” he says. For UAM, the data to create the machine-learning model could come from piloted helicopter operations in urban environments. “Large commercial aircraft would be different,” Stoschek says.

A³ was set up in 2016 to be at arm’s length from Airbus and chartered to disrupt the company from within by taking on projects too risky for the business units. But Wayfinder is closely tied into the parent company. “There is a tight interface between A³ and the Airbus development organization,” says Stoschek. “In an increasingly crowded UAM market, that’s the differentiator. Coming from Airbus, with its history of certified aircraft, safety is our key mantra in approaching autonomy.”
ill urban air mobility (UAM) ever be a transportation option for the masses? Consultant KPMG thinks not, but it does believe UAM could be an attractive premium market for business travelers—if the price is right. And infrastructure financier Nexa Capital Partners says some of the world’s largest cities already have the facilities in place to enable that market.

Executives from both organizations are presenting results from studies of the global UAM market at Aviation Week’s Urban Air Mobility 2019 conference in Atlanta on April 9-10. While KPMG has looked at the top 100 urban centers around the world to forecast the potential UAM market by 2050, Nexa is looking at infrastructure in 78 cities to see where opportunities for UAM could emerge first.

“We looked at mass-transit infrastructure and living and working patterns, and identified where congestion makes high-value routes slow on the ground and which could open up attractive premium options,” says Tom Mayor, KPMG’s industrial manufacturing strategy leader. Examples include Manhattan to the New York-area airports and London’s Canary Wharf to Heathrow and Gatwick airports. KPMG’s study used smartphone data to identify origin and destination (O&D) routes “used by a large number of not excessively price-conscious people who value their time,” says Mayor. These data showed routes where people were moving between high-income residential areas, business centers and airports with no subway or light rail and long travel times. The data was then extrapolated to 2050 using projections for urbanization and regional GDP growth to identify routes where congestion would slow ground transportation.

“Our analysis suggests that if you can get a cost gap between UAM and ground transportation that is reasonable, then congestion-driven travel times in high O&D travel lanes could allow attractive UAM markets to develop in at least 50 large megacities and megaregions around the world,” he says. “This could account for 400 million or more annual passenger enplanements by 2050.”

This is a projection for UAM as a premium service, as Mayor does not believe UAM will be an option for mass public transportation. “The fundamental physics says it will never be the cheapest option, because the motors are fighting gravity and not rolling along the ground,” he says. And for a premium market, the key factors are speed, frequency of service and price relative to black cars and rail services.

“This market will depend on safe and reliable delivery speed at not too premium a cost,” Mayor says. The core of the enplanements forecast for 2050 are high-frequency airport shuttle services, but in the most congested cities the movement patterns show potential opportunities for UAM “commuter” routes.

Nexa’s infrastructure study, which is still ongoing, is sponsored by several manufacturers developing UAM vehicles and unmanned traffic management companies planning to provide airspace services, as well as cities interested in being early adopters of UAM.

Nexa chose to study 70 cities based on their metropolitan GDP, bookended by Tokyo as the largest and Dubai as the smallest. Eight more were added at the request of those cities. Planned to be completed by July, the study aims to “rack and stack” the cities by where the UAM opportunity will come first, says Michael Dyment, Nexa managing partner.

“We are trying to analyze the cities in terms of business viability. Can a city support an intense air-taxi service like that being promoted by Uber Elevate? That is the fundamental question,” he says. “The most promising opportunities in cities are in getting business travelers to the airport. We also see opportunities in business aviation, in linking the corporate headquarters with the corporate jet.”

An initial study finding is that Tokyo’s core has more than 370 helipads, on the tops of buildings, that are not licensed for operations because of noise constraints. The Tokyo region could have more than 500 heliports, Dyment says. That would make the infrastructure available for UAM services similar to that in Sao Paulo, which already has a dense operating network of helicopters.

Attractive UAM markets could develop in 50 large megacities and mega-regions around the world, says KPMG.
Air navigation service providers (ANSP) responsible for managing air traffic crossing the North Atlantic Ocean began space-based surveillance of aircraft in March, a capability they say will deliver immediate safety and capacity benefits for oceanic travel.

Plans called for Nav Canada and UK NATS to initiate operations using the Aireon system of automatic dependent surveillance-broadcast (ADS-B) receivers carried by Iridium Next satellites on the night of March 27 for eastbound traffic, continuing for westbound traffic the next day. This began an operational trial by ANSPs responsible for the world’s busiest oceanic airspace.

Using space-based ADS-B, controllers will receive far more frequent position updates from aircraft plying oceanic or remote airspace beyond the range of radar coverage. This allows them to substantially reduce separations between aircraft on the track structures that are established daily based on prevailing winds to channel east- and westbound traffic. About half of flights use the organized track system (OTS); the others choose random routes that remain clear of the OTS or join or exit a track. Eventually, the track system may be eliminated, ANSPs say.

Space-based ADS-B will have a dramatic impact on an oceanic region that accommodates 500,000 flights per year—traffic is forecast to grow an average of 3.4% annually to about 800,000 flights by 2030. Nav Canada predicts up to 90% of flights crossing the North Atlantic will be allocated the flight trajectories operators request, compared to about 60% currently, and 80% of traffic will fly without speed restrictions compared to the region’s current fixed-speed environment.

“We strongly believe [space-based ADS-B] will have an immediate effect on current capacity demand and future traffic growth,” says Rudy Kellar, Nav Canada executive vice president of service delivery. “This is essential to be able to handle it, to provide the same level or perhaps greater levels of efficiency for such a higher growth rate of traffic,” he adds.

“It’s exciting,” says Juliet Kennedy, UK NATS operations director. “Most people outside the industry don’t realize that you are not surveilled [when flying] over the oceans. From a safety perspective, the ability to have almost real-time position data is exciting for us because we haven’t had it before.”

Nav Canada manages the western half of the oceanic airspace from its
Oceanic tracks are depicted on this controller display, the user interface of Nav Canada’s Gander Automated Air Traffic System (GAATS+) automation platform.

This UK NATS illustration depicts the North Atlantic oceanic flight information regions.

Gander Area Control Center in Newfoundland; UK NATS manages the eastern half from its Oceanic Area Control Center in Prestwick, Scotland, with participation by the Irish Aviation Authority (IAA) at Ballygirreen, Ireland. The three ANSPs, NavigAir of Denmark, ENAV of Italy and Iridium are partners in the Aireon joint venture, which in early February received control of its final ADS-B receiver payloads from Iridium.

Now that the surveillance network is deployed, Nav Canada and UK NATS plan to conduct a two-phase operational trial of the system through November 2020. The trial covers airspace from 29,000-41,000 ft. for all OTS and non-OTS flights transiting the Nav Canada Gander and UK NATS Shannon oceanic flight information regions (FIR). Both ANSPs will process and display aircraft target data using the Nav Canada-developed GAATS+ automation platform.

The ANSPs will not charge additional service fees during the trial. Nav Canada charges a flat fee of C$89 ($62) for aircraft crossing the Gander FIR, with additional international communications charges of C$49.66 for position reporting by voice radio and C$18.68 using data link.

“Later this year, Nav Canada will begin consultations on our actual costs and how it will impact our fee structure within both domestic and oceanic operations,” the ANSP says. “We plan to adjust our fees in 2020, but we anticipate that the efficiency and safety benefits of Aireon will compensate for the increased charge.”

UK NATS says airlines currently pay around £58 ($76.64) each time an aircraft crosses the Shannon FIR. The IAA charges separately for providing high-frequency (HF) radio communications within the FIR.

Upon completion of the trial, ANSPs expect that regulatory agencies Transport Canada and the UK Civil Aviation Authority will approve the new surveillance regime.

As of March, McLean, Virginia-based Aireon was nearing final certification of its system by the European Aviation Safety Agency (EASA) for use in the oceanic environment, capping a three-year evaluation of the company’s system design and validation techniques, training and safety practices and operations. The process of obtaining EASA certification, which establishes Aireon as a surveillance service provider, was “useful” but not necessary to begin the North Atlantic trial, says Aireon CEO Don Thoma.

Outside radar range of about 250 nm from land, the ANSPs’ track aircraft by satellite-routed automatic dependent surveillance-contract (ADS-C) position reports at 14-min. intervals and exchange text messages with pilots that contain instructions or information requests by controller-pilot data link communications (CPDLC)—components of the Future Air Navigation System concept dating to the 1990s.

Radio officers contact pilots by HF SELCAL (selective calling) when an aircraft crosses oceanic FIRs, say executives at the IAA’s North Atlantic Communications Center at Ballygirreen, a township near Shannon Airport. Additional routine communications are transmitted by data link if the aircraft is CPDLC-capable, otherwise HF radio is used.

The IAA station has provided long-range HF radio communications in the Shanwick FIR in coordination with UK controllers at Prestwick ever since an agreement the countries forged in 1966 to prevent duplication of air traffic and communications services.

Space-based ADS-B “is going to change the face of how we provide air traffic control services and effectively, over time, it will make the radio officer position redundant,” says Bill Hahn, IAA director of air traffic management operations and strategy, during an Aviation Week visit to Ballygirreen.

“It isn’t quite there yet, but that is obviously a challenge we’re facing here because we provide radio services to the transatlantic traffic.”

The International Civil Aviation Organization’s (ICAO) Global Air Navigation Plan calls for HF radio to support oceanic communications until 2028, and IAA executives are quick to point out that HF’s impending demise has been predicted for years.

With transponder-equipped aircraft regularly broadcasting their GPS-derived position, heading, velocity and other data by ADS-B through Aireon’s satellite and ground network, ANSPs expect to receive position updates every 5-8 sec. This will provide the situational awareness needed to
close the gap enforced between aircraft by “procedural” separations from about 40 nm longitudinally within tracks to 14 nm or 17 nm, depending on the angle between aircraft flying in the same direction converging. Most traffic would converge at less than a 45-deg. angle, enabling 14-nm separations, Nav Canada says.

Lateral separations between tracks will be reduced to 19 nm from 30 nm during the trial’s second phase, slated to begin six months from late March. “Because it’s a big change and a significant reduction in separations, we want to make sure we get it right, which is why we’re going to do it in two phases,” explains Kennedy.

According to a presentation Kennedy and Ben Girard, Nav Canada vice president for operational support, gave during the World ATM Congress in Madrid in March, application of space-based ADS-B on the most efficient North Atlantic routes will save airlines 406-649 kg (895-1,430 lb.) in fuel per flight, with commensurate reduction in CO₂ emissions.

From a safety perspective, the additional “conformance awareness” that space-based ADS-B gives controllers regarding deviations between an aircraft’s cleared flight level and its selected one has reduced by 76% the vertical collision risk from the potential of 19.8 fatal accidents per billion flight hours to 4.6.

This is the first time that the vertical collision risk from the potential of 19.8 fatal accidents per billion flight hours has been reduced to below 5 fatal accidents per billion flight hours—since 1997, when the implementation of reduced vertical separation minima above 29,000 ft. closed vertical separations between aircraft from 2,000 to 1,000 ft.

“We will now have full surveillance, with controllers seeing the aircraft descend or climb,” says Kellar. “Consequently, we’ll be able to intervene [to] give the airplane a clearance to proceed where they need to go, or deny space above the Yukon and Northwest Territories, most of Nunavut Territory, the province of Alberta and portions of British Columbia and Saskatchewan. It is the largest FIR of its kind in the world, Nav Canada says.

Much of the Edmonton airspace lacks coverage by ground-based radar, which requires controllers to apply procedural separations of aircraft greater than the 5 nm typically applied for domestic en route airspace, Kellar explains.

Plans called for activating space-based surveillance in the Edmonton FIR in successive phases, beginning at a high level in the eastern sector of the airspace, where VHF radio is available to communicate with pilots.

“Now that we overlay ideal surveillance with Aireon’s technology at a [position] update rate less than 8 sec. and down as low as 2 or 3 sec., and we have communications, we immediately will go into providing the same level of service—5-mi. separations—as we would in southern Canada, where we have layers of ground radar surveillance,” Kellar says.

The next phase was scheduled to begin a month later to introduce surveillance in the western part of the FIR, which aligns with airspace managed by the FAA’s Anchorage air route traffic control center. “We’ll be going to 5-nm [separations] there to support a Pacific flow of traffic,” Kellar says.

The final phase will see reduced aircraft separations applied in the high-north sector of the FIR for flights transiting the polar region, using CPDLC to communicate with pilots.
A wall map displayed at the Irish Aviation Authority depicts Atlantic oceanic hours—since 1997, when the implementation—5 fatal accidents per billion flight hours to 4.6. 

According to a presentation Kennedy gives, lateral separations between tracks aging air traffic in the Gander oceanic flight information region.

From a safety perspective, the addition in CO2 emissions.

FIR and Gander FIR domestic airspace, Kellar explains. The millennial generation, which will be the main pur-chase decision-maker in travel by the beginning of the next decade, is extremely tech-savvy and demands a smooth, digital-enabled travel experience just as in ride-hailing or food delivery,” says Christian Langer; vice president of digital strategy and managing director of the Lufthansa Innovation Hub (LIH), which was established to help the German airline group provide just that.

As well as the LIH, Lufthansa has set up a new dedicated digital fund of €20 million ($22.4 million) annually, in addition to its existing idea-validation fund of €10 million annually.

Lufthansa went back to the drawing board to discover what today’s passengers want from an airline and is using the LIH to spearhead the group’s travel and mobility tech activities, with a focus on the entire travel chain, Langer explains.

“We do not think of our customers as passengers flying with us, but as travelers who are looking for experiences and, more generally, interactions. The flight is just one part of that and from a traveler’s perspective obviously not the most important one. We no longer draw the conventional ‘travel chain’ as a linear process from A to B. For us, it is a horizontal eight—an infinite story with the flight as its core element. Consequently, our focus is on maintaining the customer relationship along all segments of the travel chain, including innercity mobility or at-destination experiences,” he explains.

The LIH staff hails primarily from the tech world and works with startups through partnerships, investments and spinoffs.

Working with startups is vital, Langer says: “According to the LIH Trend & Market Intelligence, over the past decade more than 2,600 startups have emerged in the travel and mobility tech context, working on digital products and services somehow touching the business of Lufthansa Group.”

While many of these companies will eventually fail, many more will succeed in scaling up their services, Langer says. “Startups are driving a fundamental change in our industry and more than ever act as a new type of intermediary between airlines and their passengers,” he notes.

In March, the LIH unveiled the RYDES app, which offers reward points for each journey with digitally bookable mobility services including car and bike sharing, e-scooters, pu-
lic transport, trains and airlines. “With this experiment, we are reacting to the changing mobility behavior of the young, tech-savvy generation that uses different mobility modes flexibly and on demand,” Langer says.

The Lufthansa Group is also carrying out a biometric boarding test run at Los Angeles International and Miami International airports in collaboration with IT partner Amadeus and U.S. Customs and Border Protection to try out self-boarding gates with facial-recognition cameras.

Biometric technology is something the Air France-KLM group is experimenting with, too, explains Amel Hammouda, executive vice president of transformation for Air France.

“We are working a lot on biometrics—for example, a biometric boarding card that allows for simple and automatic bag drop as well as facial-recognition technology at boarding gates—to try to simplify and smooth the airport experience, which can be the most stressful part of the trip,” she says.

Overall, the Air France-KLM group, which invests about €150-200 million per year in digital, sees two main areas of focus for digital development: simplifying the lives of its customers and increasing personalization. Everything from the airlines’ apps to onboard streaming, inflight entertainment (IFE) to social media—with 30 million followers and counting—can contribute to these two goals.

When it comes to personalization, Air France’s Digital Factory, which was set up late last year, has an important role to play, Hammouda says.

“Two years ago, we realized that we had invested a lot in developing digital products for our clients, and we also needed to invest in digital transformation internally so our employees could benefit from the same tools and technologies we had developed for our clients,” she says. All cabin crew are now equipped with iPads to allow them to access information about customers that can help them anticipate their needs and adapt the service to their preferences. Equipping pilots with iPads has allowed them to become more reactive with much better information and also eliminates a heavy briefcase full of paper documentation, helping to reduce carbon dioxide emissions on every flight, she adds.

The two airlines make sure their digital innovations help to promote the look and feel of their individual brands, but behind the scenes, teams of developers work together for them both.

Onboard, IFE and connectivity are important areas of focus for digital teams who help to ensure the airline caters both to the customers who want to stay connected throughout as well as those who prefer a more zen approach to travel—and appreciate the efforts the group has made in providing relaxation and meditation as part of its IFE offering.

Hammouda also sees voice technology becoming more important for airlines. “We have seen an enormous shift toward voice technology in the past few years and are looking into how it can change the relationship between us and our clients. We are a launch company for Alexa, and we are continuing to develop new functionalities there,” she notes.

Passengers seem to appreciate the digital efforts: The Air France app has now been downloaded 6.6 million times and the company is working on enhancing it. “It has become a travel companion for our customers,” Hammouda says. “It goes beyond simply booking tickets. It allows you to prepare your trip and provides information on such things as getting to the airport and checking in, which are aimed at simplifying the experience.”

British budget carrier EasyJet is also continuing to invest in its app, which has been downloaded more than 30 million times.

“Since the launch of the app in 2011, it has evolved from easy booking and check-in functionality to include popular features such as passport scanning, live flight tracking, mobile boarding passes and Touch ID. It is also complemented by our Apple Watch app and real-time airport push notifications for go-to-gate and bag reclaim information,” says Daniel Young, EasyJet’s head of digital experience.

The airline’s digital team is continuing to work on innovations—one recent launch was the Look&Book service via which customers can upload Instagram screenshots and book flights to the relevant destination.

“This is the Instagram generation,” Young says. “Images and videos offer a unique insight into the lives of friends and celebrities. They can also be inspirational—propelling a person to go somewhere new or try something they haven’t before. Not only has Look&Book solved a customer pain point by simplifying the journey from inspiration to booking, but in the process it has created a new sales channel for the brand, delivering directly attributable revenue.”

EasyJet is also working on developing its Worldwide connections service further. After it recently signed up Cathay Pacific Airways as its latest airline partner, it chalked up a record month in December and has shown strong momentum in the first part of 2019 as well, Young says.

“Our airline has been at the forefront of digital innovation in the industry, and its digital strategy is a core part of its wider customer strategy,” Young says digital focus has helped to drive revenue, create cost savings and boost customer loyalty and satisfaction. “EasyJet’s increasingly sophisticated use of data will enable us to make travel more seamless for our customers in the long term,” he adds.

But the airlines’ innovation experts are quick to point out that digital development has its limits.

Air France’s chatbot Lucie, for example, may be able to offer would-be passengers inspiration for their next trip, “But we must not forget the human side,” Hammouda says. We are developing a whole panoply of services including a chatbot to respond to simple requests quickly, but our human advisors are there to take over when our clients need it. “That is very important—we can be as digital as we like, but our people remain our greatest asset.”

COMMERCIAL AVIATION

Air France’s Digital Factory opened last year.

Air France's head of digital experience.
NOW EQUIPPED WITH iPADS TO ALLOW THEM TO ACCESS INFORMATION NEEDED TO INVEST IN DIGITAL TRANSFORMATION INTERNALLY SO OUR PLAY, HAMMOUDA SAYS.

FOCUS FOR DIGITAL DEVELOPMENT: SIMPLIFYING THE LIVES OF ITS CUSTOMERS LAST YEAR.

AIR FRANCE’S BAG DROP AS WELL AS FACIAL-RECOGNITION TECHNOLOGY AT BOARDING

HOFF COULD OFFER WOULD-BE PASSENGERS INSPIRATION FOR THEIR NEXT TRIP, “BUT THE AIRLINES’ INNOVATION EXPERTS ARE QUICK TO POINT OUT

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*Actual salary may vary depending on the scope and complexity of the position and the qualifications and current compensation of the selectee.

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The Naval Center for Space Technology (NCST) located at the Naval Research Laboratory (NRL) in Washington, DC plays an acruial role in the United States (US) space program. The Center is comprised of two departments, each headed by an SES member: the Space Systems Development Department and the Spacecraft Engineering Department. The Center’s mission is to preserve and enhance existing space technology base and provide expert assistance in the development and acquisition of space systems.

Technology transfer is a major goal and motivates a continuous search for new technologies and capabilities and the development of prototypes demonstrating the integration of such technologies. NCST has 301 civilian employees and operates an annual budget of $423M and substantially influences an additional $2B. The Director makes recommendations and predictions so as to guide higher management in policy decisions concerning NRL’s degree of involvement in the US space program. The Director provides reviews and briefings for top Navy and Department of Defense management and national authorities. The Director is responsible for obtaining support for NCST programs. The Director is a national authority figure on matters relating to naval space technology and a scientific consultant to the Navy, other departments of the Government, allied foreign governments and various interested groups. The Director is expected to have international recognition in naval space technology.

For more information and specific instructions on how to apply, go to www.usajobs.gov, from 01 April 2019 through 30 April 2019 and enter the following announcement number: DE-10431877-19-JS. Please carefully read the announcement and follow instructions when applying. The announcement closes 30 April 2019. Please contact Lesley Renfro at lesley.renfro@nrl.navy.mil for more information. NRL is an Equal Opportunity Employer.
Budgeting for Aerospace Competitiveness

By Eric Fanning

In the spring of 1961, President John F. Kennedy stood before Congress asking lawmakers to fund the most ambitious plan in U.S. history: putting an American on the Moon. He called for a “major national commitment” that was focused not on the present, but on securing U.S. leadership into the future.

Today, as we celebrate the 50th anniversary of achieving Kennedy’s vision, President Donald Trump’s fiscal 2020 budget request calls for much of the aerospace and defense spending our nation requires, but it includes severe, long-term problems that highlight the need for Congress to strike a deal and overturn the Budget Control Act (BCA) caps.

There is a lot to applaud in this budget. The increase in the defense topline is consistent with the bipartisan National Defense Strategy Commission’s call for annual real budget growth of 3-5%. Defense investment accounts fare well, continuing the restoration of our armed services and laying the groundwork for the next generation of cutting-edge technology and capability. On the civil aviation side, funding for the NextGen system grows substantially, as well.

But the budget request simply does not fully meet the country’s needs for continuing economic growth or putting our national security investments on a path to long-term success. It jeopardizes our technological innovation—the engine that drives both our economy and our security—by cutting investments in science and science, technology, engineering and math (STEM) education.

Even for NASA, a stated administration priority, the request is nearly half a billion dollars below what Congress enacted for fiscal 2019. This flies in the face of what nonpartisan budget experts have repeatedly urged. The National Research Council called for annual growth in NASA’s budget of 3% above inflation for an extended period in its 2014 report, “Pathways to Exploration.”

The request allocates more money to space exploration but cancels key programs in NASA STEM education, aeronautics, Earth sciences and future space telescopes. This is particularly problematic when coupled with severe cuts to the Department of Education. We must invest more, not less, in STEM education to build a diverse and capable 21st-century workforce. We risk undermining the future promise of space advancement—and the scientific and economic benefits that come with it.

In addition to unfortunate nondefense investment cuts, necessary funding for defense budgets only comes through significant increases in Overseas Contingency Operations (OCO) accounts. Bipartisan opposition to the use of OCO to circumvent BCA caps already exists in Congress, jeopardizing this approach from the start. OCO funding is an important tool to provide critical support to warfighters engaged in overseas operations, but we must move beyond using this account to fund base requirements simply because we have established artificially low budget caps that will not meet our national security needs.

The root of these problems is the BCA caps. Statutory caps on spending were never a good idea, designed to be so onerous we would do anything to avoid them. And by leaving BCA caps intact in 2020, the request signals no interest in offsetting BCA caps in 2021. Clearly, we are being set up to repeat this whole exercise again next year.

To secure American leadership, we need a budget that reflects the importance of nondefense discretionary funding for technological innovation and makes the needed investments in national security, instead of sticking to punitive and shortsighted budget caps. It is not just about national security, but about the technological cutting edge that sets us apart from other countries. America’s global competitors are stealing our intellectual property, using government tools to support their industries and running with our playbook by investing heavily in technology and growing their STEM workforce.

We welcome this administration’s focus on space and the defense industrial base, but to stay competitive in the global market and maintain American leadership in civil aviation, defense and space, we must do more.

Kennedy’s vision spurred a national commitment that put Americans on the Moon, fueled economic success and led to countless technologies we take for granted today. It did so by focusing on the future—showing the true potential of the U.S. when we are unified for the benefit of our country.

We need that unbridled commitment once again. The president and Congress should return to a regular, strategy-driven appropriations process.

THE PRESIDENT AND CONGRESS SHOULD RETURN TO A REGULAR, STRATEGY-DRIVEN APPROPRIATIONS PROCESS

U.S. Funding for Aerospace-related Agencies (U.S. $ billions)

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<thead>
<tr>
<th>Fiscal 2019 Enacted</th>
<th>Fiscal 2020</th>
<th>% Change</th>
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<tbody>
<tr>
<td><strong>Defense Department Base</strong></td>
<td>$616.1</td>
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<td><strong>Overseas Contingency Operations</strong></td>
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<td><strong>Defense Department Total</strong></td>
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<td><strong>NASA</strong></td>
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*Does not include other national defense funding.

Source: U.S. Government

Eric Fanning is the CEO of the Aerospace Industries Association and the former secretary of the U.S. Army. The views expressed are not necessarily those of Aviation Week.
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<tr>
<td>Total *</td>
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<td>$544.5</td>
<td>-12%</td>
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</table>

*Does not include other national defense funding.

Source: U.S. Government
Norsk Titanium now proudly offers additively manufactured Ti-6Al-4V specified to an SAE International Aerospace Material Specification. This specification allows companies in any market and of any size to incorporate the advantages of Norsk Titanium’s wire-based directed energy process into their designs. Certified additive — once only available to those who could afford their own specification — is now available to all.