STARTS AFTER **PAGE 38**

InsideMRO™

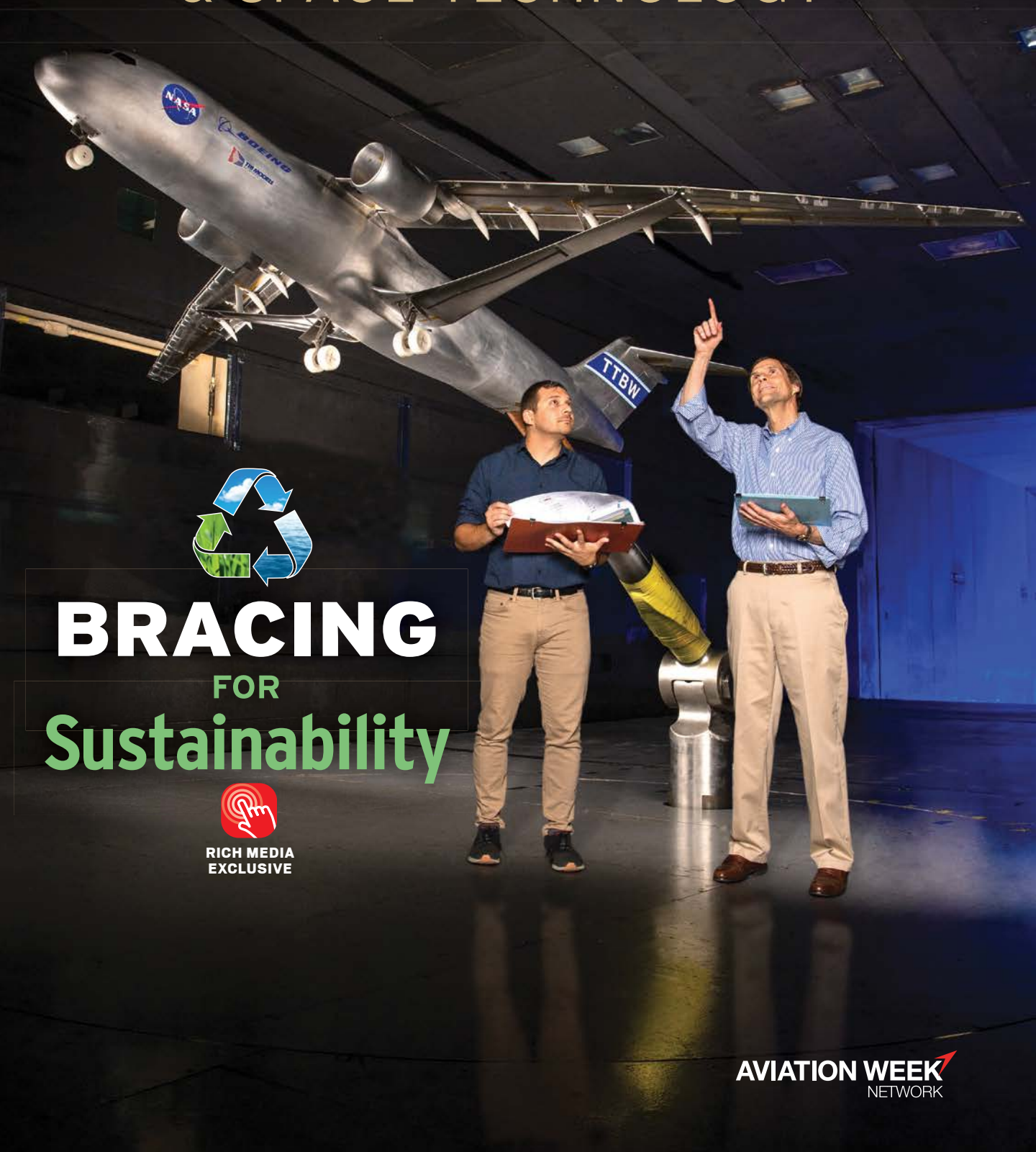
How AAR Is Solving Its Workforce Crisis

RICH MEDIA EXCLUSIVE

Singapore Doubles Down on Aviation

$14.95 FEBRUARY 10-23, 2020

AVIATION WEEK & SPACE TECHNOLOGY



BRACING FOR Sustainability

RICH MEDIA EXCLUSIVE

AVIATION WEEK NETWORK

AAR is connecting the world.

From MRO services to government solutions, we are an aviation expert committed to helping you maintain high levels of safety, quality and efficiency.

Learn how we're doing what's right – even when no one's looking.

STRONG & GROWING
65
1955 | 2020
AAR

Meet the AAR team February 11-16, 2020 during the Singapore Airshow at booth #S01.

+1.630.227.2000 | aarcorp.com

AOG 24/7 worldwide: +1 630.227.2470 | AOG@aarcorp.com

JESSE H. NEAL AWARDS
Est. 1955
2019 Winner

AVIATIONWEEK & SPACE TECHNOLOGY

February 10-23, 2020 · Volume 182 · Number 3

56 | *Chinese commercial aircraft are mostly idle. Xiamen Airlines canceled 77% of its flights on Feb. 4.*

FEATURES

DEPARTMENTS

DEFENSE

COMMERCIAL AVIATION

BUSINESS

INTERVIEW

AVIATION WEEK EXPLAINS

ROTORCRAFT

SPACE

VIEWPOINT

ON THE COVER

Ahead of runs to evaluate the high-lift system, NASA engineer Greg Gatlin (right) and Boeing engineer Mike Beyar inspect an 8%-scale model of the Transonic Truss-Braced Wing ultra-efficient airliner in the 14 X 22-ft. Subsonic Tunnel at NASA Langley Research Center. Technology Executive Editor Graham Warwick's report begins on page 52. NASA photo by Harlen Capen.

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

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

AVIATIONWEEK & SPACE TECHNOLOGY

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

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

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

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

President, Aviation Week Network
Gregory Hamilton
Managing Director, Intelligence & Data Services
Anne McMahon

AVIATION WEEK NETWORK
By Informa Markets

FEEDBACK

ISTOCK/GETTY IMAGES PLUS

WHO DOES BETTER?

Regarding the recent article "Climate of Fear" *(Jan. 13-26, p. 32)*, it is acknowledged that aircraft account for about 3% of CO_2 emissions. If one takes into account all greenhouse gas emissions (CO_2, methane, extra water vapor, etc.), this percentage falls to about 2%. Question: Who or what is responsible for the other 98%, and what is to be done about it? Could the answer be a theme to develop to put things in perspective?

Also, I recently flew a Paris-Mexico leg on an Airbus A380 with about 500 passengers onboard (9,100 km or 5,656 mi.) during which I was told about 10,000 liters (26,400 gal.) were consumed. A short calculation shows that means each passenger consumed about 2.2 liters per 100 km (115 mi. per gal.). Apart from railways, who does better?

It seems to me that aviation is the weakest economic/political element of all the greenhouse gas producers and therefore the one most likely to be attacked and pinpointed as the "bad guy."

Pierre Papucci, Nantes, France

ADDING TO THE PUNCH LIST

In "After Muilenburg" *(Jan. 13-26, p. 66)*, *AW&ST* Editor-In-Chief Joe Anselmo provided new Boeing CEO David Calhoun a set of New Year's resolutions that Calhoun must make to get Boeing back to coordinated flight, straight and level. As a former engineer in the aerospace business, these "conventional wisdom" general observations always made me wonder: What do I do differently, starting tomorrow, having read the media opinion of today? What really is the crux of the problem, the thing we must actually fix?

Countless people at Boeing and the FAA have dedicated their efforts to safety management systems and numerous, virtually continuous failure-mode, effects and criticality analysis (FMECA) over 60 years as 10,000 737s were produced and 50,000 crews flew them.

FAR/AC 25.1309, arguably the guiding principle for complex system design and certification, itself matured during those 60 years. But what may have changed most over time is the external environment associated with complex system problem-solving that each of us uses in whatever way we touch the aerospace product. The "basal instinct" unstructured approach by which we guess our way through personal computer hardware-software challenges every day has established the method by which we learn.

The integrity of the whole aviation system depends upon reliable and accurate embedded processes, from design to operations to maintenance. So added to Anselmo's punch list for Calhoun must be the significant task of stabilizing and rebasing that whole external environment in which aviation problem-solving operates. That is probably the greatest challenge.

Ted Ralston, Honolulu, Hawaii

MANUAL CONTROL A MUST

My perspective on your coverage of the Boeing 737 MAX and manual flight control is that I flew U.S. Air Force C-130s and C-141s for Military Airlift Command between 1969 and 1972. Military or civilian, all transport aircraft are designed to have margins and stability and be able to be flown manually in any normal flight regime, from start of takeoff to rollout after landing.

We learned all we could about the autopilots because at high altitude they do a much better job of precise altitude and heading control and saved us a lot of work. With the autopilot or flight control system, one rule prevails: If at any time the aircraft is not doing what you want it to do when on autopilot, after a brief check to be sure that you are in fact on autopilot, the first and best thing to do is to disconnect the autopilot and hand-fly it until further analysis can be made.

It always pays to be suspicious of automated systems. They are wonderful things, but they can and occasionally do fail. Trying to use manual control to override a malfunctioning autopilot that can't be manually taken offline is a scenario that the designers must not let happen again.

The pilot has to be able to intuitively, quickly and simply take it offline. A guarded switch is easy to include on the panel. You don't want that maneuver to have to be on a checklist. The stick, rudder and trim controls should all work as advertised, whether or not they are being commanded by the autopilot. We still have a lot of ground to cover in the autopilot and autonomous-flight regime, it appears, before we can trust our aircraft's automated flight systems as much as we trust ourselves.

Jim Johnson, Olympia, Washington

ONLINE, regarding "Declassified Sensors Fill Cracks In Israeli Air And Missile Defense Net" *(Jan. 27-Feb. 9, p. 62)*, *RENGAB1 writes:*

Radar stealth is being neutralized by sensors fusion.

Soon, even with highly directional sound sensors.

In response to "Opinion: Why Governments Must Decide When Not To Fly" *(Jan. 27-Feb. 9, p. 66)*, BERNARD.*MOOREII writes:*

Excellent but long overdue piece. These accidental (but not completely accidental) shootdowns are at least negligent manslaughter in my view. . . . The airlines, governments AND pilots share responsibility. And everyone should recognize once more that militaries with modern, expensive weaponry make lots of misidentifications in war. And there is every reason to believe it will happen again.

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

WHO'S WHERE

Surrey Satellite Technology Ltd. has hired **Phil Brownnett** as managing director. He had been UK managing director of geointelligence at Airbus Defense and Space. He succeeds Sarah Parker, who has left the company. Brownnett has extensive experience in oil exploration and infrastructure engineering and construction.

NASA has promoted **Dennis Andrucyk** to director of the Goddard Space Flight Center, Greenbelt, Maryland, from deputy associate administrator of the Science Mission Directorate, Washington, where he fostered cost-saving collaboration with related U.S. and international entities. Andrucyk has held several engineering and technologist executive positions since joining NASA in 1988. He also worked at the National Security Agency, Naval Research Laboratory, Westinghouse, Northrop and General Electric.

Ashmita Sethi has been hired as *Pratt & Whitney* managing director for India. Sethi joins the company following extensive experience in corporate and public affairs and communications, with Boeing and Rolls-Royce.

Lynn M. Bamford has been promoted to president of the defense and power segments at *Curtiss-Wright Corp.* from defense solutions senior vice president/general manager, and **Kevin M. Rayment** has been promoted to president of the commercial/industrial segment from senior vice president/general manager of the industrial division.

Top Aces has promoted **Russ Quinn** to president from chief commercial officer. He was L-3 Technologies vice president of U.S. Air Force business development. The company also has hired **Kevin Fesler** as vice president of business development. He was executive director of U.S. Air Force Programs at Aerojet Rocketdyne and before that deputy director of F135 Sustainment at Pratt & Whitney Military Engines.

Engine maintenance, repair and overhaul (MRO) business *iAero Thrust* has hired **Tommy Mitchell** as president, **Mike Wilson** as production manager and **Sebastien Maury** as vice president for commercial. Mitchell has 27 years of supply chain management experience. Wilson has 30 years' experience, including 22 years at Delta Air Lines. Maury brings 21 years of aviation sales experience

Barfield Inc., an AFI KLM E&M subsidiary, has promoted **Gilles Mercier** to senior vice president based in Doral, Florida. His prior AFI KLM E&M positions include engineer, cost and pricing manager, engine-shop manager and Air France transformation leader.

BridgeComm has hired **Michael Abad-Santos** as senior vice president of business development and strategy. Abad-Santos was Trustcomm chief commercial officer and before that LeoSat senior vice president for the Americas.

Danette Bewley has been promoted to president/CEO of the *Tucson Airport Authority* from president of operations/chief operating officer.

General Dynamics Land Systems has named **Danny Deep** president, a promotion from chief operating officer. He succeeds Gary L. Whited, who will retire in April.

Virgin Galactic has promoted **Enrico Palermo** to chief operating officer in addition to his role as president of The Spaceship Co., Virgin Galactic's wholly owned aerospace manufacturing and development subsidiary.

Consolidated Analysis Center International (CACI) has hired U.S. Army Lt. Gen. (ret.) **Michael Nagata** as senior vice president and corporate strategic advisor. He was director of the National Counterterrorism Center's Directorate of Strategic and Operational Planning. CACI also has hired **Marlin Edwards** as senior vice president of business development. He had overseen business development at ManTech.

Copenhagen-based *Infare,* an air-fare-pricing data service, has hired **Fredrik Palm** as chief technology officer. Palm was Qlik vice president of research and development and before that Zaplox chief technology officer.

CAG Holdings has appointed **Ginger Evans** as chief strategy officer. She was CEO of Reach Airports, a CAG/Munich Airport joint venture, and before that was commissioner of the Chicago Department of Aviation. CAG also has named **Krystal Brumfield** chief of staff. She was Reach president and CEO of the Airport Minority Advisory Council.

The *Aerospace Industries Association* has named **Alison Lynn** vice president of communications. She was senior director for product communications at the American Chemistry Council.

Nano Dimension has hired veteran turnaround executive **Yoav Stern** as president/CEO. Cofounder and former CEO **Amit Dror** will become customer success officer and continue to serve as a director on the company's board.

Airbus Helicopters has promoted **Laurence Petiard** to head of external communications. She has managed external communications for several civil and military helicopter programs.

Commercial Jet has hired **R. Rick Townsend** as vice president of sales and marketing. Townsend has held senior positions at Avianor, Lufthansa Technik and AAR Aircraft Services.

Gulfstream has promoted **Matt Baer** to regional vice president of sales for the Northeastern U.S. and Eastern Canada. He was northeast regional sales manager.

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.*

THE FUTURE. NOW UNDER CONSTRUCTION.

WE MAKE IT FLY

Whether it's integrating cutting-edge technology to reduce our environmental impact, driving innovation to improve society or ensuring we operate ethically throughout our entire supply chain, Airbus is committed to developing a sustainable future for our business, our stakeholders and the planet. That's why we embrace the UN's Sustainable Development Goals. It's not only what we make; it's what we're made of.

Sustainability. We make it fly.

airbus.com

AIRBUS

FIRST TAKE

For the latest, go to
AVIATIONWEEK.COM

BOEING

COMMERCIAL AVIATION

After two days of delays caused by bad weather, Boeing's 777-9, the first of the company's flagship, long-range 777X family, made its first flight, from Everett, Washington, on Jan. 25 (page 28).

Boeing reported a net loss of $636 million for 2019—down from a profit of $10.5 billion for 2018—on revenues of $76.6 billion, down 24% and far from the $109.5-111.5 billion envisioned before the 737 MAX crisis (page 32).

Airbus has reached an "agreement in principle" with French, UK and U.S. authorities to pay €3.6 billion ($4 billion) in penalties to settle allegations of bribery and corruption in aircraft sales (page 34).

The U.S. Energy Department's advanced research projects agency plans a $55 million investment toward developing propulsion technology for all-electric, 150-200-seat narrowbody airliners.

A European industry/academia consortium will develop a road map to hybrid-electric propulsion for commercial aircraft under the Imothep project, backed by €10.4 million from the European Commission.

France's transport ministry has set targets for use of sustainable jet fuel in commercial aviation, replacing 2% of fossil fuels with biofuels in 2025, increasing to 5% by 2030 and reaching 50% by 2050.

Delta Air Lines has signed an offtake agreement with Northwest Advanced Bio-Fuels that could result in deliveries of sustainable aviation fuel produced from forest residues by the end of 2024.

Mitsubishi Aircraft has deferred first delivery of the SpaceJet regional aircraft by at least another nine months, delaying handover to no earlier than the start of its fiscal year beginning April 2021.

Abu Dhabi-based Etihad Airways plans to sell a large portfolio of its Boeing 777-300ERs, Airbus A330-200s and -300s to U.S. aviation financier Altavair Air-Finance and global investment specialist KKR for $1 billion.

The Indian government has launched another attempt to sell off Air India, this time offering 100% of the debt-laden airline. A prior attempt in 2018 to find a buyer for a majority stake in the airline failed.

SkyTeam members Air France-KLM and Delta Air Lines' transatlantic joint venture with UK long-haul carrier Virgin Atlantic will take effect Feb. 13, bringing together a network of 110 nonstop routes.

UNITED AIRCRAFT CORP.

DEFENSE

Russia's first modernized Tupolev Tu-160M bomber, with new flight control, navigation, communication, radar and electronic countermeasures systems, made its 34-min. first flight on Feb. 2 from Kazan Aircraft Factory.

Germany has canceled plans to develop a signals-intelligence platform based on Northrop Grumman's MQ-4 Triton high-altitude, long-endurance unmanned aircraft. It is looking at using a business jet as the platform instead.

Poland formally signed a letter of offer and acceptance on Jan. 31 to buy 32 Lockheed Martin F-35As for $4.6 billion, becoming the first NATO country bordering Russian territory to adopt the stealth fighter.

U.S. Special Operations Command has revived the Defense Department's on-again, off-again pursuit of a light-attack fleet by announcing plans to acquire 75 manned aircraft for the "armed overwatch" mission.

Arms agency Rosoberonexport has secured the first sale of Russian Helicopters' new heavy transport with an unspecified number of military Mi-38Ts to be delivered to an undisclosed customer in 2021-22.

Northrop Grumman has won a role on a significant hypersonic defense pro-

LIVING LEGENDS OF AVIATION

AWARDED

William Garvey, *Business and Commercial Aviation* editor-in-chief, was inducted into the "Living Legends of Aviation" in Beverly Hills, California, on Jan. 16. Along with other Class of 2020 inductees—including Apollo 13 commander Jim Lovell, Gulfstream's Larry Flynn and Sergei Sikorsky—Bill was introduced by the evening's host, actor/pilot John Travolta, and honored for his long and storied career in aviation journalism.

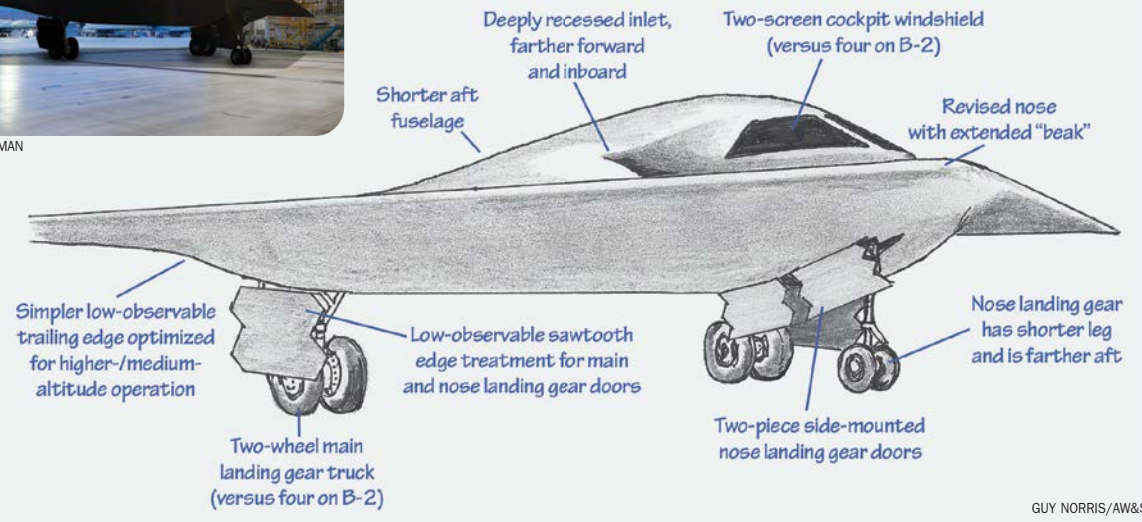
The list of more than 100 past recipients includes astronauts Neil Armstrong and Buzz Aldrin, airline pilots Al Haynes and Chesley "Sully" Sullenberger, celebrity pilots Harrison Ford and Morgan Freeman, and general aviation leaders Jack Pelton, Brian Barents and Clay Lacy. The ceremony is produced annually for the Kiddie Hawk Air Academy, which is dedicated to sparking children's interest in aviation.

After experiencing a record-breaking year in 2019, Myrtle Beach International Airport in Florida was crowned overall winner of the Aviation Week Network's Routes Americas 2020 Awards in Indianapolis on Feb. 5.

NORTHROP GRUMMAN

B-21 Design Changes Compared to B-2

A U.S. Air Force rendering of the Northrop Grumman B-21A released on Jan. 31 provided the first detailed view of the secretive stealth bomber. Aviation Week editors quickly produced this sketch to help interpret the key design changes from today's B-2A, suggesting it is a significantly smaller aircraft.



GUY NORRIS/AW&ST

gram managed by DARPA, receiving a $13 million contract under the Glide Breaker program to develop an advanced interceptor.

GENERAL AVIATION

Leonardo Helicopters is set to take over fledgling Swiss rotorcraft manufacturer Kopter Group and its in-development SH09 single-turbine light helicopter in a $185 million deal (page 42).

Despite the Jan. 26 Sikorsky S-76B crash that killed basketball legend Kobe Bryant, fatal U.S. helicopter accidents decreased over the past two decades but hit a plateau in 2018 and 2019.

European regulator EASA has proposed the first certification rules for electrified aircraft propulsion. The draft Special Condition for Electric and Hybrid Propulsion Systems is open for public comment until March 6.

Erickson and Sikorsky will install Matrix autonomy technology on the S-64F Aircrane heavy-lift helicopter and demonstrate autonomous firefighting capabilities in 2021 (page 44).

Embraer's Phenom 300E light jet is being upgraded with improvements in performance, comfort and technology as well as an optional new interior. Certification is expected in the first quarter of the year.

SPACE

The FAA will introduce a new Space Data Integrator system in August to track space launch and recovery operations in real time with traditional air traffic and to reduce the airspace blocked off to other users.

Rocket Lab kicked off planned monthly launches with a Jan. 30 classified mission for the U.S. National Reconnaissance Office, a flight that also demonstrated guided reentry of the Electron first stage.

A SpaceX Falcon 9 rocket lifted off from Cape Canaveral on Jan. 29, orbiting a fourth batch of 60 Starlink satellites as the company gears up to begin offering high-speed, low-latency internet services.

60 YEARS AGO IN AVIATION WEEK

The first of 10 Convair 880s ordered by Delta Air Lines appeared on our cover of Feb. 15, 1960, five days after setting a new U.S. coast-to-coast commercial speed record during its delivery flight—traveling from San Diego to Miami in 3 hr., 31 min. and 54 sec. Built in San Diego by the Convair division of General Dynamics and powered by four General Electric CJ805-3 turbojets, the 84-110-seat 880 was conceived as a smaller, faster competitor to the Boeing 707 and Douglas DC-8. Delta launched its commercial service on May 15, 1960, between Houston and New York. But the speedy jet proved to be a commercial flop, hobbled by high per-seat operating costs. Just 65 were built before production ceased in 1962, and Delta retired the last of its 880s in 1974. The following year, singer Elvis Presley bought a used Convair for personal use and named it after his daughter, Lisa Marie.

Read every issue of Aviation Week back to 1916 at:
archive.aviationweek.com

UP FRONT

RICHARD ABOULAFIA

Advantage Airbus

Why Boeing must **refresh its product line**

ONE OF INCOMING BOEING CEO Dave Calhoun's first actions has been to order a rethink of the company's new midmarket airplane (NMA). This is the right move. It has never been clear how the NMA, a twin-aisle design, could match the economics of the single-aisle A321neo.

Yet Calhoun should keep in mind three realities that weigh on Boeing's new product strategy. First, the middle market is booming, and Airbus is winning it with the A321neo. Second, Airbus can expand and update its single-aisle and midmarket product line. The third is that Boeing cannot do that. There is a lot at stake for Boeing and not much time.

First, airlines clearly want midsize jets. Last year, there were just 673 net orders for all Airbus and Boeing jets; 476 of these were for the A321neo. This is more than just upgauging; much is due to increasing airline route fragmentation, a trend that will keep growing for years to come.

This midmarket growth also reflects a shift away from twin-aisles (Boeing's strongest position) and toward single-aisles (where Airbus is strongest). Airbus has sold 3,255 A321neos since the type was launched in 2011, or three times as many as the 1,049 Boeing 757s sold over 25 years. By contrast, Boeing has sold around 650 737 MAX 9/10s (the company does not break out variant orders). The A321neo is winning by a 5:1 ratio.

While the 737 MAX 8 has done well against the A320neo, as the A321neo continues to grow in popularity, it will bolster Airbus' smaller single-aisles, as airlines seek commonality across their fleets.

Second, Calhoun should remember that there is quite a lot that Airbus can do with its single-aisle product line. In addition to increasing commonality between the A220 and A320 families, it could stretch the former C Series, creating a 145-150-seat A220-500, likely offering lower seat-mile costs.

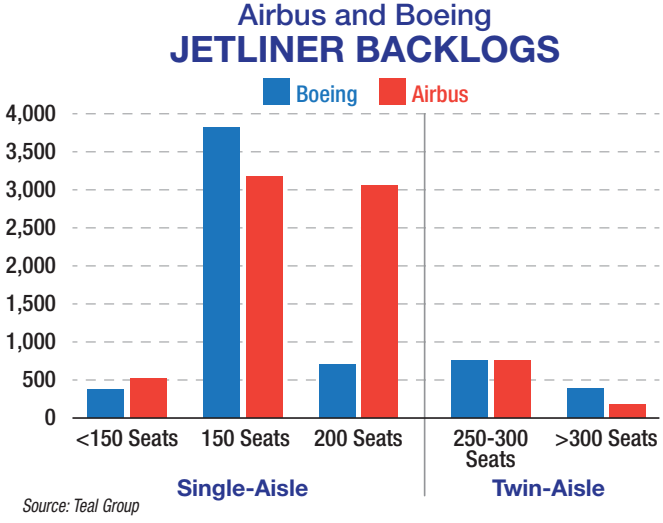
While an A220-500 would take away demand for the A320neo, Airbus could compensate by making the A320neo and A321neo more capable models. The A220's wings use resin transfer infusion (RTI) composites. Adapting this technology for the A320/321neo, perhaps with an engine update, would produce 150-240-seat jets with greater range and superb economics.

Most intriguingly, if the A321neo can be stretched, Airbus would have an even greater midmarket category killer. With new RTI wings and new, more powerful engines, an A322neo would be a true global route-fragmentation machine, building on the Boeing 787's remarkable work in creating new thinner routes.

Third, by contrast with this incredible menu of Airbus possibilities, Boeing can do nothing more to the 737. The MAX 9/10 and MAX 200 are clearly outclassed by the A321neo, and there is probably nothing that Boeing can do to make them more competitive.

Most of all, the 737 family has clearly reached the end of its evolutionary line. After the MAX program, there will not be a fifth 737 incarnation. Boeing needs a new clean-sheet, single-aisle model eventually.

Analysts, including me, point to the McDonnell Douglas experience as an example of what can happen when a jetmaker neglects new product investment. But there is a difference. When McDonnell absorbed Douglas in 1967, it inherited a single-aisle jet—the DC-9—that proved reasonably well-suited to updates. And its MD-80 series was a success, staying in production through 1999. This also allowed McDonnell to address the core of the single-aisle market, albeit in a declining way, without having to launch any new products.



Source: Teal Group

But if Boeing is to copy McDonnell and neglect investment in its jetliner business, it will not have 30 years to coast. The 737 MAX will have 10-12 years before it needs replacement.

And unlike during the McDonnell sunset years, the market is shifting upward. If Boeing does not build a clean-sheet midmarket airplane, it will lose at least 15%, and perhaps 20%, of the market. What was a 50/50 duopoly will become a 65/35 duopoly, or perhaps even a 70/30 one. In an industry that is heavily dependent on volume to achieve the lower costs that airline customers demand, such a market-share decline would be tough to recover from.

Whether Calhoun remains as CEO or not, Boeing needs to digest the clear conclusion from these three realities: Product development inaction is a recipe for Airbus market dominance, possibly for decades to come.

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


ATR
shorter runway.
wider horizons.
the ATR 42-600S can land and take off
on runways just 800m long
atr-intolife.com
into life

GOING CONCERNS
MICHAEL BRUNO

BOEING'S JAN. 29 TELECONFERENCE will be remembered as one of the most humbling earnings reports in the 103-year-old company's history, but for 737 MAX suppliers it will also set the tone for the next two or three years.

"Slowly" was the buzzword repeated often by Boeing leadership, especially when it came to the narrowbody's monthly production rate ramp-up—assuming the MAX is set to become "ungrounded" and production resumes after halting this month. Boeing CEO David Calhoun and Chief Financial Officer Greg Smith said during the call that production flow will return "one step at a time," even "one airplane at a time."

Boeing still has not forecast production plans beyond stating it can restart manufacturing months before the MAX is returned to service. But already major suppliers, analysts and consultants are piecing together a road map that foresees MAX monthly unit production rates hitting the mid-20s this year, the 30s most of next year and possibly back to 52—where it stood before the MAX crisis—by the end of 2022.

"Probably the most distressing aspect of the line shutdown was the relative lack of guidance provided to suppliers," Teal Group analyst Richard Aboulafia said Jan. 23. "Rate 52—if we get that in late 2022, I'd be super happy."

Considering that Boeing has indicated a new public marker of a midyear MAX return to service that seemingly is backed by the FAA, the supply chain is expecting Boeing's own production to restart in March or April. "We've assumed roughly a 90-day production delay, which is consistent with direction that we've received from Boeing," says United Technologies Corp. (UTC) Chairman and CEO Greg Hayes.

More anecdotal evidence came Jan. 30 from aerostructures leader Spirit AeroSystems, when managers there announced a new agreement with Boeing over MAX production. "Under the agreement, Spirit will restart production slowly, ramping up deliveries throughout the year to reach a total of 216 MAX shipsets delivered to Boeing in 2020," the Wichita supplier said. "Spirit does not expect to achieve a production rate of 52 shipsets per month until late 2022."

In turn, that would imply an average production rate of 24 per month in 2020, according to financial analysts Sheila Kahyaoglu and Greg Konrad at Jefferies, who note that Spirit already counts about 95 737 units parked in or near its factory.

'One Airplane at a Time'

JASON REDMOND/GETTY IMAGES

Other suppliers are making similar noises. Hayes of UTC, home to Collins Aerospace and Pratt & Whitney, says managers assume an average production rate of 21 per month in the second half of the year for Collins. General Electric executives say their Leap engine production has not stopped, but the rate this year will fall to roughly half what it was in 2019, also indicating a rate of 21.

This is all a world apart from the five-a-month jumps Boeing and suppliers originally envisioned shortly after MAX production was cut to 42 a month last April. Based on what they heard at Aviation Week's MRO Americas 2019 conference, Leeham News and Analysis reported at the time that MAX-makers had eyed a rate increase to 47 in June, 52 by August and finally 57 by last September. Of course, rate 57 is where Boeing and suppliers were poised to go to before the MAX crisis erupted.

Now it is a "creep, crawl, walk, jog, and then run approach," as industry consultant Jim McAleese puts it. Among the consequences, the first year of "normal" MAX production will be 2023, also when Boeing might get up to rate 57.

In turn, Boeing and its suppliers have to adjust their earnings expectations to account for both the lack of previously planned deliveries as well as new costs, since they were positioned for rate 57 by last summer. For its part, Boeing added $9.2 billion to its summary of MAX-related financial charges as part of its latest earnings report, bringing the total to $18.6 billion so far.

Cost estimates from the supply chain are trickling in, and they range from mild to eye-popping. Hayes says the production pause is projected to cost UTC just $100 million per month in sales. "We do not anticipate any layoffs," he adds. "I think that would be the easiest thing to do, but quite frankly, given the scarcity of talented aerospace workers out there, we're not going to be laying anybody off for a 90-day delay here. I think we're going to work on the backlog."

But Spirit has already announced layoffs of at least 2,800 workers in Wichita. Increasingly, smaller suppliers are warning Wall Street of bad news, too. British aerostructures provider Senior said Jan. 31 its aerospace revenue this year could drop 20% compared with last year, due to the MAX production halt. Senior's operating margins will slip as well, and according to media reports the company is saying the recently announced sale of its aerostructures business might have to be shelved until more MAX certainty emerges.

Reflecting on the past. Looking to the future.

Our 600+ airline customers have helped CFM define the power of flight and these relationships have been the very heart of our business for more than four decades. Today, we have the power to redefine the future. Extraordinary together.

cfmaeroengines.com

CFM International is a 50/50 joint company between GE and Safran Aircraft Engines

Extraordinary together

cfm

INSIDE BUSINESS AVIATION
WILLIAM GARVEY

DON'T LET THE SNOW AND ICE and freezing temperatures fool you; it's that time of the year. Again. The performers and maintainers are making their way to their hangars with fresh oil and clean rags, touch-up paint and polish, ready for run-ups and radio checks. The curtain is about to rise on Air Show Season 2020.

According to the International Council of Air Shows (ICAS), the U.S. gatherings begin with the Washington's Birthday Celebration Association's Stars & Stripes Air Show in Laredo, Texas, on Feb. 16, featuring a full array of warplanes past and present, along with aerobats, sky divers and sunburns. The ICAS calendar lists over 170 shows through November, some multiday events, mostly in the U.S. and Canada with a few international venues. As you might expect, California claims the most with 23; Texas and Florida follow with 14 and 13, respectively. The balance range from Maine to Arizona—even Rhode Island is a host: The National Guard Open House and Air Show is set for June 20-21 in North Kingstown.

However, notably absent from the list is an air event in which ICAS is intimately involved. And while it might not meet the criteria typically attached to an air show, it's going to turn a lot of faces skyward and will likely be the last of its kind.

The Arsenal of Democracy Flyover is to take place in Washington on Friday, May 8, the 75th anniversary of Victory in Europe—VE Day. That's the date Nazi Germany surrendered unconditionally, and the artillery, machine guns, bombs and missiles of World War II were finally silenced on the blood-soaked continent where that most terrible conflict began. The flyover is intended as a very visible, audible and physical salute to the servicemen and women whose courage, smarts and determination defeated the enemy, and to honor those on the home front whose work and sacrifice provided the tools for them to prevail.

Long in planning, the flyover is expected to involve nearly every type of training plane, fighter, bomber and transport used by the Allies in the war, some 100+ aircraft in all, many of them rarely seen. They will include Spitfires, Hurricanes, an Avro Lancaster, Airacobra, Douglas A-20 Havoc and A-26 Invader, de Havilland Mosquitos, Westland Lysander, five Boeing B-17 Flying Fortresses, a pair of Boeing B-29 SuperForts, plus a brace of F4U Corsairs and a squadron of P-51s. If all goes according to plan, the D-Day invasion will be commemorated by a flight of five C-47s, four of which actually participated in the invasion of France in June 1944.

Pete Bunce, president of the General Aviation Manufacturers Association (GAMA), a retired U.S. Air Force fighter pilot and a leader in the flyover program, said, "We can't parade tanks down Constitution Avenue nor float ships in the Tidal Basin, but through incredible coordination with a myriad of federal agencies, we are being allowed to parade World War II aircraft through the most restrictive airspace in our nation to honor the greatest generation that secured for the world the freedoms we cherish today."

Aerial Salute

Sounds, sights and moving shadows as thanks to **exiting heroes**

TONY GRANATA/ICAS

The program will launch aircraft from general aviation airports in Manassas and Culpeper, Virginia, proceeding in echelons at different altitudes south along the Potomac River, turning left at the Lincoln Memorial, flying past the World War II Memorial and east along the Mall, and then exiting to the right past the Smithsonian National Air and Space Museum and the new Dwight D. Eisenhower Memorial, which is being dedicated that day. All the aircraft are to fly at an altitude slightly above 1,000 ft. and progress at 169 kt. From start to finish, the flyby is expected to take 100 min.

Operations at nearby Reagan National Airport will be halted for 2 hr. to accommodate the aerial parade.

According to ICAS President John Cudahy, many aircraft will carry dignitaries, foremost among them veterans of the war. One honorary leader is former Sen. Bob Dole (R-Kan.), a wounded veteran of that conflict, and his wife Elizabeth, and Linda Hope, representing the Bob and Dolores Hope Foundation, which helped finance the effort. "Nobody is making a dime" from the flyover, Bunce says; contributions, which are most welcome, will be used to cover the cost of aircraft fuel and oil.

While guesstimates of spectators range from 100,000 to 200,000, organizers note that the flyover is likely to be the last gathering of significant numbers of war veterans as time diminishes that corps steadily and rapidly. The flyover "is the last chance to bring the nation together with a large contingent of the last remaining veterans of that conflict to pay tribute to their service and sacrifice," says Bruce.

Other participating organizations include the National Air Traffic Controllers Association and the Commemorative Air Force.

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

THE 777X TAKES TO THE SKIES

The world's largest and most efficient twin-engine jet took its first flight, a major milestone for Boeing's 777X built on years of development, testing and rigor. With technological advances that allow it to fly farther with less fuel and emissions, the 777X will fly passengers more comfortably and efficiently than ever before. Keeping safety at the core of everything we do, we're building the future of flight together.

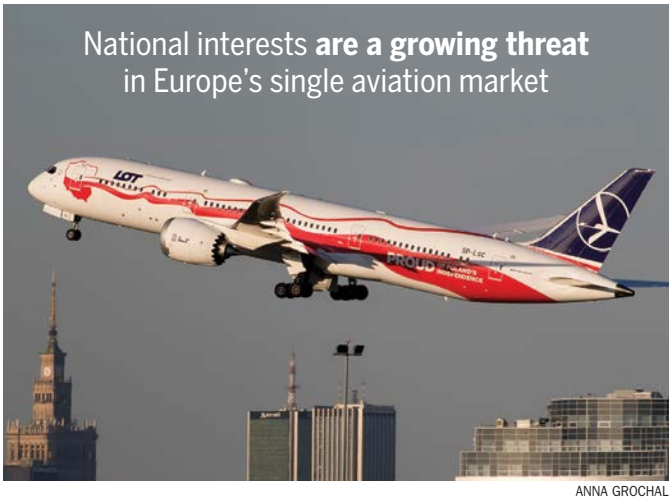
boeing.com/777X
#777X

BOEING

AIRLINE INTEL
JENS FLOTTAU

Looking for Loopholes

National interests **are a growing threat** in Europe's single aviation market



ANNA GROCHAL

LATE IN JANUARY, AN INTERESTING combination of airlines was announced. Polish Aviation Group (PGL), the parent of LOT Polish Airlines, confirmed that it plans to buy German airline Condor, doubling the company's size and adding a leisure market portfolio to the growing business. If all goes well, the deal should close by the end of April.

The combination is interesting because it sheds light on aeropolitical trends in Europe. LOT is an airline that was on the brink of collapse in 2014, rescued only by a €200 million ($220 million) capital increase subscribed by its sole shareholder, the Polish government.

The European Commission (EC) approved the state aid because LOT made its own painful contributions to the restructuring (as it obviously should have) and because it presented a turnaround plan the authority considered viable. PGL is a government-controlled company set up in 2018 that initially included LOT and several Polish maintenance, repair and overhaul and ground-handling specialists. Condor is flying today only because the German government provided a €380 million bridge loan last fall that gave the airline the time to find a buyer.

Get the picture? European governments continue to be highly involved in the airline sector. Tarom gets help from the Romanian government, Croatia Airlines has public-service obligation funding on routes where it arguably does not need it, the UK just insured that Flybe can continue flying rather than collapse—and then ,of course, there is the never-ending story of Alitalia. How many times has the deadline for its sale been extended? How many times has the government loan been prolonged? How many times has the EC said now was really, really the last time it would allow financial aid?

Some cases are not so clear-cut: One is Condor's. The airline was in relatively good shape and profitable. German tour operators and consumers had a high interest in its survival because it ensured competition, and it only got in trouble when its parent collapsed. Its rescue may ultimately have made sense from an overall market point of view. But as nationalism gains more traction inside the EU, so does the questionable involvement of governments in airlines, and the EC seems to be ignoring blatant violations of its own state aid rules. It is a sign of how member states are focusing on their own national agendas, which the EC appears too weak to counteract.

Poland has a clear government agenda for aviation: LOT is to be turned into a major player in Europe's air transport sector, flying from a newly built Warsaw airport in a few years, which will enable it to build another hub-and-spoke operation. Yes, Poland's economy is growing faster than those of other European countries, so there is some justification for a growing airline there if it is commercially viable. But it shouldn't grow just because of state policy and state support.

Yet Wizz Air CEO Joszef Varadi says, "Warsaw is a miserable place for every airline because the government does everything to support LOT."

Subsidies are not the only issue. There is overwhelming evidence Air Berlin and Alitalia were effectively controlled by Etihad when the Abu Dhabi-based carrier was a shareholder, violating ownership and control regulations. Instead of pushing hard for long-overdue ownership and control reforms, though the EC allowed their erosion where it suited national governments (Germany and Italy in that case). There is no coherent policy, leading member states to act on their own. It works the other way, too, with individual countries imposing aviation taxes on top of EU-level measures such as emissions trading.

It is unclear how the LOT-Condor combination makes sense. There are no obvious network synergies, though the airlines will surely be able to find some in back-office functions and procurement. The idea that Condor will be able to establish itself as a leisure carrier in Poland and Hungary, competing against Ryanair and Wizz Air, is creative, to put it politely. And what the EC does not resolve despite official complaints by, among others, Wizz Air, perhaps Lufthansa will handle—that airline is seriously considering canceling a long-standing partnership agreement that includes Frankfurt feeder flights for Condor's long-haul network and partnering in the Miles & More frequent-flier program. It would hardly be possible to sustain a long-haul operation of Condor's size without that feed.

Europe's single aviation market has been a great success, enabling the industry to grow in ways previously unthinkable. Too often, though, countries and airlines look for regulatory loopholes, and too often they get away with it.

Set your sights on the future of flight

SINGAPORE AIRSHOW 2020

Asia's largest aerospace and defence event

Zoom in on the latest innovations by aviation and aerospace giants and engage with top leaders from the government, defence and commercial sectors. Aviation's finest comes together at Singapore Airshow 2020 to tap into the fastest growing region. Register your attendance now and be amongst the wise ones to get ahead of the future.

REGISTER FOR A TRADE PASS TODAY!

Enjoy the **Early Bird Rates** and stand to win in our Pre-Registration Lucky Draw when you register as a trade visitor by **29 November 2019**!
Terms & Conditions apply.

LEARN MORE ABOUT THE SHOW AT WWW.SINGAPOREAIRSHOW.COM

SINGAPORE AIRSHOW 2020 11-16 Feb

Organised by: experia events that influence

Official Media Partner: AVIATION WEEK NETWORK

Supporting Media Partners: AIN, FlightGlobal

Held in: SG Singapore Passion Made Possible

HYPER HAWCs

> PENTAGON OFFICIALS SEEK HYPERSONIC AIR-BREATHING WEAPON FOLLOW-ON

> AWARENESS OF BOOST-GLIDE CHALLENGES SINKS IN

Steve Trimble Washington and **Guy Norris** Orlando, Florida

Fielding an operational scramjet-powered cruise missile has emerged as a new priority for the U.S. Defense Department's proliferating portfolio of maneuvering hypersonic weapons.

Senior defense officials are putting together a program to develop an operational follow-on to DARPA's Hypersonic Air-breathing Weapon Concept (HAWC), which currently supports competing scramjet-powered missile demonstrators designed by Lockheed Martin/Aerojet Rocketdyne and Raytheon/Northrop Grumman Innovation Systems teams.

"We are in the process of trying to figure out what [an operational program] would look like," says Mike White, assistant director for hypersonics in the office of the under secretary of defense for research and engineering.

As the U.S. military rushed after 2017 to respond to Russian and Chinese hypersonic advances, air-breathing hypersonic cruise missiles fell to the bottom of the priority list. Funding for operational programs favored boost-glide technology over the seemingly less mature field of weapons powered by scramjets (supersonic combustion ramjets).

But that assumption is being challenged. Along with the flight-test experience accumulated a decade ago by the Air Force Research Laboratory's (AFRL) X-51 scramjet vehicle, recent ground tests and simulations indicate scramjet technology is more advanced than previously understood. In September, the AFRL announced it had achieved thrust levels over 13,000 lb. with a Northrop-designed engine at speeds "above Mach 4" in a hypersonic wind tunnel. In June, Raytheon reported the maturity of its scramjet-powered HAWC demonstrator had exceeded that of its boost-glide design.

In December 2018, Michael Griffin, under secretary of defense for research and engineering, described hypersonic cruise missiles as "further out" than boost-glide weapons. But the technology advanced so quickly that another official, Air Force acquisition chief Will Roper, concluded seven months later the HAWC program would be "a nearer-term not a far-term capability."

"We'd like to see HAWC transition to a fully operational system," says Mark Lewis, the Defense Department's director of research and engineering for modernization. "It's probably the issue that our hypersonic team is spending most time on right now."

Awareness is also growing for the technical challenges still facing medium-range boost-glide missiles in the class of DARPA's Tactical Boost Glide (TBG) missile demonstrators. The Air Force's 2017 decision to launch the AGM-183A Air-launched Rapid Response Weapon (ARRW), an operational follow-on to the TBG, helped legitimize the Defense Department's revived interest in hypersonic weapons, White says.

"I think people underestimate the importance of this decision of the Air Force [to launch ARRW] in the hypersonic community," he says. "We've always been kind of stuck in the [research and development] realm. The Air Force in 2017, they were the first service that said: 'Hey, we want hypersonic weapons.'"

But the TBG-derived ARRW represents a particularly difficult technical challenge. The design uses a higher lift-over-drag ratio wing shape, which has never been successfully tested by the U.S. government. By contrast, the axisymmetric shape of the lower lift-over-drag glider developed for the Common Hypersonic Glide Body (C-HGB)—the front-end designed for the Air Force Hypersonic Conventional Strike Weapon, the Army's Long-Range Hypersonic Weapon (LRHW) and the Navy's Intermediate-Range Conventional Prompt Strike (IRCPS)—has logged several successful flight tests since the late 1970s. The winged TBG's greater maneuverability, albeit with shorter range, makes it far more challenging to design.

"It's DARPA-hard, and TBG is hard," Lewis says.

Ongoing studies by the Air Force's Warfighting Integration Capability are also starting to highlight the operational benefits of cruise missiles compared to medium-range boost-glide systems. A cruise missile still requires a booster rocket to accelerate to hypersonic speed, but it does not need to carry as much oxidizer and fuel as a boost-glide rocket because it remains within the atmosphere. Air-breathing cruise missiles' smaller size means a single aircraft, such as a Boeing B-52, can carry them in much greater numbers.

"For a hypersonic boost-glide vehicle you can get two, maybe four, on a B-52," White says. "But you can get 15 or maybe 20 hypersonic cruise missiles [on a B-52] because the size is much smaller. So you can carry them internally in the rotary rack. There are significant advantages for the air breathers, but they offer different technical challenges."

The smaller size and increased packaging advantages of air breathers would give the Air Force significant tactical advantage, Lewis adds. "The No. 1 question we should be asking is: 'How do we deliver lots of these things?' In my mind, one way to do that is to fit a lot of them in a weapons bay. Getting 15-20 per bomb bay is a lot, but if I'm [launching them from] a single mobile launcher, I'm not sure I can deliver the numbers I need. We are not interested in capability when we build two and declare it a suc-

cess—that doesn't do anything."

The Pentagon's hypersonic weapons portfolio emerged in a blur of bureaucratic activity between 2017 and 2018. The first step was the Air Force's decision to launch the medium-range ARRW program in 2017 as the follow-on to TBG. Shortly afterward, the Air Force also decided to launch the longer-range HCSW. In November 2017, the Navy conducted a successful test of the proposed C-HGB, which prompted the Navy and the Army to support funding toward the operational prototypes of the IRCPS and LRHW—for submarine and ground launch, respectively.

As it stands now, the portfolio includes air-launched medium-range and long-range boost-glide systems, an intermediate-range submarine-launched missile and a long-range weapon launched from a tractor trailer. If an operational follow-on of the HAWC is approved, with Air Force and Navy concepts under consideration, new air- and surface-launched options for medium-range targets could become available.

In addition to the offensive programs, the Defense Department's road map also includes development of a counter-hypersonic system—starting with the Missile Defense Agency's Regional Glide-Phase Weapon System as well as multiple programs for booster development and continued funding of basic science and technology. Additional DARPA programs include the ground-launched Operational Fires, which seeks to integrate a TBG front-end on a two-stage booster stack that includes a throttled upper stage, and the Advanced Full-Range Engine, a dual-mode ramjet that could power a future hypersonic aircraft.

Such a diverse yet overlapping road map has prompted criticism. In July, the chairman of the House appropriations subcommittee on defense, Rep. Peter Visclosky (D-Ind.), warned defense officials that they "need to better define the strategy for the investment in these systems." Visclosky's committee proposed cutting some funding for the Army's hypersonic program, but a joint conference committee of Congressional appropriators ultimately restored the funding and added more for other hypersonic programs.

Lewis believes the development of a multitude of hypersonic missile programs is justified.

"Too many people think hypersonics is just one thing," Lewis says. "They think, for example, [it's just for the long-range, conventional prompt strike mission]. But no, it's a range of capabilities.

"Even at the tactical level it's, for lack of a better phrase, a high-low mix," Lewis adds. "We should probably have a mix of air breathers and boost-glide systems. They probably have different capabilities, different ranges and so on. We have F-16s and F-15s, and they have different roles, and that should be the same with tactical hypersonic systems as well."

Pentagon Hypersonic Weapon Portfolio

	Weapon	Subtype	Operator	Type	Launch Mode	Booster Configuration	Contractor
OPERATIONAL							
	Air-Launched Rapid Response Weapon	None	Air Force	Medium-range boost-glide	Air	Single-stage	Lockheed Martin
	Common Hypersonic Glide Body	Hypersonic Conventional Strike Weapon	Air Force	Long-range boost-glide	Air	Single-stage, 32-in. diameter	Lockheed Martin
		Intermediate-Range Conventional Prompt Strike	Navy	Intermediate-range boost-glide	Surface and subsurface	Two-stage, 34-in. diameter	Lockheed Martin
		Long-Range Hypersonic Weapon	Army	Long-range boost-glide	Ground	Two-stage, 34-in. diameter	Lockheed Martin
DEMONSTRATOR							
	Hypersonic Air-Breathing Weapon Concept	None	DARPA	Medium-range cruise missile	Air	Single-stage	Lockheed Martin, Raytheon
	Tactical Boost-Glide	None	DARPA	Medium-range boost-glide	Air	Single-stage	Lockheed Martin, Raytheon
	Operational Fires	None	DARPA	Medium- and long-range boost-glide	Ground	Two-stage, throttled upper stage	Lockheed Martin
DEFENSIVE							
?	Regional Glide-Phase Weapon System	None	Missile Defense Agency	Medium-to-intermediate range	Unknown	Unknown	In competition

Photos (top to bottom): U.S. Air Force, Steve Trimble/AW&ST, U.S. Army, Raytheon, Raytheon, DARPA

Source: U.S. Defense Department

U.S. Air Force Defines Radical Vision for Command and Control

> SERVICE ADOPTS LEAD SYSTEMS INTEGRATOR-LIKE MODEL

> ABMS ARCHITECTURE BUILT ON GOVERNMENT OWNERSHIP

Steve Trimble

The U.S. Air Force has released the full, sweeping vision for the Advanced Battle Management System (ABMS), a two-year-old concept that proposes to disrupt modern norms for its command-and-control doctrine, military acquisition policy and industrial participation.

The newly released ABMS architecture defines not a traditional program of record but 28 new "product lines" divided into six major components. The implementation strategy is not focused around traditional acquisition milestones measured in years, but rather development "sprints" fielding morsels of new capabilities every four months. The rights for much of the technology, including a new radar, communication gateway and software-defined radio, are claimed not by an industrial supplier, but by the Air Force itself.

The strategy's release on Jan. 21 comes three weeks before the Air Force plans to release a budget plan that would shift $9 billion over the next five years to a "Connect the Joint Force" initiative. The funding would come from retiring certain capabilities, including aircraft fleets, within the next five years, with a clear implication: The Air Force is willing, if Congress approves, to trade some capability now to obtain the ABMS over time.

"I think of it as we're finally building the 'Internet of Things' inside the military, something very overdue," said Will Roper, assistant secretary of the Air Force for acquisition, during the architecture's Pentagon unveiling.

The scale of the project's ambition has evolved since the ABMS was first proposed in 2018. Air Force leaders unveiled the concept two years ago as a replacement for the airborne Battle Management and Command and Control (BMC2) suite on the Northrop Grumman E-8C Joint Stars fleet. By September 2018, Roper first suggested the same technology could be applied to replace the aging fleet of Boeing RC-135 Rivet Joints and, sometime in the 2030s, the Boeing E-3C Airborne Warning and Control System.

Those aims remain intact, but the revealed architecture clarifies that the goals of the ABMS are far broader. If the system is fully realized, the Air Force will create a "combat cloud" on a mobile ad hoc network, transposing the Internet of Things model from civilian technology to the battlefield.

As a result, the nearly four-decade-old concept of a centralized command-and-control center would be swept away by a future, decentralized digital network. Using computer processors and software algorithms instead of humans, machines would identify targets from sensor data, select the weapons and platforms to prosecute the target automatically, and finally notify the human operator when—or, crucially, whether—to pull the trigger.

Roper compares the ABMS' effect on command and control to commercial services on a smartphone, such as the Waze app for drivers navigating traffic. Waze is not driven by a human staff monitoring and reporting traffic hazards, who then review each request for directions and customize a recommended route. Instead, Waze harvests traffic and hazard data from its users, while algorithms mine that information to respond to user requests for service. The Air Force's command-and-control system is built around the human staff model but is moving to the Waze approach.

"If it didn't exist in the world around us, you'd probably say it was impossible," Roper says. "But it does [exist]."

The Air Force's challenge is to defend and execute that vision for the ABMS. The Air Force needs to secure the support of the other armed services, whose participation is vital to extracting the benefits of such a system. Moreover, the Air Force needs to sell the concept to Congress, despite the system lacking obvious jobs in specific legislative districts, such as future factory sites and operational bases. Roper acknowledges the problem of building support for an architecture, rather than a platform,

Breaking Down THE ADVANCED BATTLE MANAGEMENT SYSTEM

Sensor Integration

OpenRadarONE: Radar system and testbed*

OpenMTIONE: Moving-target-indicator mode for RadarONE

OpenIntONE: Open architecture for multi-domain sensors

Data

FeedONE: Cloud-based data feeds from all sources

WrapONE: Automated metadata wrapper

DataONE: Cloud-based data library

Secure Processing

CloudONE: Security cloud that supports multilevel classification

CrossDomainONE: Moves data across classification levels

PlatformONE: Cloud-based software development environment

EdgeONE: Local cloud if disconnected from CloudONE

BoxONE: Workstation to access CloudONE or EdgeONE

PhoneONE: Smartphone that accesses CloudONE or EdgeONE

AssistONE: Rapid deployment team to support devices

Connectivity

GatewayONE: Waveform translator*

RadioONE: Software-defined radio*

MeshONE: Software-defined mesh network*

ApertureONE: Common aperture for communications and radar

CommercialONE: Secures classified messages on gateways

NationalONE: Connects intelligence community to remote users

Link16e: Enhanced Link 16

Apps

AI/SmartONE: Cloud-based algorithm developer

FuseONE: Cloud-based fusion enviornment

OmniaONE: Cloud-based common operating picture, enabled by FuseONE

CommandONE: Cloud-based battle management, command and control

Effects Integration

MissionDataONE: Cloud-based update for mission data files

SmartMunONE: Smart weapons retasking third-party sensors

AttritableONE: Multirole attritable systems

*Government-owned system

Source: U.S. Air Force

4th Annual Civil Aircraft Operation Support Technology International Forum

June 18th-19th Qingdao, China

More than 20 Chinese Airlines attend
Covering MRO development in China

Contact Tel: 86-021-51559030
Sara LIU Email: marketing@galleon.cc

such as a new fighter, bomber or ship.

"Those are easy things to sell in this town. You can count them," he says. "But the internet is not something easy to count or quantify, even though we're all very aware of its power."

The Air Force has briefed congressional defense committee staffs on the ABMS concept, but some remain skeptical. A Capitol Hill staffer familiar with the program doubts other services support the Air Force. The model also is unlikely to be embraced by industry, the staffer says. A key point of Roper's plan requires companies to cede some intellectual property rights to the Air Force.

But the Air Force is not waiting. Development started last year, even before an analysis of alternatives had been completed. In December, the service staged the first demonstration of four new capabilities: transmitting data on a low-probability-of-intercept link via a gateway between stealthy Air Force and nonstealthy Navy fighters; connecting a C-130 to the SpaceX Starlink satellite constellation; demonstrating a cloud-based command-and-control network up to a "secret" classification level; and setting up an unclassified common operational picture display at a remote command center inside a tent.

As the second in the planned series of triannual events, the Air Force plans to stage the next demonstration in April, involving U.S. Space Force, Strategic Command and Northern Command.

Roper, an Oxford-trained physicist, has little patience for the military's traditional development process, although he has made exceptions for complex, hardware-driven programs such as the Northrop Grumman B-21 bomber and the Ground-Based Strategic Deterrent. For most other programs, he wants to trickle out new features at Silicon Valley speed. A common refrain by acquisition reformers for decades has been to emphasize delivering an incomplete, "80% solution" sooner rather than wait for a system that meets each of sometimes hundreds of detailed requirements.

However, for Roper the timeline for delivering even an 80% solution in certain cases is far too long. "[We should] covet the 10-15% solutions that take the next step forward," he said. "Because the learning in that step is so valuable to keep the velocity."

To execute the ABMS vision, he appointed Preston Dunlap last year as the lead architect. Unlike a traditional program executive officer (PEO), the architect is a role introduced to the Air Force by Roper, who previously served as the chief architect for the Missile Defense Agency. The six components and 28 production lines for the ABMS are spread across multiple program offices rather than consolidated under a single PEO. Thus, the role of the architect is to define the vision and then shape acquisition schedules as the various technologies reach maturity.

Under Dunlap's architecture, the ABMS is built around six components: new sensors feeding databases in a cloud-based computing environment using software-defined radios, with new apps fusing the data into a common operational picture and integrated effects allowing cruise missiles, for example, to automatically retask sensors on other platforms during flight. Among the 28 product lines, the Air Force proposes to own the radar, software-defined radio and communications-gateway rights.

The Air Force's role resembles the lead systems integrator (LSI) model used for a series of largely failed acquisition programs 15-20 years ago, including the Army's Future Combat System and Coast Guard's Deepwater. But in this case the LSI is the Air Force, not an industrial supplier. Such an approach is not unprecedented. The Navy is using a similar model to manage the MQ-25A program, with Boeing selected as a subcontractor to deliver the air vehicle and Naval Air Systems Command providing the ground station and integrating both on an aircraft carrier.

The gateway used in the first ABMS demonstration in December offers an example, Roper says. "We took a radio system actually built in concert with Northrop Grumman and Lockheed Martin to be able to deal with both platforms with the waveforms, and then a Honeywell antenna was able to speak across the frequencies associated with both radio systems," Roper said. "So we got those three primary vendors working together underneath our government leadership."

—With Lee Hudson

FARNBOROUGH INTERNATIONAL

AIRSHOW

20-24 JULY 2020

LEADING AEROSPACE

JOIN THE WORLD'S AEROSPACE LEADERS AT FIA2020

Discover a range of new business opportunities and networking events at FIA2020. With attendance from leading global influencers plus the latest thought leadership, industry insight and skills, FIA delivers the best value for your business. **The future starts here.**

LEADING NETWORKING

RESEARCH & DEVELOPMENT

AEROSPACE 4.0

FINN SESSIONS

Urban Air Zone

MEET THE BUYER

SPACE ZONE

FARNBOROUGH FRIDAY

BOOK YOUR VISITOR PASSES TODAY!

U.S. Navy Carrier Finally Hosts Aircraft

> FLIGHT DECK CERTIFICATION SLATED FOR MARCH

> FORD WILL SERVE AS CARRIER-QUALIFICATION PLATFORM

Lee Hudson Aboard the USS Gerald R. Ford

As the shipbuilder slowly fixes technical problems on the U.S. Navy's multibillion-dollar aircraft carrier famously derided by President Donald Trump, the service is evaluating aircraft compatibility before its scheduled deployment in 2022.

The start of aircraft compatibility testing is an essential step toward initial operations for an aircraft carrier. In this case, Jan. 16 marked the first time many of the Navy's aircraft were able to take off and land on the Huntington Ingalls Industries USS Gerald R. Ford (CVN-78)—the Navy's first new class of carriers since the 1970s.

These compatibility tests will also allow the crew to further test two new technologies that have caused numerous cost overruns and schedule delays—the Advanced Arresting Gear (AAG) and the Electromagnetic Aircraft Launch System (EMALS)—that are unique to the ship class. Additionally, the crew and test personnel can evaluate the carrier's air wake, what naval aviators call burble, and its compatibility with the different types of military aircraft.

The AAG and EMALS, both developed by General Atomics, promise to increase the sortie rate by 25% compared to the legacy Nimitz-class carriers, which feature a steam catapult that is prone to corrosion.

EMALS replaces the Nimitz-class steam catapult to launch aircraft from the Ford's flight deck. But issues with its development have been so bad that Trump has threatened the Navy with a return to "goddamned steam." One lingering area of concern is the crew's inability to electrically isolate EMALS' components during flight operations because of the shared nature of both the energy-storage groups and power-conversion subsystem inverters.

The Navy applied technical analysis and rehearsed maintenance procedures during aircraft compatibility testing, and the crew was able to fix some of the electrical systems, says Cmdr. Mehdi "Metro" Akacem, the Ford's air boss.

"In the past, we were just very cautious about high-energy electrical systems, even coming close to them, [and] now there are components that basically turn EMALS off," Akacem says.

Another challenge the Navy faced during testing was using the AAG, the new technology for aircraft landings. Parts of the AAG system are still maturing, and maintenance documentation and technical manuals are under revision.

During qualifications, sailors are finding ways to improve the system. In the past, the crew had to climb around the AAG with a grease gun to coat bearings. Now there is a manifold, and the crew can walk up. This simple change is saving maintainers 45 min., Akacem says.

Meanwhile, the test team is adjusting to the new configuration of the carrier. The island on the flight deck is 40% smaller and 100 ft. aft compared to Nimitz-class carriers. The flight deck is also a half-acre larger on the Ford. Test personnel are assessing how various loads on the aircraft affect launch and when aircraft land, says Capt. Elizabeth

U.S. NAVY PHOTOS

Sailors assigned to the USS Ford's air department supported a Sikorsky MH-60 Sea Hawk during flight operations.

"Lizard" Somerville, Air Test and Evaluation Sqdn. 23 chief test pilot.

"There's been some discussion of how does this impact how the aircraft handles behind the ship in various wind conditions—high wind conditions, low wind conditions, winds that aren't right down the landing area, starboard," Somerville says.

This is the first time the Northrop Grumman E-2D Advanced Hawkeye, Grumman C-2A Greyhound, Boeing EA-18G Growler and McDonnell Douglas T-45 Goshawk have taken off and landed on the Ford. The Boeing F/A-18E/F Super Hornet was previously used for Ford testing in 2018. Throughout the calendar year, the Ford will be the only ship available to naval aviators for carrier qualification.

Before pilots can use the Ford to become carrier-qualified, the ship must receive its flight deck certification, which is slated for March.

"The certification is sort of a holistic evaluation that looks at manpower, training and equipment," Akacem says.

Until the flight deck is certified, pilots are operating like they have a driver's permit and their father is sitting in the front passenger seat, says Capt. J.J. "Yank" Cummings, CVN-78 commanding officer. A flight deck certification is more than a purely technical term: It signals the crew is ready to handle aircraft, says Navy acquisition executive Hondo Geurts.

While the Navy is focused on aircraft compatibility testing, Huntington's Newport News Shipbuilding is still trying to fix the aircraft carrier's Advanced Weapons Elevators (AWE). Four of the 11 AWEs are up and running, and the Navy anticipates a fifth elevator will be certified in March. The operationally certified elevators are the three upper-stage elevators and one utility elevator that is also used for medical evacuations.

These elevators are used to move ordnance up to the flight deck. The AWEs use an electromechanical system that operates 50% faster than hydraulic elevators used on the Nimitz class. The Ford, which has two more elevators than legacy carriers, can carry more than double the capacity of weapons on its elevators, 24,000 lb. (11,000 kg) compared to 10,500 lb.

The main challenge with the Ford's AWEs is that all the doors are custom sized to maximize space. To ensure efficiency on future ships, the shipbuilder has developed AWE specialists who will work on all future Ford-class carriers. The Navy is committed to purchase four of the new carriers, but the service may decide to buy more.

A congressionally mandated cost cap remains in place on the Ford. However, in late September, the Navy was cleared to add $197 million to the ship's price, for a total of $13.2 billion. The funding was necessary to correct deficiencies on the elevators and will come from the fiscal 2019-21 budgets.

Seeing shipyard personnel work with efficiency and effectiveness on the AWEs while the carrier was at sea was a "pleasant surprise," says Geurts.

These comments come after stakeholders met for a "Make Ford Ready" summit hosted by Acting Navy Secretary Thomas Modly. He has characterized the $13 billion aircraft carrier as the service's "whipping boy" for why the Navy cannot do anything right, tarnishing its reputation.

"The Ford is something the president cares a lot about; it's something he talks a lot about; and I think his concerns are justified," Modly said. "It's very, very expensive, and it needs to work."

The aim of the initiative is to make sure the Ford is ready for its deployment. "There is a trail of tears that explains why we are where we are, but right now we need to fix that ship and make sure it works," Modly said.

A Grumman C-2A Greyhound landed on the USS Gerald R. Ford aircraft carrier during compatibility testing of the vessel's Electromagnetic Aircraft Launch System and Advanced Arresting Gear.

Clean Sheet

> ORIGINAL NMA LAUNCH PLAN WAS DELAYED BY MAX CRISIS

> CHANGE IN APPROACH SHIFTS FOCUS BACK TO 737-757 REPLACEMENT

Technology from the sidelined NMA concept will find a place in Boeing's next new airplane.

Guy Norris Los Angeles

As Boeing doubles down on its prime task of returning the 737 MAX to service by the middle of 2020, the company is rethinking its plans for what happens next.

As part of his campaign to put the embattled company back on track, Boeing's newly installed CEO David Calhoun wants the product development strategists to go back to the drawing board over plans for a new midmarket airplane (NMA).

Instead of doggedly pursuing the NMA, Calhoun is asking for a refocus on a fresh next-generation design that meets the more immediate demands of the market. The revised design will also build on lessons learned from the MAX and potentially incorporate fundamental changes to the company's traditional approach to flight control doctrine and piloting.

Revealing the change in direction, the "NMA project is going to be a new clean sheet of paper," Calhoun says. "Things have changed a bit," since the program began in earnest in 2015, he says. "Not so much MAX-related, but the competitive playing field's a little different." Speaking on the company's quarterly earnings call, he added: "If we were not having trouble with the MAX, I would have made the same decision on the NMA.

"There is some streamlining and prioritizing that we can do, and we will," he added. "We will take the time to reassess our product development strategy in a fairly methodical way. I think that's a natural course for any new incoming leader to take. This is not intended to delay—simply to refresh."

Boeing was on the cusp of seeking board authority to offer the NMA to airlines in March-April 2019 when the plan was derailed by the second 737 MAX accident and subsequent worldwide grounding of the model. Stemming from earlier 757-replacement studies, the baseline NMA-family concept was expanded to include a successor to the 767 and by early last year was considered ready for market. The program was focused on two main versions, the 225-seat NMA-6X and 275-seat NMA-7X, with the larger of the pair expected to be developed first.

Key program elements focused on broadening Boeing's new product portfolio with a twin-aisle design capable of 5,000-nm missions that could be delivered with single-aisle production costs. The larger NMA, believed to be dubbed internally as the 7K7-7X, was provisionally targeted at entry into service in 2025 and was expected to counter the similar-sized Airbus A321XLR. The new Airbus variant was officially approved by the European manufacturer in June 2019 and has recently gained ground in the key U.S. market, where both American Airlines and United Airlines have selected the model. The latter plans to take its first A321XLR in 2024 and begin transatlantic services with the longer-range variant in 2025.

The overall rethink on the NMA means Boeing's product development strategy is widely expected to pivot back to studies that encompass the Future Small Airplane (FSA) as well as the earlier phases of 757 replacement evaluations. The result could be a new-generation family covering the roughly 160-220-seat sector that targets the bulk of the current 737 market. Although Boeing opted to reengine the 737 and launch the MAX in 2011 in favor of an all-new FSA, the 4,000-plus order backlog for the MAX means production is set to continue well into the decade, even if Boeing experiences significant cancellations.

This is likely to provide additional buffer time for Boeing to develop a 737-replacement family, which senior Boeing sources say would leverage the work already performed over the past four years on the low-cost production system concepts and advanced materials, structures and systems developed for the NMA. Much of the sourcing activity for the NMA, including engine selection, was well underway earlier in 2019 when the MAX crisis took hold.

Calhoun indicated he has faith in the resilience of the MAX backlog, despite the grounding, and that this will give the company some breathing room for developing a successor. "I am guessing and projecting that the MAX will hold its own [and] that the market split that existed prior to the MCAS [Maneuvering Characteristics Augmentation System—the flight control system software at the heart of the MAX acci-

GO BEYOND

PRATT & WHITNEY
GTF

THERE IS NO COMPARISON. NO EQUAL. THERE IS ONLY ONE.

THE COMMERCIAL JET ENGINE IN A LEAGUE OF ITS OWN.

Powered by an industry-first geared architecture – and more than 40 other groundbreaking innovations – the **Pratt & Whitney GTF**™ is unlike any engine that's come before it.

EXPLORE THE FUTURE OF FLIGHT AT **PW.UTC.COM**

A UNITED TECHNOLOGIES COMPANY

dents] will restore itself, and that will give us a lot of freedom on that next airplane. But I wouldn't kid you if there were a reason that share position didn't restore itself."

The revised focus on a new aircraft family smaller than the NMA will also challenge the engine-makers which, up until now, have been designing new powerplants in the 50,000-lb.-thrust range. The General Electric-Safran CFM International joint venture was competing against Pratt & Whitney to be sole-source supplier for the NMA, and the change in direction may enable Rolls-Royce to reenter the fray. Rolls dropped out of the NMA race in February 2019, citing concerns over its ability to meet Boeing's original development schedule. All three manufacturers are now expected to begin evaluating new, smaller, engines.

Commenting on the potential change in flight control design thinking that would come with the revised design approach, Calhoun said: "I have had discussions with the FAA; we might have to start with the flight control philosophy before we actually get to the airplane. Because the decision around pilots flying airplanes, that's a very important decision for the regulator and for us to get our heads around."

Calhoun referenced how the change may see Boeing move closer to the flight control system approach adopted by Airbus. "We have always favored airplanes that required more pilot flying than maybe our competitor did," he said. "But we're all going to have to get our head around exactly what we want out of that. So that'll be a process that will go on alongside the next airplane development."

In an Airbus design, the flight control system will protect the aircraft from entering proscribed attitudes and speeds by limiting or augmenting the movement of control surfaces, while in a Boeing fly-by-wire design (such as the 777 and 787) the pilot retains final control authority to override the limits of the flight control system.

Boeing 777X Flight-Test Campaign Takes Off

BOEING/PAUL WEATHERMAN

- 777-9 TEST EFFORT WILL INVOLVE FOUR DEDICATED AIRCRAFT
- INITIAL TESTS SHOWED TROUBLE-FREE OPERATION OF FOLDING WINGTIPS

The initial 777-9 WH001 has continued envelope expansion since its first flight on Jan. 25.

Guy Norris Los Angeles and Seattle

The 777X is already pivotal to Boeing's future, but the newly begun flight-test and certification campaign for the long-range flagship has assumed even greater significance as the company strives to rebuild trust amid the crisis over the 737 MAX.

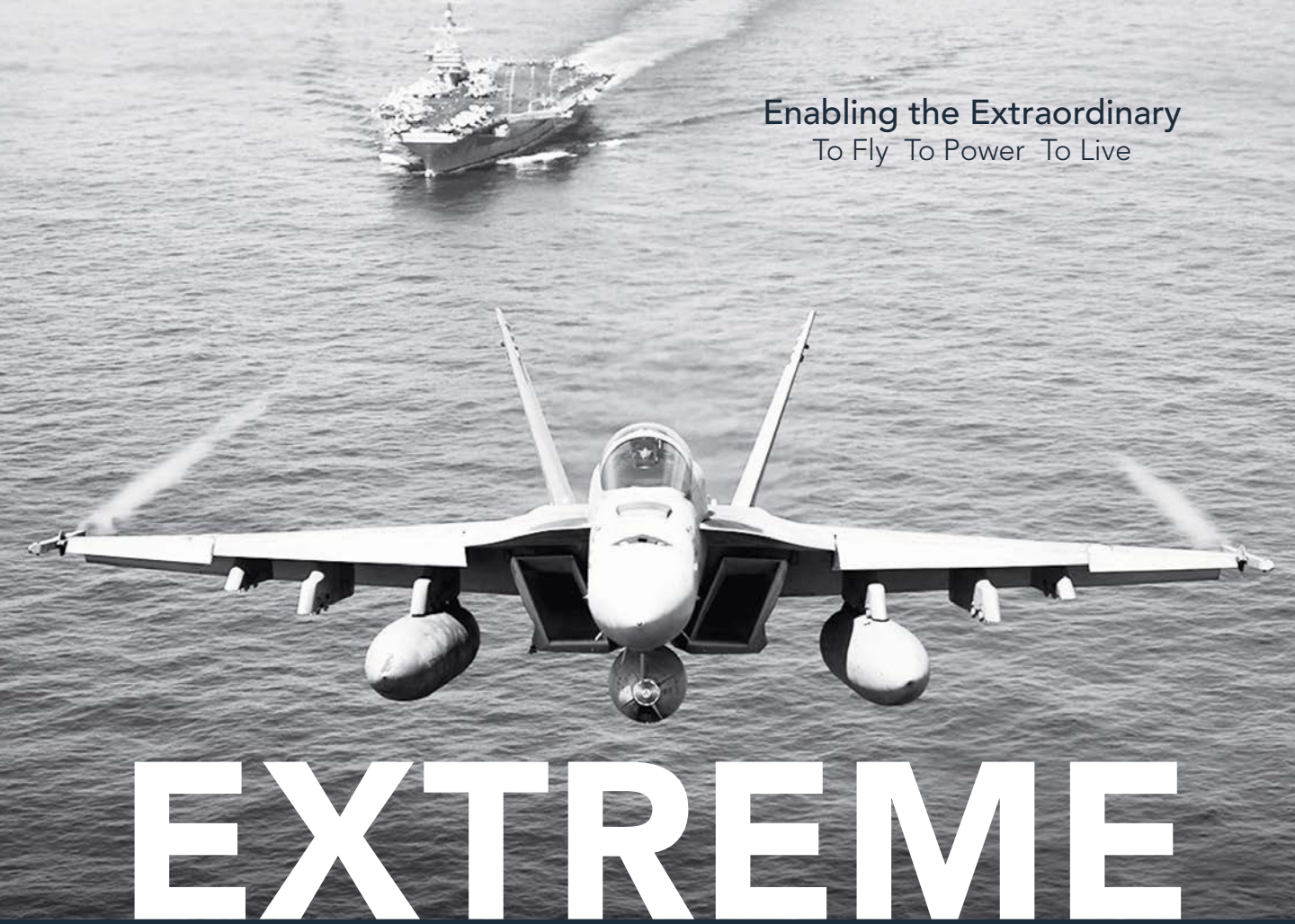
The success of the first flight on Jan. 25, after two days of frustrating bad-weather delays, therefore marked a significant boost for the beleaguered manufacturer as it prioritizes the return to service for the MAX and scours the market for new business to offset the recent slump in twin-aisle orders.

Coming more than 25 years after the first flight of the original 777 and almost 17 years after the first flight of the GE90-115B-powered 777-300ER, the test debut of the 777-9—the first member of the 777X family—also marks a critical positive step for the company's long-term widebody strategy. The big twin is designed to succeed earlier generations of 747s, 777s, Airbus A340s and A380s, and is expected to satisfy a demand that Boeing forecasts could be between 60-100 aircraft per year through 2030 for replacements alone.

First deliveries of the 777-9 are expected to launch customer Emirates in 2021, a year later than planned, after initial development issues and a six-month delay to the start of flight tests caused by durability issues with the General Electric GE9X engines. After recent adjustments, the 777X family orderbook stands at 309, including an unspecified number of the 777-9's shorter 777-8 sibling, the introduction of which is being deferred to 2024.

Although some of the initial orders from key Middle Eastern and Asian carriers, including Emirates and Cathay Pacific, are thought to be vulnerable to deferral, substitution or even cancellation, Boeing says the 13% lower operating costs of the 777-9 compared to the 777-300ER will underpin the long-term demand. "There are about 800 aircraft out there that need to be replaced over the next decade, and that's not including additional demand for growth" says Boeing 777X Marketing Director Wendy Sowers.

However, the program's success ultimately hinges on the performance



Enabling the Extraordinary
To Fly To Power To Live

EXTREME

Advanced thermal management for extreme military environments

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

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

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

MEGGITT

www.meggittdefense.com

of the aircraft and the progress of its passage through what will be an intense and closely scrutinized test campaign. This finally got underway when the 777-9—flown by chief test pilot Van Chaney and Craig Bomben, vice president of flight operations and 777-9 chief test pilot—took off from the company's Everett, Washington, facility at Paine Field at 10:09 a.m. and landed at Boeing Field, Seattle, after a 3-hr. 51-min. flight.

The flight began with a standard first-of-model departure to the north from Paine Field's Runway 34 Left. The 777-9, with the Boeing code WH001, disappeared almost immediately after takeoff into the low clouds before heading to eastern Washington, where system checks as well as basic flying qualities and handling assessments were conducted at an altitude of 15,000 ft. and speeds of 160-270 kt.

A series of low-speed checks were made while the crew flew a racetrack pattern over the northern part of the state. The 777-9 was then flown southwest, reaching an altitude of over 16,500 ft. before joining up with a chase aircraft for a photoshoot session around Mount Rainier. The 777-9 then returned to Seattle for its first landing on Boeing Field's Runway 14R.

Observers noted the relatively shallow pitch attitude used for rotation on takeoff as well as for the landing flare, most likely associated with the aircraft's 252-ft. overall length. The 777-9 is the largest twinjet ever built and is 43 ft. longer than the initial 777-200 variant. The very low noise signature of the GE9X engines was also noted on both departure and arrival. The crew reported the aircraft performed well and flew like the -300ER, despite the increased fuselage length and wingspan.

Following a brief post-flight ground-test period, WH001 flew for a second time on Jan. 29 to continue envelope expansion. The 4-hr. 43-min. flight, conducted over eastern Washington, will be followed over the following weeks with additional flights for further envelope expansion and flutter clearance testing. The second of four dedicated test aircraft, WH002, is expected to join the program in the coming weeks.

Initial tests using WH001 will clear the way for FAA Type Inspection Authority, which will enable Boeing and the regulatory authority to begin the certification campaign along with ongoing engineering tests. The 777X's new 235.4-ft. span wing, and the folding tip sections that make up almost 24-ft. of span, will be a focus for the tests. The fourth-generation composite design incorporates a modified trailing edge variable camber system derived from the 787 as well as a maneuver load alleviation system to limit stresses on the wing and reduce structural weight.

The folding tips, which resemble 777-9 winglets while stowed on the ground, appear to have performed as expected during the initial flights. The tips were seen to deploy rapidly as the aircraft took to the runway before takeoff and retracted promptly into stowed position after landing. The folding wingtip is extended by a command from the flight crew before takeoff, but on landing, it is designed to automatically fold after touchdown, as soon as ground speed slows below 50 kt. The characteristic feature, the first of its type ever to fly on a commercial airliner, was developed to maximize aerodynamic performance while simultaneously enabling the 777-8/9 to operate at International Civil Aviation Organization Code E standard taxiways, as well as gate and ramp areas in common with the current 747-400 and 777-300ER.

Ground testing will evaluate standard and nonstandard operations of the device, which in normal operational mode will take 20 sec. to fully extend and fold. For nonstandard operations, such as in the event of a rejected takeoff (RTO), the autofold feature is enabled along with autobrakes and speed brakes if the takeoff is abandoned at a ground speed of 85 kt. or more. However, if the RTO occurs at less than 85 kt., the autofold function will not trigger, and the crew will need to manually activate the wingtip folding system.

Designed to meet a set of special certification conditions developed by the FAA, the wingtip ground tests will cover checks of additional safeguards to ensure against accidental retraction in flight or unlocking during takeoff, as well as checking robust performance in gusting winds. Test standards for the wingtips are designed to conform with the same certification requirements as other moving surfaces such as ailerons and flaps.

GE Aviation is proud to partner with Boeing and congratulates them on the 777X first flight.

Maintenance, Repair and Overhaul

> BOEING'S FINANCIAL RESULTS FOR 2019 WERE THE WORST IN A GENERATION

> GETTING BACK TO NORMAL, WHATEVER THAT IS, COULD TAKE YEARS

Michael Bruno Washington

DAVID RYDER/GETTY IMAGES

Boeing will not be normal again for three years—not financially, not in its aircraft production and maybe not even in its culture and way of doing business. Instead, the next three years will see the world's largest publicly traded aerospace and defense company, the 103-year-old backbone of modern commercial aviation and defense prime contracting, try to fix itself and mend the airliner supply chain along the way.

"We will restore production health, both within Boeing's four walls and the industry at large," new CEO and President David Calhoun told a worldwide audience tuning in to Boeing's 2019 earnings teleconference Jan. 29, perhaps the most anticipated quarterly report in the company's history. "That said, there [is] always some investment reprioritizing and streamlining that we can do, and we will. We'll take the time to reassess our product development strategy in a fairly methodical way."

Last year turned out to be the ugliest for Boeing's finances in a generation, with the Chicago-based manufacturer of the embattled 737 MAX and other aerospace and defense products reporting a net loss of $636 million.

The 2019 loss contrasted with 2018 profits of $10.46 billion, Boeing's best on record. Revenue last year was almost $76.6 billion, down 24% from $101.13 billion in 2018 and far from the $109.5-111.5 billion once envisioned before the narrowbody crisis. In turn, shareholders will see a loss of $1.12 per share against a gain of $17.85 in 2018.

"We recognize we have a lot of work to do," Calhoun said. "We are focused on returning the 737 MAX to service safely and restoring the long-standing trust that the Boeing brand represents with the flying public. We are committed to transparency and excellence in everything we do."

The 2019 losses were the first for Boeing since 1997. What is more, the company disclosed $9.2 billion in new or pending charges due to the production-halted and grounded MAX, bringing the total cost of the embattled program to at least $18.6 billion.

By category, Boeing added $2.6 billion to the amount expected for customer compensation, increasing that to $8.2 billion. Another $2.6 billion was added to the 3,100-aircraft multiyear 737 program check accounting basis, now $6.2 billion. Finally, in a new twist, Boeing unveiled a $4 billion charge for "abnormal production costs" that will be expensed as incurred, primarily in 2020.

Of the last, some will be spent supporting suppliers on an individual basis. "We're engaged at all tiers of the supply chain and have been for quite some time," Chief Financial Officer Greg Smith said at the teleconference of the more than 600 suppliers involved. "It's in all of our best interests to make sure they are healthy—and frankly, coming out of this process healthier than they did coming in."

There are hundreds of parked 737 MAXs and fuselages around the U.S., and delivering them will slow production increases.

Boeing provided no financial guidance for 2020, and since forecasts for 2019 were scrapped last spring after the MAX issue emerged, analysts had little consensus to compare against and were not surprised by the red ink. In notes to investor clients, many said they viewed the earnings report as a "kitchen-sinking," in which Calhoun and Smith were looking to disclose as much bad news now as possible.

Still, some analysts say their eyebrows were raised by a few details. For starters, Boeing reported cash outflow of $2.7 billion for the fourth quarter of 2019, far below the $1 billion cash gain many expected. While it was not detailed how the money was spent, Smith said Boeing paid $1.4 billion in compensation to MAX customers in 2019.

Among other sour notes was confir-

mation that the 787 widebody production rate will drop to 10 new aircraft a month in early 2021, with the hope of returning to 12 in 2023. Also, Boeing Defense and Security's revenue was 13% lower than the previous year's, and the company says the division's fourth-quarter operating margin decreased to 0.5%, due in part to a $410 million pretax Commercial Crew charge primarily to provision for an additional uncrewed mission for the NASA program. Another $143 million in charges were taken on the troubled and delayed KC-46A aerial refueling tanker for the U.S. Air Force, as well.

Several analysts expressed continued caution, at best. "We think investors will continue to be worried that we have yet to really set a new baseline for earnings and cash flow, with the cash from the 2019 MAX charges yet to flow through, and then there is another $4 billion of estimated cost still to go," say Rob Stallard and Karl Oehlschlaeger of Vertical Research Partners. "Oh, and the 787 rate is coming down, and the Defense [and Space] division has another problem program."

Not surprisingly, Boeing is turning to debt financing to help carry it through this period. Smith said Boeing is finalizing a new term loan worth at least $12 billion, although it could be more when the debt financing closes this month. The company ended 2019 with $10 billion in cash and securities but also $27 billion in total debt.

This will weigh on Boeing, says Moody's Investors Service Senior Vice President and lead analyst Jonathan Root. "We now anticipate the road to restoring the MAX production system and Boeing's credit profile will run into 2023 and be much costlier, given significant negative free cash flow near $10 billion in 2020, even if the FAA ungrounds the aircraft by midspring," he says.

Boeing still has not forecast production plans beyond stating that it can restart manufacturing months before the MAX is returned to service. But already major suppliers, analysts and consultants are piecing together a road map that foresees MAX monthly unit production rates hitting the mid-20s this year, the 30s most of next year and possibly back to 52—where it stood before the MAX crisis—by the end of 2022.

Calhoun and Smith talked about adding one airplane at a time to the production process. "Remember, we emptied the line," Calhoun noted.

More details will emerge in the coming weeks as the rest of the supply chain reports its own latest quarterly financials, but expectations are almost universally negative.

"For industry, the supply chain is going to be hurt more than they think," Eric Bernardini, AlixPartners aerospace, defense and aviation managing partner, tells Aviation Week. He thinks it will take at least two years for things to get back to normal, but the good news is it will be smoother and slower.

Yet, resynchronizing the supply chain toward rates of 52, 57 and beyond will be even harder than before, Bernardini believes, due in part to the need to mitigate the current disruption but also because bad blood lingers from the precrisis Partnership for Success supply chain squeeze. Savvy suppliers will use this time to better prepare for more sustainable production, and a few might even be able to renegotiate terms with Boeing. "Some suppliers are really upset with Boeing," he says. "They are still really demanding."

To effect any positive change, many say Boeing must change its culture— and they have yet to see the new management even acknowledge the depth of the challenge.

Major providers concur. "We have gotten various production rates; they're not all the same just due to each individual [company]. The Tier 1s have their own rates that they're looking at," Woodward Chairman, CEO and President Tom Gendron told analysts Feb. 3. "It's a challenging environment because you know you're going to go down, but then you're going to come back up. And the type of product we make does require very skilled labor, and a lot of special machinery in specialty activity from our supply base that we need to retain."

Consultants fear some Tier 2 and 3 suppliers might go out of business or exit the A&D sector. "Many suppliers added significant resources to grow their MAX-related operations to keep pace with [about] 50 per month, and [Boeing] largely kept them engaged at the 40-50 range throughout 2019," says Peter Zimm, a principal at Charles Edwards Management Consulting. "Many of them have discounted their prices in response to Boeing's Partnership for Success program and don't have the means to keep people on the payroll throughout the pause."

Zimm adds: "Some of the subtier suppliers will ask themselves: Why endure the rate reduction only to face future cost-reduction pressures when high rates resume?"

The MAX has created other effects in the supply chain. At leading composites provider Hexcel, capital expenditures are forecast to be $100-120 million this year, lower than previous guidance as the narrowbody's issues have led it to slow the previously announced carbon-fiber factory capacity addition at its Decatur, Alabama, facility.

"With the slowdown on the MAX and even now with some additional softness with the 787 coming out later in the year by the rate 10 in 2021, that gives us the confidence that we can push that CapEx spending to the right and decrease our overall CapEx spend in 2020 and even 2020 and 2021," says Hexcel Chairman, CEO and President Nick Stanage.

Still, to effect any positive change, many observers say Boeing must change its culture—and they have yet to see the new management even acknowledge the depth of the challenge.

"While the new CEO expressed more contrition, and there was a significantly lower quota for the word 'solid' in management commentary, much of what we heard in [the teleconference] was the same old Boeing," say the Vertical analysts, a critical pair who were not allowed to ask a question on the teleconference. "We're still banned from asking questions on the conference call, but the questions with any 'bite' versus the softballs saw classic management responses.

"For example, the MAX issues are a 'hiccup'; the value case of the aircraft remains strong; widebody demand is 'solid;' don't worry—China will order loads of 787s; Boeing cares about supply chain health; and there are no broad corporate culture concerns," Stallard and Oehlschlaeger lament. "And for CEO Calhoun to claim that he is an 'outsider', having been on the board for 10 years while effectively firing the prior CEO, stretches credulity. Fixing a problem requires recognition that there is a problem in the first place—and Boeing is not there yet."

Huge Fine Clears Way for Airbus

> COMMERCIAL AND MILITARY AIRCRAFT AS WELL AS SATELLITE SALES INVOLVED BRIBES

> CASE IS NOW RIPPLING THROUGH CUSTOMERS

Thierry Dubois Lyon, France

The €3.6 billion ($4 billion) final agreements Airbus has reached with French, UK and U.S. authorities to resolve a corruption case, although colossal, is in fact a satisfactory outcome for the company.

Not only does Airbus conclude long period of investigation, it also avoids even longer judicial procedures and accompanying sensational trials. It also steers clear of any admission of liability under French or UK laws. No Airbus employee was convicted or even named in the proceedings.

The end of judicial trouble for Airbus comes as its competitor is bogged down in an even more costly crisis, as the Boeing 737 MAX is grounded and production halted.

PH. DELMUR /AIRBUS

Aircraft sales agreed to in 2014 by AirAsia Executive Director Tony Fernandes (left) and then-Airbus Commercial President Fabrice Bregier (right) were marred by corruption, according to the UK Serious Fraud Office.

For France's Parquet National Financier (PNF), the agreement is a way to establish itself as an international counter-corruption authority.

Meanwhile, some carriers whose employees were involved in bribery may face undesired consequences.

Under the final settlement agreements, Airbus will pay PNF €2.083 billion, the UK's Serious Fraud Office (SFO) €984 million, the U.S. Justice Department €526 million and the State Department €9 million. These amounts and promised compliance programs resolve "the authorities' investigations into allegations of bribery and corruption," as well as investigations into "inaccurate and misleading filings made with the [State Department] pursuant to the U.S. International Traffic in Arms Regulations," says Airbus.

Strong statements were issued about the gravity of the facts behind the case. "The number of countries subject to intense criminal investigation by the various agencies and the scale and scope of the wrongdoing disclosed in the Statement of Facts demonstrate that bribery was . . . endemic in two core business areas within Airbus," says Victoria Sharp, president of the Queen's Bench Division at the SFO. The two divisions are Airbus Commercial and Airbus Defense & Space.

"Through bribes, Airbus allowed rampant corruption to invade the U.S. system," says Jessie K. Liu, U.S. Attorney for the District of Columbia. "Additionally, Airbus falsely reported information about their conduct to the U.S. government for more than five years in order to gain valuable licenses to export U.S. military technology." In the latter instance, Airbus failed to provide the State Department's Directorate of Defense Trade Controls with "accurate information related to commissions paid by Airbus to third-party brokers who were hired to solicit, promote or otherwise secure the sale of defense articles and defense services to foreign armed forces," according to the Justice Department.

Nevertheless, Airbus points out that neither the SFO nor the PNF agreement amount to an admission of liability. In Europe, "it is very good for Airbus; nobody can say Airbus has acknowledged guilt," says Jean Tamalet, partner in Paris-based Bird & Bird's Dispute Resolution Group and an expert in white collar crime.

"The fine is massive, but one should compare it to a 4- or 5-year judicial investigation, followed by two months of trial in a courtroom full of journalists," Tamalet notes. Without even considering the potential sentence, just the sheer impact on Airbus' image would cause more damage than the agreed €3.6 billion penalty.

The law firms advising Airbus in the bargaining process issued press releases to highlight their roles—they would not have done so if the result would have been seen as negative for the airframer.

Why would the PNF or another administration choose negotiation instead of proceeding with a prosecution? "When prosecutors are sure about the case, their interest is not to offer a negotiation; but if they know some legal elements might cause them to fail in court, they look for a trade-off," says Tamalet.

The penalty should be described as a civil penalty, not a fine resulting from a conviction, says Tamalet.

The amounts the Justice Department, PNF and SFO decided on are based on both clear rules and subjective interpretation. They factor in the gravity of the wrongdoing (such as bribery of public officials), that the involved executives have left and Airbus' cooperative attitude. The company reported itself in 2016, and the acts are understood to have happened between 2008 and 2015.

To put the amounts in perspective, Airbus reported revenues of €64 billion for 2018, as well as earnings before interest and taxes of €5 billion and free cash flow (before mergers and acquisitions and customer financing) of €2.9 billion.

The fact the PNF is imposing such a heavy penalty may be a message to its U.S. counterpart. In recent years, French governments and the country's media have expressed unease about U.S. sanctions against French companies. The main

Airbus' Long Reach

Customers mentioned in the bribery and ITAR allegations

Commercial Aviation

AirAsia
AirAsia X
中華航空 CHINA AIRLINES
Avianca
Citilink
Garuda Indonesia
KOREAN AIR
Chinese airlines (unspecified)
復興航空 TransAsia
AirArabia العربية للطيران
Nepal Airlines
SriLankan Airlines

Satellites

عرب سات ARABSAT
عالمنا... عالمكم.
Our world. Your world.

RSCC
Russian Satellite Communications Company

Military Aircraft

Austria
Ghana
Indonesia
Vietnam

Judicial documents show Airbus employees were involved in bribery for the sale of commercial aircraft and satellites and concealed information they should have transmitted to U.S. authorities in the ITAR framework.

Source: U.S. Justice Department, UK Serious Fraud Office and French Parquet National Financier

concern, as voiced in a 2019 parliamentary report, is that the U.S. has used such sentences to sap foreign companies' strength and clear the way for their U.S. competitors.

One goal in establishing the PNF and an anti-corruption agency in recent years was to convince the U.S. that France has a strong policy against bribery. And the Airbus case is a signal to the U.S. that it does not have to sue French companies because France is watching them, Tamalet notes. In any case, the PNF, SFO and Justice Department have closely cooperated, he adds.

The next step for EU countries may be to give the European Commission the power to enforce anti-corruption rules globally, just as it does with competition rules.

In both air transport and military aviation, the end of Airbus' judicial woes may mark the beginning of trouble for certain customers.

The government of Ghana has been drawn into the controversy, after it emerged that payments were made to secure the sale of C295 turboprop airlifters to the African republic's military. SFO documents reveal that Airbus paid about €5 million to an intermediary—said to be a close relative of a high-ranking Ghanaian government official—to secure the order in 2011 and a follow-up order in 2015. According to the SFO, "false documentation was created by or with the agreement of Airbus employees in order to support and disguise these payments." They were intended "to induce or reward improper favor."

Ghanaian President Nana Addo Dankwa Akufo-Addo has called for a probe into the involvement of Ghanaian government officials.

In Colombia, Avianca announced an internal investigation into "its relationship with Airbus and whether it has been the victim of wrongdoing."

In Malaysia, AirAsia refutes allegations that some aircraft orders were improperly linked to sponsorship by Airbus of a sports team owned by AirAsia executives. The Malaysian Anti-Corruption Commission says it is in touch with UK authorities and investigating the matter. AirAsia co-founders Datuk Kamarudin Meranun, executive chairman, and Tony Fernandes, executive director, have relinquished their executive roles "with immediate effect for a period of two months . . . to facilitate a full and independent investigation by AirAsia.," the two said in a statement.

Both protest that the investigation by the SFO "did not even once reach out" to them, nor AirAsia, for any explanation or clarification. "We welcome any investigation," they add.

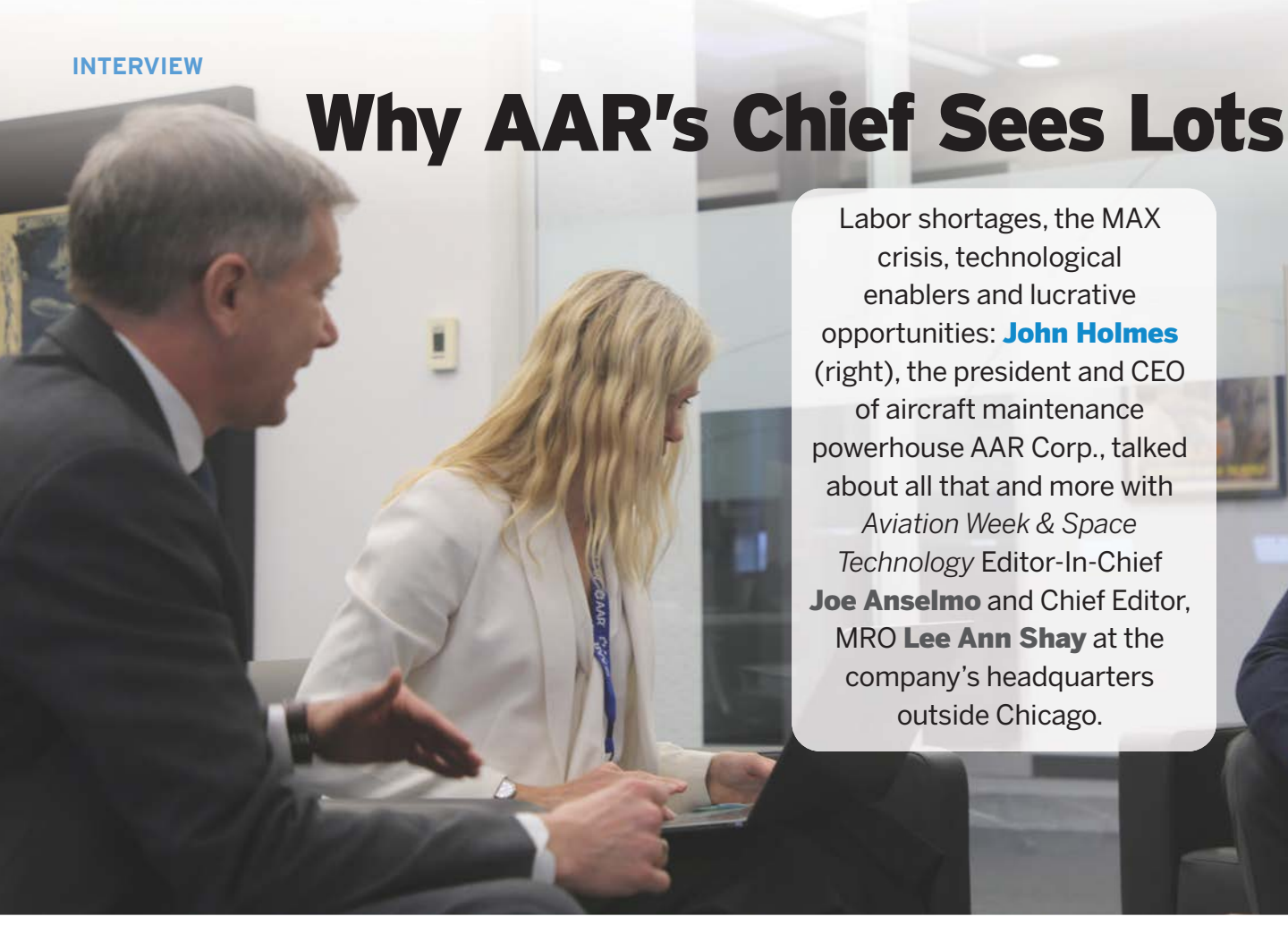
The SFO establishes a clear and direct link between Airbus aircraft sales and inappropriate sponsorship of the sports team. Between October 2013 and January 2015, Airbus "paid $50 million as sponsorship. . . . The sports team was jointly owned by AirAsia Executive 1 and AirAsia Executive 2 but was legally unrelated to AirAsia and AirAsia X." The payments were intended to secure or reward improper favor by the unnamed executives regarding the order of 180 aircraft from Airbus, according to the SFO.

In the SFO's statement of facts, the contracts subject to the "agreed wrongdoing" are dated December 2012-November 2014. The last one is for 55 A330-900neos, essentially confirming a memorandum of understanding signed at the 2014 Farnborough Airshow a few months earlier.

The related payments to the sports team were made between October 2013 and January 2015. They "were intended by Airbus employees to influence AirAsia Executive 1 and AirAsia Executive 2 to act improperly," the statement of facts says. The SFO substantiates its conclusion with numerous emails, such as one from Airbus mentioning a clause that "for obvious reasons will not refer to aircraft orders."

—With Tony Osborne in London

Why AAR's Chief Sees Lots



Labor shortages, the MAX crisis, technological enablers and lucrative opportunities: **John Holmes** (right), the president and CEO of aircraft maintenance powerhouse AAR Corp., talked about all that and more with *Aviation Week & Space Technology* Editor-In-Chief **Joe Anselmo** and Chief Editor, MRO **Lee Ann Shay** at the company's headquarters outside Chicago.

AW&ST: **AAR's annual sales are approaching $2.2 billion, and yet a lot of people still don't know much about your company.** We're the largest MRO in North America, but AAR for a long time was a difficult company to understand because we did a lot of different things. We had manufacturing, cargo and, for a little while, an airline where we were owning and flying aircraft. And then we were selling new and used parts and making repairs.

The team and I have been really focused the last 4-5 years on simplifying that story. We do three things: sell parts, new and used; repair aircraft and aircraft parts; and provide programs by putting those two things together under long-term contracts for an integrated solution for commercial and government customers. It's good to be able to say that in 20 sec.

How has the Boeing 737 MAX crisis affected the MRO industry? We service Southwest Airlines, Air Canada and United Airlines—all of whom are MAX customers—and we've had to work with them to support changes to their maintenance schedules. The impact on the aftermarket parts-supply business is neutral to slightly positive, but over the long term it will be positive because it's going to extend that [demand] for at least a couple more years. There's so much demand for those parts that once 737NGs and A320s start to retire, it's going to be good for guys like us because we will actually have some [parts] we've had demand for.

Further out on the curve, the retirements will outstrip demand, but at that point, the MAX will start to break open and mature, and you'll have a whole other revenue stream. But certainly the MAX grounding has shifted that curve out to the right. I had the chief operating officer of a well-known MAX operator in here this morning, and they were like: "Yeah, we're canceled through the end of June, and we're not counting on having that aircraft back this summer." This is taking a long time.

What about Comac's C919 and beyond that, the 929? Are those programs you have an eye on?

We're certainly aware of what's happening there. Given what's going on with the MAX, I thought if there were ever a time where [Comac] might see some traction, it would be now. But, obviously, we haven't seen that. Our time is being spent on current-generation platforms, where we've got so much opportunity.

How serious is the shortage of maintenance technicians? I spent my first year as CEO dealing with that. I don't think the seasonality in the business was well understood, particularly in the investment community. We would go from an average of 55 aircraft in work to the low-30s during the summer [the airlines' busy season]. And then in September, you'd go out and say, "Okay, let's get everybody back. We're busy again."

In September 2018, we went out, and the people weren't there. We would have a contract labor provider say, "We'll have 100 guys show up at your facility on Monday," and we would get seven. And the people we were getting weren't as experienced.

# of Runway

AAR CORP.

We had to lower our financial guidance, and our stock went from $48 a share all the way down to $29.

[Since then] we have very aggressively enhanced our recruiting efforts, raised wages where we needed to and changed agreements with certain customers so we could afford to keep a workforce together. We've announced seven different EAGLE (ethics, airworthiness, greatness, leadership, engagement) Career Pathway partnerships. We also started a school in Chicago with Olive-Harvey College [to train students in aviation sheet-metalworking]. We wrote the curriculum, found the instructor, donated tooling and equipment and have been recruiting the students. All of that is giving us a proprietary workforce. And it's working.

Another thing is that our customers kept a lot more aircraft in our hangars [in 2019], unlike [in] prior years, so that we could hold the workforce together during the summer.

AAR has begun using automated drone technology for maintenance in Miami. How is that progressing? The first step is aircraft inspection, looking over the skin to see if there are any indentations. And then it's going into more detail on inspections. Could you have a drone that could use a sensor to test whether or not I put a screw in properly? We will have to do this in close coordination with the FAA, because we want to make sure that all the repairs are conforming to their standards. We also want to make sure a drone doesn't escape a hangar and fly out onto an airfield.

You're also using augmented reality. There are big, expensive ways to do it, where I'm wearing glasses and looking at the plane, and things are turning red and green and telling me what to do. Or you can have an experienced mechanic looking over the shoulder of six less-experienced mechanics and seeing what they're seeing on their screens and literally giving over-the-shoulder guidance as somebody is performing a task. That's much less of an investment and allows us to leverage a person with 20 years of experience to help a person with five years of experience.

Defense accounts for about one-third of your business. After the 9/11 attacks [in 2001], our defense business really took off. And for a period of time we were majority defense. But we like balance, and ideally over time we will have about a 50/50 balance between government and commercial customers. That government business has changed a lot.

How so? Before 9/11, we were manufacturing pallets, shelters and containers. We still do that, but the government business we do today is much longer-term, sophisticated supply chain management contracts where we're the prime contractor.

We made a strategic decision about five years ago to migrate from being a subcontractor to a prime contractor to the government. We were doing complicated work for Northrop Grumman on the KC-10. And we thought, "We're doing a lot of really difficult things here. Is there a reason there needs to be someone in between us and the customer?"

Since then, we've won several billion dollars' worth of prime contracts. The INL Global Aviation Support Services contract with the U.S. State Department and the [Naval Air Systems Command] C-40 and P-8A maintenance contracts are big ones. We also sell used material to the U.S. government. We've said for a long time that if the Air Force bought parts like Delta [Air Lines] does, it would save a lot of money.

The C-40 was an interesting win. We're really proud of that award because it demonstrates the power of the aftermarket. Two Boeing 737-700s will be converted into C-40 aircraft. The original solicitation from the Navy was only for new aircraft. And we had to work over a long period of time to get that changed to also allow for used aircraft. It's a great solution: You get two aircraft; we put new engines on them and do all the engineering work to convert them from passenger to a combination of passenger and freighter. We put it all together in our facility in Rockford [Illinois]. There's nobody else in the world that could have done all of that work in-house the way we did.

We estimate the government is going to save $60 million, and they're going to get the aircraft a year sooner than they would have had they bought two new aircraft.

AAR announced a joint venture with Indamer to open an MRO facility in Nagpur, India, in 2019. What's the status? India considers it to be a work in process. It's our first time doing anything like this in India, so we've learned along the way. Things have taken longer than our initial expectations, but the long-term market opportunity remains compelling. The Asia-Pacific region in general is a focus for us. We're seeing good growth in Japan, and we continue to drive business in the Middle East. We've also had

a fair amount of success in Australia and New Zealand.

How is the focus on sustainability affecting how you do business? It's affecting everything we do. We have a number of facilities that have reduced their waste by 70-80% and facilities that have reduced their electrical consumption by 30-40%.

Where do you see the company in five years? We've got a long-term organic growth target of 5-10% annually. The last two years we've been growing in the teens. Half of that is from commercial growth, and the other half is largely due to government contract wins. The State Department contract, for example, is $200 million a year for 11 years. And there are more out there of that size. They don't happen every day, and they take a long time to secure, but when you get them, you're on them for a long time.

Are you looking for acquisitions? We definitely are, and we have a lot of balance-sheet capacity. We've talked about the desire to bring more intellectual property to the company. Certainly, anything that would expand our geography would be interesting. But anything we buy has to be connected with the businesses that we're in. If we find a business that fits those criteria and the math makes sense, we're prepared to move.

AAR CORP.

Video *Watch an inspection drone in action at AAR's Miami facility:* **AviationWeek.com/AAR-CEO-Interview**

FEBRUARY 2020

InsideMRO™

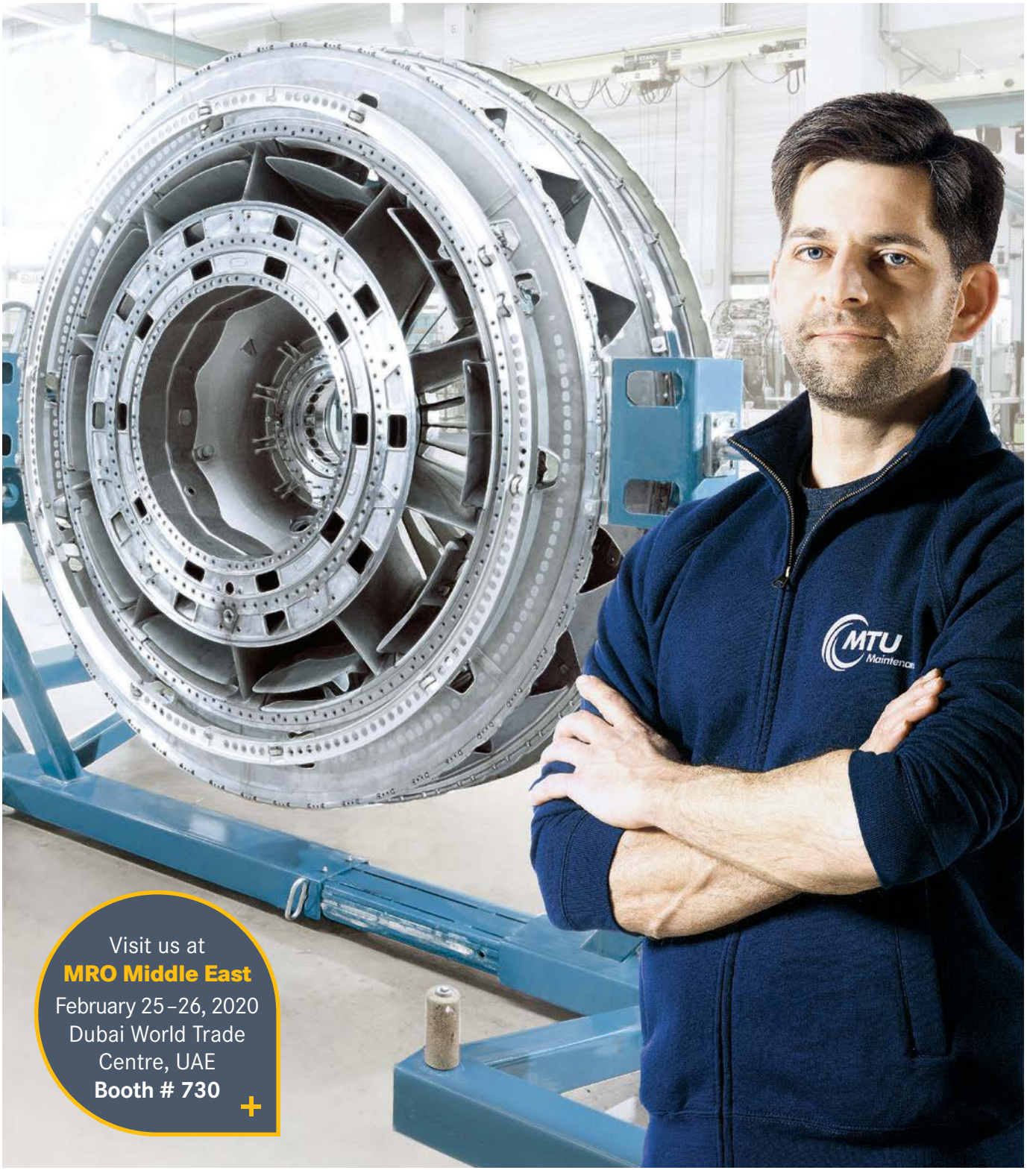
CABIN INTERIOR CONCEPTS

Take a Seat

What Now for A380 Engines?

Building Blockchain

AVIATION WEEK NETWORK



We are your engine experts

MTU Maintenance

Our people make the difference. We are passionate. We are dedicated. We marry engineering with intelligent creativity. And we never give up unless an optimal solution has been found. As the global market leader in customized solutions for aero engines, MTU Maintenance supports you with the right product across the lifecycle of your engine. From innovative maintenance, repair and overhaul (MRO) services, to integrated leasing and asset management.

Contact us and find your solution today.

www.mtu.de/en

COVER: STEVE CASH PHOTOGRAPHY

MAINTENANCE CHECK

Coronavirus Impact on MRO

Airlines around the world have suspended operations to parts or all of China to try to limit the spread of the novel coronavirus outbreak, which the World Health Organization (WHO) has declared a "public health emergency of international concern" because of its spread to 18 countries outside of China as of Jan. 31.

Demand for travel within China naturally has decreased significantly. Aviation Week's Beijing Bureau Chief Bradley Perrett reports: "The country's airlines eliminated 11,007 flights, or 40% of their original schedules of 27,630 flights, in the 24 hr. to the morning of Feb. 4, according to local consultancy Veriflight."

While "the vast majority of cases outside China have a travel history to Wuhan or contact with someone with a travel history to Wuhan," WHO says, the Chinese government extended the Lunar New Year from Jan. 30 to at least Feb. 2, and dozens of provinces have lengthened it further to limit the virus' spread.

For instance, Guandong Province, in which MTU Maintenance Zhuhai is based, issued a directive for companies to remain closed until Feb. 9. "In the meantime, MTU Maintenance Zhuhai will operate with a small team to deliver the most urgent engines and support customers in aircraft-on-ground and 0 spare situations. We expect the site to resume full operations on Feb. 10," says a company spokeswoman.

Haeco Composite Structures in Jinjiang, Fujian Province, which extended the lunar holiday through Feb. 9, also has very limited activity due to the restriction. Sunny Mirchandani, director and general manager, points out that scheduled maintenance work around the lunar holidays usually drops off. How work will ramp up is still unclear, given the temporary travel restrictions and flight cancellations, but he says when things clear, there could be "a new 'peak travel' season" as people resume travel. "This phase could defer maintenance plans or component removals," so "it would be wise to expect a slowdown in MRO operations for a few months once the aviation activity and travel resumes," he notes.

"It would be wise to expect a slowdown in MRO operations for a few months."

Unlike Severe Acute Respiratory Syndrome (SARS), which lasted about six months in 2003, this outbreak is predicted to have a bigger impact on the global economy because China produces more advanced, higher-tech products now, its economic might is stronger, and global supply chains and businesses are more connected.

SARS caused air traffic to decline markedly for three months, which took a toll on the aftermarket for about six months, said Gregory Hayes, United Technologies chairman, CEO and president, during the company's Jan. 28 fourth-quarter earnings call. He noted that airlines are healthier now than in 2003, but he predicted "there will be a blip in Asia this quarter" as a result of the epidemic.

"While we expect there will be some impact to the commercial aftermarket, we don't expect it to be significant," Hayes said, adding: "We saw a 20% drop in the aftermarket [for two quarters in 2003]. I don't expect it's going to be that bad this time."

Let's hope he's right.

—Lee Ann Shay

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

Highlights

EASA Issues Trent 1000 De-Pair Mandate

A new mandate to de-pair high-time Rolls-Royce Trent 1000s related to unexplained engine compressor surge issues is not expected to lead to more Boeing 787 groundings, the engine manufacturer said.

The latest issue causes "engine surges on certain Trent 1000 engines, particularly those that have accumulated a high number of flight hours (FH) and engine flight cycles (EFC)," the European Union Aviation Safety Agency (EASA) explained in a Jan. 24 airworthiness directive (AD). The AD, based on a Rolls-Royce service bulletin issued in December 2019, requires 787 operators to ensure aircraft do not have pairs of engines with high numbers of both flight hours and EFCs. EASA's directive applies only to European operators but is expected to be mandated globally.

The de-pairing limits vary. Engines with at least 24,000 FH or 8,000 EFC must be paired with engines with no more than 17,000 FH and 5,500 EFC. Engines that have hit both upper-end thresholds can be operated with those that are below both the 24,000 FH and 8,000 EFC marks.

EASA's directive gives affected operators through Feb. 28 to de-pair the engines.

ATS Launches Narrowbody Teardown Business

Aviation Technical Services' (ATS) announced it has purchased a Boeing 767-3G5ER for teardown to increase the inventory of available parts at its Ranger Air Dallas/Fort Worth component sales and inventory management facility. It signals a new business for the busy MRO and provides some hope that more plentiful and affordable supplies of used parts are at least on the horizon.

"Our ATS teardown strategy is designed with our customers' needs in the forefront," says Christopher Olds, ATS vice president for asset acquisitions and trading. "The core platforms we are targeting are Boeing 737NGs and the Airbus A320 family of aircraft."

ATS component repair sites in Dallas/Fort Worth and Seattle also benefit from 757, 767 and 777 component support programs. "Future growth platforms may include additional widebodies as well as regional aircraft as our business continues to evolve," Olds adds.

Conservatively, ATS is targeting the acquisition of six aircraft in 2020, most likely a combination of entire aircraft, airframes and/or engines. In 2021, the goal is to double this to 12 assets.

MRO Holdings in Expansion Mode

MRO Holdings intends to purchase Aviation Exteriors Louisiana (AvEx) to expand its paint operations to 10 dedicated lines in 2020. The companies did not release the acquisition price.

AvEx paints commercial, corporate and military aircraft in three hangars with 119,100 ft.^{2} in New Iberia, Louisiana. Those hangars provide four total lines of paint. Founded in 1990 as Pride Aviation, the business has grown steadily and lists several major U.S. carriers as customers. "The core of the AvEx business is rock solid," says Greg Colgan, MRO Holdings CEO.

MRO Holdings, which operates three heavy maintenance facilities—Aeroman in El Salvador; Flightstar in Jacksonville, Florida; and TechOps MX in Queretaro, Mexico—is seeking additional paint capabilities. "AvEx accelerates that path and meets the internal demand we currently have and can't satisfy," he says.

MRO Holdings also submitted a proposal to acquire Mexicana MRO for an undisclosed sum. "This is not just a marketing play. . . . We did our homework," Colgan says. Airframe MRO capacity is tight in Latin America, and MRO Holdings still has more demand than it can handle.

Contracts

Acia Aero Capital of the UK took over full ownership of Switzerland's **IPR Conversions** and **IPR Leasing**; it completed large cargo-door (LCD) conversion of an ex-Alitalia ATR 72-212 (467) under a plan to convert five ATRs in 2020.

Aeronautical Engineers won a contract from **Airwork** of New Zealand to convert a 12th 737-400 (28702; ex-Blue Air) to a freighter starting in February. All modification touch labor and maintenance will be performed by **Commercial Jet** in Miami.

Avair of Arizona was selected by **Whippany Actuation Systems** of New Jersey to exclusively facilitate aftermarket parts sales to its airline and MRO customers. The deal includes sale of overhaul and shop-visit materials, a joint exchange pool and special rate discounting.

Broward Aviation Services of Florida acquired ex-AtlasGlobal A319-100 (1124) for part-out in Wales.

CFM International won a $1.3 billion **Jazeera Airways** contract to maintain its Leap 1As (for 20 A320neos) on a rate-per-flight-hour basis.

RPI UK secured a **Delta TechOps** order for two integrated rotor measurement and assembly platforms and module tooling sets for Trent maintenance.

ST Engineering booked S$1.1 billion ($806 million) in new contracts in the fourth quarter of 2019 versus S$450 million in the fourth quarter of 2018.

TDA of the Netherlands acquired two ex-British Airways A319-100s (1445/1604) for part-out.

Willis Lease Finance of California entered into a Constant Access agreement with **SAS** to guarantee availability of CFM56-5Cs to cover airlines' spare engine requirements (from planned/unplanned removals) for its eight A340-300s over the next three years.

Contract Source: SpeedNews

Engine Issue Spotlights Data Analytics' Value

Using deep data dives to flag reliability issues is a promising tool for predictive analytics, but the ongoing probe into a GE90 engine failure shows how precise analysis can help isolate engines for checks stemming from airworthiness issues.

JOEPREISAVIATION.NET

A Thai Airways GE90 failure opened the door for GE Aviation to leverage its data analytics to identify risk factors.

The FAA on Jan. 17 issued an emergency airworthiness directive (EAD) calling for removal of high-pressure turbine (HPT) interstage seals from 16 GE90-115Bs identified by serial number. The EAD and a related GE service bulletin issued days earlier stem from the ongoing probe into the October 2019 failure of a GE Aviation GE90-115B on a Thai Airways Boeing 777-300ER. The flight was departing Bangkok for Zurich when the crew rejected the takeoff while still at low speed. Debris from the damaged engine impacted the 777's fuselage and other engine.

Soon after the incident, GE targeted eight engines operated by five airlines for HPT interstage seal checks, which the regulator mandated in October. The January action narrowed the risk population to two airlines and eight aircraft that operated similar mission profiles. A source with knowledge of the situation tells *Inside MRO* the common links in these incidents included operating shorter routes, using shorter runways and turning the aircraft more quickly than a typical 777 long-haul mission.

GE Aviation, citing the ongoing investigation, declined to provide details beyond what was in the FAA directives. But the specificity of each mandate points to GE using its vast vault of engine data to analyze the issue and identify common trends between the failed engine and others in the fleet.

GE used a similar approach to target CFM Leap 1Bs for inspections following a March 2019 failure of a Southwest Airlines 737 MAX being ferried from Orlando, Florida, to Victorville, California.

GE quickly linked the failure to coking—deposits of evaporated fuel and other material on fuel nozzles that lead to uneven temperature flow regions within the combustion chamber and hot spots within the high-pressure turbine. These hot spots can cause premature wear. Within hours of the failure, the company analyzed the engine's operating history and compared it against data from each of the other 1,560 Leaps in service.

Aware of coking, a common issue with gas turbine engines, the manufacturer had rotable pools of fuel nozzles ready for use at certain thresholds. Following the Southwest failure, GE revised its analytics and reduced those thresholds. Engines exceeding the revised limits were recommended for inspections.

The GE examples underscore how the combination of quality data and experts who can generate actionable insights from them is proving valuable. Operators are spared unnecessary work that broader fleet mandates would require, and the manufacturers and regulators can more quickly pinpoint airworthiness issues while getting clear pictures of their scope.

—Sean Broderick

EASA Issues Updated Safety Plan

The European Union Aviation Safety Agency (EASA) has issued its ninth European Plan for Aviation Safety (EPAS), the de facto annual regional safety blueprint for member states that identifies the primary safety risks and sets out mitigation strategies.

EPAS aligns its big-picture strategy with the International Civil Aviation Organization's Global Aviation Safety Plan (GASP), comparing global risks highlighted in GASP with region-specific data to ensure the alignment. The most recent version of GASP, covering 2020-22, identifies five high-risk accident categories as targets for improvement: controlled flight into terrain, loss of control in flight, midair collision, runway excursion and runway incursion.

Among the document's features is a broad overview of all rulemaking activities, including status updates. The report lists 12 MRO-related rulemakings, including changes to instructions for continued airworthiness (ICA) and parts-marking rules that are on track for a late-2021 introduction.

Several rulemakings listed in other categories have airworthiness links, including a proposed rulemaking on tire

inflation-pressure monitoring listed in both operations and design/production categories.

"The rulemaking proposal should consider better enforcing the operator's responsibility to ensure regular tire-pressure checks, and also the aircraft manufacturer's obligation to define the tire-pressure check procedures and intervals in the" ICA, EASA says. "Since a tire-pressure check legal obligation would not always guarantee that the tires are correctly inflated, the rulemaking proposal should also include the installation of a tire-pressure monitoring system which will alert the pilots when a tire pressure is abnormal or out of tolerance."

The rulemaking tasks have been upgraded to "ongoing" from "deprioritized," the report notes. EASA projects having a proposed rule out by April and a final rule in place by the end of 2022.

—Sean Broderick

EASA plans to mandate tire-pressure monitoring systems.

SEAN BRODERICK/AW&ST

Pitch-Trim Incident Uncovers E-Jet Airworthiness Issues

Chafed flight control system wires and an incorrectly installed cockpit switch with a service bulletin against it but that regulators have not mandated have raised the NTSB's concern and triggered recommendations that apply to Embraer E-Jets.

The recommendations, made to Brazil's ANAC and the FAA, stem from an ongoing investigation into a November 2019 incident aboard a Republic Airways Embraer 175. The crew departed Atlanta Hartsfield-Jackson International Airport (ATL) en route to New York LaGuardia Airport and experienced an excessive uncommanded pitch-up 4 min. into the flight. The captain immediately diagnosed the issue as a runaway horizontal stabilizer and executed Republic's single-item quick reference handbook (QRH) memory checklist by pushing and holding the left-side pitch trim disconnect switch. The captain then asked the first officer to push and hold the right-side switch. Fight data recorder data later verified that the switches had no effect. The crew regained control of the airplane using electric trim inputs and made an emergency landing back at ATL.

Investigators discovered chafed insulation around the wires connecting the horizontal stabilizer actuator control electronics to the captain's pitch-trim switch and autopilot/trim disconnect button. The chafing was linked to an untucked safety-wire end near a safety bolt.

"The maintenance procedures in the EMB-175 airplane maintenance manual (AMM) for adjusting the mechanical stop bolt do not currently draw any specific attention to this critical area," the NTSB said in its recommendation letter. Concerned that other aircraft could be at risk, the NTSB reached out and urged operators to voluntarily inspect their E-Jets. Republic found nine aircraft with chafed wiring, and other unidentified operators found more examples, the NTSB said.

It is not clear if the chafed wiring contributed to the incident. But the NTSB is concerned that other E-Jets are at risk and has urged Brazil's ANAC and the FAA to order Embraer to address the issue with inspections and updated AMM instructions.

The NTSB also discovered that the left-side pitch-trim cutout switch was installed "in an inverted position," the letter said. Embraer became aware of the issue in 2015 after flight crews reported similar pitch-trim malfunctions that were traced to incorrectly installed switches and issued service bulletins (SB) that recommended installation of a support to prevent the switches from being installed backward. The SBs covered the entire E-Jet and E2 family, as well as the Lineage 1000 business jets. Neither ANAC nor the FAA mandated the SBs, however, and the aircraft involved in the Republic incident did not have the modification.

"Although it is currently unknown if an inverted pitch-trim installation was a factor in this incident, the NTSB is concerned that an inverted switch installation resulting in pitch-trim operation opposite to that expected by a flight crew could lead to confusion, delaying appropriate recognition and response to increased control forces," the board said. It recommended ANAC and the FAA mandate the bulletins.

The NTSB also expressed concern about the runaway trim emergency scenario. Embraer's memory-item list for runaway trim recommends both cutout switches be used, but Republic's version only mentions "Pitch Trim System 1," or the left-side switch. Embraer's QRH does not tell pilots to retrim the aircraft; the Republic crew relied on their understanding of the system and use of the electric trim switches to adjust the horizontal stabilizer and bring the nose down. Other crews may not have as much knowledge, the board said. The NTSB recommended ANAC examine the E-Jets checklists and ensure they "adequately address all potential trim system failures."

—Sean Broderick

ARSA UPDATE

Better Correct Than Current

IN NOVEMBER 2018, ARSA RELEASED A "TOOLKIT" for maintenance providers seeking exemption from 14 CFR §145.109(d) in an effort to level the playing field for its members, particularly small-to-medium-size businesses, which make up the majority of repair stations.

The playing field is muddy, messy and hilly for all repair stations—small, medium, large and superlarge. First, the FAA does not enforce the requirement for design approval holders (e.g., manufacturers) to create and make maintenance data available (§21.50(b)) but doesn't have any issues with

JOEPREISAVIATION.NET

demanding compliance with §145.109(d). Next, the requirement to maintain this "current" information is absent from all other maintenance providers' requirements—mechanics and airlines are required to comply only with Part 43.

Section 43.13(a) allows persons to complete maintenance, preventive maintenance and alteration using "methods, techniques and practices acceptable to the Administrator," which include current and previous versions of manufacturer-provided maintenance data as well as that developed independently by repair stations, mechanics and airlines. This flexibility is vital to aviation safety because the "current" data are not always correct.

For example, as one repair station reported to ARSA, "[a manufacturer] revised their [repair] manual and removed schematics and parts lists of older manufactured circuit boards. However, there are still aircraft flying today . . . that have these older-version circuit boards in them. The only way a repair station can support these units is to reference the older (noncurrent) manual."

Unfortunately, §145.109(d) requires repair stations to maintain libraries of "current" data, even when not required . . . and even when it may be wrong for the work to be performed!

The cost to industry, to owners and operators of aircraft, and to the flying public that ultimately pays all the bills, is very high. A small business with average annual revenue of $2,500,000 reports being quoted $731,251 per year to maintain the currency of its library, which, according to simple math, represents more than 29% of the company's average annual revenue.

The exemption effort gave small business a mechanism to demonstrate this pointless waste to the agency and seek relief. Unfortunately, the agency closed that door; its responses to petitioners stated: "There are no unique factors that would limit applicability of the exemption to the petitioner. . . . The more appropriate vehicle for the petitioner's request is with a petition for rulemaking."

ARSA was delighted to pick up the FAA's gauntlet. On Dec. 23, 2019, the association gave the agency a holiday gift: a petition for rulemaking to delete the last sentence of §145.109(d).

"The requirement to maintain current and accessible documents and data irrelevant to the work performed provides no safety benefit," the petition said. "The costs cannot be justified and the unnecessary sentence causes substantial confusion and expense for the agency. The requested amendment of section 145.109(d) will eliminate needless and discriminatory burdens."

You can learn more about the effort, read and support the petition by visiting the docket at regulations.gov/docket?D=FAA-2019-1106. You'll see—if you don't already recognize—that it makes more sense to be correct than to be current.

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 more than 30 years.

Viva Air

Nicolas Takahashi, Viva Air's director of engineering and maintenance, spoke with Lee Ann Shay on the sidelines of MRO Latin America about the Colombian LCC's big growth plan and technology investments. Takahashi joined Viva Air in its start-up process and is known for having reduced maintenance costs while increasing productivity.

VIVA AIR

FOUNDED: 2012

OWNERSHIP: Irelandia Aviation

FLEET (NUMBER OF AIRCRAFT, BY TYPE): 22 A320 aircraft

ROUTES: 33

PASSENGERS CARRIED (2019): 6.3 million

HEADQUARTERS: Medellin, Colombia

MAINTENANCE BASE LOCATIONS: Bogota, Colombia, and Lima, Peru

How many additional aircraft does Viva Air plan to receive in 2020 to accommodate growth? CEO Felix Antelo recently said he hopes the carrier will transport 7.2 million passengers in 2020, compared to 6.3 million in 2019.

We target four new aircraft, but in the next three years we hope to receive 35 new neos from Airbus plus the 15 new A320ceos received to date, for a total of 50 aircraft. These aircraft have more density, 188 passengers, so by adding these aircraft and increasing our operation we can reach those numbers.

How do you handle maintenance for your Airbus fleet? What is done in-house?

We perform line maintenance in-house and up to A checks. We have two main bases in Colombia—Medellin and Bogota. We outsource line maintenance in Peru to Avianca, and we subcontract the C checks. We subcontract outstations in Colombia to Avianca, and in Peru we use a mix of suppliers, including Avianca.

For components, we have a power-by-the-hour agreement (PBH) with Airbus for the new fleet and a PBH for the older fleet with AFI KLM E&M. For engines, we just signed a 12-year, $3.2 billion contract for maintenance of the neo engines with CFM. We are launching an RFP (request for proposal) for the ceo engines. That one would be of 12-year duration, too. We hope to bid and close that by June.

What turnaround times does Viva Air strive for between flights?

Our average turnaround time for domestic flights is 30 min., but international can vary between 40-90 min.—with most closer to 40 min. But the U.S. takes more time due to TSA. Our turnaround is quick so we can increase the number of operations.

The new aircraft have wider aisles so we can offload and load passengers quicker, which also helps with the short turnaround times. We also have good coordination with the ground personnel and crew before aircraft arrive, which is a key point of the operation.

Right now, Viva Air has the second-highest on-time performance in the region, but we perform a lot more cycles with shorter turnaround times. If we adjusted the measurement to compare apples to apples, we would be first in the region.

How does maintenance contribute to this punctual performance?

Maintenance performs everything that is planned, and we do it on time. So preparation is key. Doing this increases the availability and reliability of the aircraft, which helps the on-time performance. We also prepare for the high season as best was we can in advance.

How do you expect Viva Air's maintenance department to change over the next few years?

We need to invest in the infrastructure and people to meet growth. We are working to have a training facility and new software systems. A predictive maintenance system will be set up in the near future. We signed an agreement with Airbus for Skywise in 2019 and are waiting for new maintenance software that can interface with Skywise—the current one does not. Predictive maintenance is the future.

Which software system are you looking at?

We are looking at all of the leading ones including TRAX, MXI and AMOS. We hope to make a decision by the end of June.

How difficult, or easy, is it to find qualified maintenance personnel?

Colombia has a population of 50 million and is quite young. Getting people is manageable and training is a key issue in keeping them at the highest level possible. It's more difficult in Peru because there are no technical schools or universities with aviation maintenance. Maintenance technicians there also move to higher paying jobs in mining and shipping.

News reports have said Viva Air is investing in new technology. Is any of that for maintenance?

Viva Air is investing in a lot of technology for operations. We have a new simulator in the region for pilots and maintenance technicians. We are also looking at a new maintenance training facility in the first half of the year. One of the challenges for maintenance, as

I mentioned before, is our maintenance software.

How much of the maintenance department's operation is paperless?
All of our technicians have an iPad. All of the manuals are included and updated on the iPads, so you don't have to print manuals. Unfortunately, we need to write tech reports due to the lessors and regulatory authorities, but the future is to use paperless tech logs.

Is the Viva Air Labs innovation center working with the maintenance department?

That's more for ground and flight operations. In the future, we could use it for maintenance.

Does Viva Air have any sustainability initiatives underway?

Viva Air has made a big investment in its fleet, which will reduce carbon dioxide by 15% and noise by 50%. We also are working on initiatives to use paper cups instead of plastic. All of the pilot manuals are integrated into an iPad, which reduces paper. We also removed as much weight from the aircraft as possible. For instance, we have two ovens now instead of three or four. The seats are lighter-weight and state-of-the-art. We also now only fill 50% of the water tanks. We use single-engine taxi and wash engines, as required. Those small initiatives add to fuel savings.

Viva Air operates an expanding fleet of A320s.

JOEPRIESAVIATION.NET

As Viva Air moves toward an initial public offering, is that process affecting your maintenance operations in any way?

We expect to be public in a few years. We need to have the best maintenance practices and the lowest operating costs as possible because that is one of our competitive advantages. Our target is to be the lowest-cost operator in the region—and one of the lowest in the world.

Middle East Expansion

The UAE accounts for most MRO growth, but the entire region must prepare for a fleet surge

James Pozzi London

The $7 billion aftermarket in the Middle East is seeing high growth levels and ambitious investments by its dominant players. MRO in the region is expanding at a compound annual growth rate of 8.2%, outstripping the global MRO growth rate of 2.9%, according to Aviation Week Fleet & MRO Forecast data. By 2029, the same analysis estimates total MRO spending of $105.4 billion in the region.

ETIHAD AIRWAYS ENGINEERING

Much of the MRO work in the Middle East is generated by larger widebodies such as the Airbus A380.

While Saudi Arabia and Qatar are seeing high levels of investment in their MRO industries, it is the United Arab Emirates (UAE) that easily dominates MRO spending in the region. The country's aftermarket is expected to reach $45 billion over the next 10 years, according to Aviation Week data. This is more than double that of the projected MRO total from Qatar, which stands at $20.6 billion, and the ambitious Saudi Arabia, which is forecast to generate $13.5 billion in 2020-29.

Much of the UAE's MRO growth stems from locally based airlines Emirates and Etihad, which operate more than 350 aircraft combined. Both carriers also have growing in-house MRO operations. Etihad Airways Engineering, the airline's MRO arm, is particularly ambitious in targeting third-party work. In the past year, it also added new repair services for aircraft such as the Airbus A350, adding to existing capabilities in A380 and Boeing 787 repairs while potentially looking to expand beyond Abu Dhabi. Emirates has more than 30 contracts in place with third-party customers.

Given projected fleet growth not just in the Middle East but also in Asia, North Africa, CIS and Eastern Europe, the Gulf state has also attracted OEMs and MRO shops to set up in the region.

The Dubai South aviation hub has served as a hive of aftermarket activity, as home to several engine and parts OEMs, MROs and independent repair specialists. GE Aviation and Boeing have set up regional headquarters in the economic zone since its inception.

Dubai South is also home to Lufthansa Technik (LHT) Middle East, the German MRO giant's regional business set up in early 2017 to service components. Ziad Al-Hazmi, CEO of LHT Middle East, says the company has doubled in size since it was established, with hangar capacity going from around 27,000 ft.^{2} to 54,000 ft.^{2} in three years while its staff has increased tenfold, from around 10 to 100 as of early this year.

Likening the growth of the MRO as playing catch-up to the expansion of the region's airlines, Al-Hazmi says new capabilities have also been added. "When we started, we were looking at nacelles made up of composite materials. Composite reversers, flaps, inlet and cowls and fan cowls—all those large items when transported out of here meant a significant cost was attached," he says. "Our initial driver to be here was to reduce turnaround times on those products before this developed into other areas." Given the growing fleet, Al-Hazmi believes there is a more solid case for carrying out certain types of maintenance locally, and LHT Middle East is looking to expand locally. "We're investing more into local material supply and assets," he says, with a greater focus on on-wing services anticipated.

As in most global regions, capacity has been problematic and has led to several solutions aimed at addressing constraints, perhaps more urgently given the rapid growth in Middle Eastern fleets. Regional players such as Abu Dhabi-based engine MRO Sanad Aerotech are seeking to rectify this by ramping up capacity to be able to overhaul 315 GEnx engines by 2035 and provide 237 quick turns on Leap engines by 2030 in Abu Dhabi. It plans to add around 200 employees across its aerospace business and grow its staff to 550-600 over the next two years, while also furthering national efforts to boost its indigenous workforce.

Keeping up with the impressive regional fleet growth is a challenge for MROs, says Al-Hamzi. "This is a challenge not because of the experience and tooling we have but more about getting the right people in and trained as quickly as possible."

While assistance was sought from other Lufthansa Technik shops around the world, Al-Hazmi says that is not an economical long-term solution. Instead, like Sanad, it will be trying to recruit more technicians from the UAE. It

has also actively recruited young talent, with around half of its 100-strong workforce under age 30. Local educational partnerships have been an effective means of recruitment.

In Jordan, several independent MRO providers are helping to address the growing regional workload. Adding capabilities for new aircraft types has been a common trend recently, with companies like Joramco gaining European Union Aviation Safety Agency Part 145 approval for Boeing 787, 737 MAX and A320neo aircraft in the past two years. The MRO has also taken on new work from Europe, including from low-cost carrier Ryanair, which has outsourced airframe maintenance of its Boeing 737NGs across two lines at Joramco's facility for heavy checks between November 2019 and March 2020.

Jordan Aeronautical Systems Co. (JAC), which repairs a mix of commercial and military aircraft, is another Jordanian company looking to become more competitive. Repair capabilities for the Boeing 737NG were added in September of last year, while certification for Airbus A320 aircraft repairs is in process and anticipated by mid-year.

Ziad Abuain, CEO and general manager of JAC, believes regional demand for maintenance on these aircraft types will continue to grow, although demand for MRO services on widebody aircraft could be even more important. Other specialist services could also be in demand, he says. "The aircraft paint business for widebody aircraft is booming in the region, and this could be a good opportunity to develop the capabilities to grab it," Abuain explains.

Capacity is limited at its site close to the Jordanian capital's Amman Civil Airport, particularly during high seasons for base maintenance. This leads it to rent additional space at the airport on a temporary basis to alleviate capacity constraints. To remedy this, Abuain says 2020 will see the building of a new maintenance hangar, along with a paint shop and a composites repair workshop.

He also identifies other noncapacity-related issues, some in common with other regions while others are more unique to the Middle East. "There are a limited number of licensed engineers, and obsolescence on some systems of the 737 Classic, and civil aviation authorities are becoming more stringent on MROs," he says. The growing prevalence of new-generation aircraft also presents challenges related to hiring skilled labor, Abuain says. "This is especially true for new-generation aircraft types in light of aviation authorities' requirements," he adds.

Top Five Middle East MRO Spending

by Country, 2020-29

United Arab Emirates	$45.3 billion
Qatar	20.6 billion
Saudi Arabia	13.5 billion
Egypt	3.5 billion
Iran	3.2 billion

Source: Aviation Week Network Fleet & MRO Forecast Data

INTERIOR INSIGHTS

Changing airline dynamics **define** aircraft cabin modifications

AVIANOR

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

Cabin retrofit specialists and suppliers are seeing a steady market as airlines take delivery of new aircraft while delaying the retirements of older models—and while the Boeing 737 MAX remains grounded.

"The 737 MAX grounding has, to some degree, driven cabin upgrades as airlines lease alternative lift to fill the capacity hole that has left," says Earl Diamond, executive board member and partner of Avianor, an aircraft interior modification company in Montreal. "Lease activity is also high due to recent airline failures, which have added lots of aircraft to the market."

Airline failures and lease returns are generating much of the upgrade and modification work at Vallair, an MRO provider in Montpellier, France. "We do a general refresh and refurbishment of the cabin, including layout and passenger amenities change-outs," explains Malcolm Chandler, Vallair's head of commercial services and marketing.

For most of 2019, the company focused primarily on the Airbus A320 family, but starting late in last year's third quarter the work transitioned to mostly Boeing narrow-bodies—especially the 737NG family. "As the Airbus market started to decline, the 737 business picked up—mainly for the 737-800—due to lease transfers likely due to the 737 MAX issue," says Chandler. "A number of 737-800s that might have been parted out or converted to freighters have continued in passenger service."

For 2020, Chandler predicts lease-transfer-related modification work will be buoyant, with a mix of 737NGs and A320s.

Interior modifications are also being driven by the introduction of such new aircraft types as the A320neo, A350, and the Boeing 787, creating a strong incentive for airlines to refresh their inflight offerings as their older aircraft undergo maintenance, says Richard Brown, managing director of Naveo Consultancy in London. "We have seen a lot of activity upgrading mature and midlife aircraft—such as A330s, 777-200ERs and, in some cases, 767s—to offer similar inflight seating and the look and feel of the latest-generation aircraft," he remarks.

A 10-year forecast of the commercial airliner interiors market released last year by Tronos Aviation Consulting (TAC) of Atlanta projects an estimated $136 billion will be spent on major cabin components over the coming decade.

Before (top) and after (bottom) views of a turn-key interior refurbishment project done by Avianor of Montreal on four Gulf Air A330s, for which the MRO had full cabin-integration and STC responsibility. This included replacing the IFE, seats, carpeting, curtains and laminates, new monuments and adding Avianor-manufactured entertainment cabinets.

This includes seats, galleys, lavatories, inflight entertainment (IFE) and connectivity, as well as lighting and soft goods such as upholstery, carpeting and curtains, says TAC Managing Officer Gary Weissel. Of the total, the retrofit market is projected to account for $76 billion and line-fit $60 billion. The TAC analysis, Weissel adds, was developed in cooperation with AeroDynamic Advisory, using Alton Fleet Forecasting data.

As Weissel explains, the new generation of cabin offerings encompasses all classes of service with new or updated business-class products, space-saver economy seats and in some cases new premium-economy sections in which seat designs are pushing what he terms "the lower boundary" of business-class seats, largely comparable to those in business class a decade ago.

One growing trend he sees is the "densification" of the coach-class cabin with the addition of more lightweight, slim-design seating. "But," says Weissel, "I think we have reached a tipping point as to how much lighter and slimmer we can design an economy-class seat and yet maintain the same level of comfort. I don't think we can get any higher densification."

BINS

Seating is not the only focus for airlines making cabin improvements. Weissel points out that for narrowbody aircraft, larger-capacity, in-cabin luggage stowage bins are a coming passenger convenience. Specifically, TAC projects that over the next 10 years, some $2.9 billion will be spent on bin upgrades and retrofits. "There are more installations of the current-generation articulating bins in progress," says Weissel, explaining that by design, the bins articulate or drop downward when opened, providing increased baggage capacity. But there is a weight tradeoff.

"Articulated bins tend to be heavier and more maintenance-intensive than traditional shelf-type bins," he notes. "However, I do see a continuing iteration of bin design, especially for narrowbody aircraft."

Naveo's Brown says checked baggage fees imposed by both low-cost carriers and legacy full-service airlines are driving the move toward larger bins. "Overhead baggage space in economy is always at a premium, but this is less of an issue in premium cabins, given the lower number of passengers relative to the bin space," he explains. "Newer aircraft, such as the 737 MAX and Airbus A220 feature larger overhead bins to accommodate the increased amount of baggage passengers are carrying."

As for galley and lavatory retrofit trends, very little is taking place with respect to major system innovations, such as lighter-weight materials, according to Weissel. The exception to that, he says, is on narrowbody aircraft densification projects, including replacement of the aft-cabin lavatories with smaller ones to accommodate extra rows of seats.

SEATS

Ben Orson, managing director of JPA Design, says that there is "definitely demand" by airlines to bring older in-service aircraft up to contemporary aircraft standards of comfort and decor. The London-based design consultancy primarily works with long-haul, international carriers that tend to operate their aircraft for an average of 10-15 years.

"During that period, they will be obliged for competitive reasons to update their interiors at least once," Orson says. "There are new types of seats coming with new forms, functions and colors, as well as new materials that are selected to showcase the airline brand within the cabin."

One trend impacting cabins is the reduction of first-class seating. "Based on our customer requests over the past 5-10 years, the number of first-class seats has been significantly reduced, although comfort levels have in most cases increased," says Orson. "For example, Singapore Airlines and Etihad Airways, have added private suites to first class."

The Collins Aerospace first-class suite on Emirates Airlines.

COLLINS AEROSPACE

Shawn Raybell, director of business development for interiors at Collins Aerospace, notes similar trends. "In general, we see international first class declining, but there are airlines that will always maintain a flagship product," he says.

The all-aisle access, lie-flat seating that used to define first-class service is slowly becoming the new standard for business-class cabins such as the newly introduced Club Suites by British Airways. "This has increased efforts going forward to better differentiate true first class," says Raybell, citing the Collins Aerospace first-class suite on Emirates Airline. He terms it "the new ceiling for privacy and luxury and the measure of first-class cabins for many years to come."

But in spite of the attention paid to their higher-priced services, airlines are not neglecting the economy cabin,

as JPA Design's Orson notes. For instance, Qatar Airways has just introduced "Quadra," a new generation of economy-class seating developed as a collaboration between JPA Design and Optimares, an Italian aircraft-seat manufacturer. Orson says the airline will initially install the seats on its new A321neo fleet.

Quadra employs an Optimares proprietary seat-recline mechanism which, upon moving, actually increases the amount of legroom for the passenger seated directly behind, Orson notes. "This is done through a combination of moveable seat cushions and a static backrest," he explains. "The additional legroom is created as the literature pocket in the seatback moves forward with the reclining cushions."

The Quadra seat was also intended to offer greater comfort and utility. It includes a winged headrest, seatback reading light, and AC and USB sockets. Lightweight, carbon-fiber composite structural material has replaced metal to reduce weight. "We made the seat lighter and more appealing in terms of comfort and style," Orson stresses.

Orson also expects to see greater use of composites in seating, given the constant desire by airlines to reduce weight to save fuel. Toward that objective, JPA Design is working with Williams Advanced Engineering and SWS Certification to develop composites technologies for seating applications.

"There is a relatively low level of understanding in the industry of the implications of composites in seat primary structures which are usually made of metal," he says. "One of the issues is that if composites are used in the structures that directly support the passenger's weight during a crash, it is vital that we can be confident that their ability to support that weight is not degraded in service by inevitable events, such as impacts from galley carts or trolley bags."

Orson adds that it is not as easy to determine visually whether or not a composite structure has been damaged, as it is with a metallic structure. One way to mitigate that issue, he suggests, is to protect composite structures with physical "armor" in the form of "sacrificial panels" (impact-absorbing bumpers) that are typically adjacent to the aisles and on the tops of the seat furniture. "But in doing so we add weight back where we have been striving for lightness," he says.

Collins Aerospace's Raybell predicts that future trends in cabin interiors will include more efforts to differentiate economy cabins. "In premium economy, which is proving to be a successful business model, designs will include increased comfort features, privacy enhancements, cushions, headrests and footrests," he says. "At the same time, we see the low-cost carriers reducing features—no seat recline, small snack tables, minimal weight, thin cushions, minimum pitch. Economy-class seating suppliers need to provide an increasingly flexible and broad set of product lines to support this widening product portfolio."

Qatar Airways' "Quadra," a new generation of economy-class seating, was developed as a collaboration between JPA Design and Optimares, an Italian aircraft- seat manufacturer.

IFE

Inflight entertainment options are also expected to undergo change, with a transition toward personal electronic devices (PED).

"In shorter-haul domestic U.S. markets, we are already seeing that," says Michael Planey, co-founder of HM Planey Consultants in Alexandria, Virginia. "American Airlines has gone to great lengths to remove seatback IFE equipment on domestic single-aisle aircraft." However, he stresses, in the international and widebody markets, the seatback screen is more popular than ever.

JPA DESIGN PHOTOS

Brussels Airlines' A330 business-class seat by JPA Design.

"About 10 years ago, I forecasted that seatback screens would be eliminated within 10 years. Now, I forecast that screens will be present for another 10 years in widebody aircraft," Planey says. "Low-cost carriers are one area where you will see less hardware provided by the airlines and greater reliance upon passengers to bring their own personal devices." But he adds that this largely will be dependent on still-pending improvements in bandwidth, latency and continuous availability of satellite internet services.

While seatback monitors are still a standard feature in legacy airline cabins, they are trending toward retirement, says Nina Schulz, head of product sales and partnerships for aircraft modification at Lufthansa Technik.

"Pricing for a full IFE including these monitors is high. Monitors generate maintenance and operational cost, and the related wiring drives weight," she explains. "As more airlines offer full connectivity solutions, and passengers get accustomed to carrying mobile communication devices, either second-screening or with their full usage as inflight entertainment connectivity [IFEC] is being fostered, that may push further drawback of seatback monitors. A powerful connectivity solution can deliver offerings for IFEC that may not necessarily require a seat-centric system anymore."

@afiklmem

Augmented Reality

BEST4YOU

100%
Innovation

100%
Global network

100%
Airline MRO

100%
Adaptiveness

SnapPress

1. Download the **SnapPress** App for free.
2. "Snap" this page.
3. Explore the page's exclusive hidden content.

"I've specialized in hydraulic component overhauls for over a decade. Because I'm responsible for certification, I always strive for perfection. Our team makes sure that all the components we handle work optimally in all possible conditions and at all times."

***Maarten**, Hydraulic components specialist*

AFI KLM E&M delivers services guaranteed to match your requirements 100%, buttressed by know-how rooted in the experience of an MRO backed by a group of world-class airlines. Our Global Network delivers those solutions on your doorstep, giving you the benefit of our wealth of innovations, so that our services are always the **Best4You.**

AIRFRANCE INDUSTRIES
KLM Engineering & Maintenance

ADAPTIVENESS®

Going the Distance

How far will airlines travel for MRO?

Alex Derber London

Over the past decade, the dominant trend in airline fleet strategy has been toward larger narrowbody aircraft. Meanwhile, aircraft manufacturers have extended the range of their single-aisle lines, opening the door for low-cost and other carriers to pursue more distant markets and longer, thinner routes than in the past.

Norwegian's transatlantic services are a prime example, and while that airline's finances remain somewhat precarious, other carriers are following in its wake. JetBlue Airways, for instance, intends to launch transatlantic flights with Airbus A321neo aircraft. As this market develops, it will affect where MRO is done.

BASE MAINTENANCE

To date, narrowbody base maintenance has been confined largely to the home regions or continents of their operators, with U.S. carriers very unlikely to choose European hangars and vice-versa. On the other hand, "widebody maintenance will occur anywhere globally, determined primarily by labor costs," says Brian Sartain, senior vice president of repair and engineering services for AAR.

The primarily regional market for narrowbody heavy checks mainly is a function of the cost of ferry flights, a desire to coordinate maintenance locations with short-to-medium-haul networks and schedules and, in some cases, the range of the aircraft themselves.

"We expect the narrowbody market to stay largely unchanged in terms of where maintenance is provided due to the route structure of the airlines remaining largely stable," says Sartain.

Conor O'Regan, vice president of sales for Europe at SR Technics, backs up this point. "Ferry flight and equipment costs up to mid-distance MRO facilities are economical, but ferrying narrowbody aircraft toward the limits of their range to secure lower-cost maintenance becomes much less economical."

AAR

Component shops can attract repair volumes from more distant customers than narrowbody airframe MRO providers.

SR Technics is building a narrowbody maintenance facility with a six-bay hangar in Malta, well-located to attract customers from Europe, the Middle East and Africa, as well as "from farther afield for lease transitions," says O'Regan.

Vilnius, Lithuania-based FL Technics usually attracts narrowbody customers within a 3-hr. flying time, but this can extend up to 7 hr. during busy periods, says CEO Zilvinas Lapinskas. "Slots in the maintenance season are scarce, which has led to us attracting clients from farther afield," he says.

This important point, echoed by other maintenance providers, illustrates how the choice of MRO provider is not always dictated solely by price, quality, turnaround time and proximity, but also by what capacity is available.

"Increasingly limited MRO capacity sometimes is forcing customers to book slots well in advance with more local regional providers to avoid having to travel longer distances to secure maintenance slots," says O'Regan.

However, an opposing dynamic is that newer-generation narrowbodies often require fewer maintenance manhours and allow longer intervals. "Thus flying longer ranges for maintenance events is less likely to be cost-effective for customers," he says.

The situation is very different for widebodies, for which global route networks and longer turnaround times mean airlines have a far more geographically diverse choice of maintenance providers.

"With an influx of low-cost, widebody maintenance providers in Asia entering the MRO market over the last 10 years, we have seen an increase in MRO activity in the APAC region," observes Sartain.

That said, there is some evidence that Western airlines are bringing widebody heavy maintenance back closer to home as the labor cost advantages of Asian providers continue to erode.

LINE MAINTENANCE

The nature of line maintenance means it needs to be performed close to the customer, although several MRO companies have expanded their reach in this field by establishing facilities in new markets or by buying foreign providers. Most also offer roving aircraft-on-ground (AOG) and mobile maintenance teams, which give them a wider geographical footprint.

"Providing [line and base maintenance] allows SR Technics maintenance teams to appreciate the importance of an effective recovery of an AOG event for one of our customers and demonstrates the quality of our services to more distant customers, encouraging them to consider our Malta facility for heavy maintenance business," says O'Regan.

Lapinskas agrees that mobile teams allow an MRO provider to demonstrate its abilities to a wider array of customers, although it is difficult

to draw a direct link between mobile teams and subsequent heavy maintenance contracts.

COMPONENT AND ENGINE MAINTENANCE

"Component shops can attract repair volumes from more distant customers, where the MRO has regular and efficient trade lanes established intra-regionally, coupled with competitive and reliable turnaround times," says O'Regan.

Sartain notes that component maintenance is usually restricted to an airline's home operating region, although exceptions are made for items such as gearboxes and APUs, for which he says there is a "global market."

One trend encouraging this has been the development of pooling programs, in which participating airlines draw a replacement part from a nearby distribution center and send off the old part for repair anywhere in the world before it returns to the pool.

Most MRO providers agree that the market for engine repairs is worldwide, with O'Regan citing a global customer base from all continents for SR Technics' CFM56 and PW4000 maintenance services at its Zurich engine center.

AAR

Airlines are sometimes willing to consider more distant MROs for servicing specialty items like APUs.

Lapinskas agrees: "Engine maintenance depends on the scope of the work that needs to be done—minor repairs could be within truck-driving distance of the mechanic performing on- or near-wing maintenance. Major work is not that sensitive to transportation costs; availability, timing, turnaround time and quality are the main factors."

Again, these days an important factor is availability. For while newer, longer-range aircraft and the spread of long-haul, low-cost carriers might not be redrawing the boundaries of the maintenance market just yet, the availability of hangar and workshop slots is likely to push some carriers into the arms of more distant providers.

The Infant Blockchain

Why you should consider using blockchain in MRO

Alex Derber London

KOTO FEJA/ISTOCK

Blockchain requires scale to fully realize its benefits, but the aftermarket can still reap value from its early development.

Although the core benefits of digitization for the aviation aftermarket are well understood and widely accepted, there is far less consensus about the present utility of blockchain—one of the lesser-known elements of digital transformation.

For example, Airbus and Lufthansa Technik are reserving judgment on distributed ledger technology—not because they cannot see its potential, rather they fear it might not be mature enough to address current industry issues. GE Aviation and MTU Maintenance, on the other hand, are pressing ahead with a blockchain-based parts-tracking system that GE has developed in partnership with Microsoft.

One of the key goals for blockchain in the aviation aftermarket is the elimination of redundant data reconciliation activities, so data can be entered just once into a single distributed ledger. In contrast, each company in today's aviation supply chain enters that data separately on its own internal server.

"Consequently, companies engaged in shared business activities have to devote considerable staff resources and time to checking that they all are using the same data in their respective internal databases, and then reconciling the data items if any discrepancies are found," says Peter McBurney, head of technology consulting for Europe, the Middle East and Asia at law firm Norton Rose Fulbright.

The burden of such reconciliation can contribute to airlines sticking with a maintenance provider or OEM service because of the amount of accumulated data residing with it and the desire to preserve the integrity of that information. However, if that data were accurate and readily available to all parties, it might reduce barriers to entry for other MRO providers and thereby increase competition.

PwC estimates that blockchain technology could cut MRO costs by about $3.5 billion per year. This might be achieved by feeding the technology into other aspects of digitization, notably data analytics, predictive maintenance and the digital-twin concept pioneered by certain engine OEMs and other large MRO providers. One idea is that blockchain-enabled access to aircraft configurations as well as complete parts histories and statuses will allow more accurate and wide-ranging predictive maintenance, potentially reducing the cost of dollar-per-flight-hour maintenance contracts. If implemented at scale, distributed ledgers would also mean airlines could react more quickly to airworthiness directives and service bulletins by showing regulators at a glance which aircraft in their fleet were affected.

The PwC analysis also points to efficiencies in line and heavy maintenance. This might result from something as simple as a mechanic checking the distributed ledger for a part's status rather than performing an inspection, or more streamlined base maintenance that could lower turnaround times by days.

Gains are also predicted for parts procurement, with airlines and MRO providers able to use the blockchain to view real-time locations of specific parts' serial numbers. This would reduce the need for resellers of parts and their associated commissions, thereby simplifying the supply chain.

"Operationally accurate, timely and consensus-validated data can be used to reduce operating costs directly, including the high cost of part replacement arbitration and 'middle-man upcharging,'" PwC partner Rachel Sealy says.

CURRENT DEVELOPMENT

GE Aviation's blockchain tracks GE engine parts from initial installation through the end of a component's lifetime. Although the system is still in development, initial industry partner MTU Maintenance says GE Aviation's blockchain has already helped it release $10 million in unsettled cash from revenue-sharing reconciliation.

However, such successes must be viewed in context. GE Aviation's distributed ledger may be the most advanced in the marketplace today, but it is still in its infancy. There are still significant hurdles to overcome before blockchain becomes ubiquitous enough to fully realize the efficiencies noted above.

That said, development must start somewhere. And some observers believe there is still value in initially small ledgers. "Critical mass is key, but the tipping point is not as far down the inventory records as may be perceived," Sealy says. "A plane, depending on the platform, may have upward of 500,000 parts, of which maybe 5,000 are of interest to carriers."

DSA 2020

17TH DEFENCE SERVICES ASIA EXHIBITION & CONFERENCE

SINCE 1988

20 - 23 APRIL 2020

MITEC, KUALA LUMPUR

Incorporating:

NATSEC ASIA 2020

THE 2ND INTERNATIONAL EXHIBITION ON NATIONAL SECURITY FOR ASIA

Hosted, Supported & Co-organised By:

MINISTRY OF DEFENCE AND MINISTRY OF HOME AFFAIRS

ADVANCING INTO A NEW ERA OF DEFENCE

Fully Supported By:

PRIME MINISTER'S OFFICE | MINISTRY OF FINANCE | MINISTRY OF TOURISM, ARTS AND CULTURE | MALAYSIAN ARMED FORCES | ROYAL MALAYSIA POLICE | NATIONAL SECURITY COUNCIL | ROYAL MALAYSIAN CUSTOMS DEPARTMENT | IMMIGRATION DEPARTMENT OF MALAYSIA | MALAYSIAN MARITIME ENFORCEMENT AGENCY | MALAYSIAN PRISON DEPARTMENT | Visit Truly Asia Malaysia 2020

A Member Of: Malaysian Industry Council for Defence, Security & Safety

Endorsed By: MATRADE – Malaysia External Trade Development Corporation

Strategic Partner: Defense & Security 2019

Official Publication: Asian Defence Journal ADJ

Official Online Media Partner: GBP Aerospace & Defence

Official E-Show Daily News & Web TV:

Official Naval Media: NAVALNEWS

Official Destination Management Company: MEJUSTIF – Mejustif Events & Travel

Organised By: DSA Defence Services Asia Exhibition & Conference – DSA Exhibition and Conference Sdn Bhd (423338-H)

For further information, kindly contact DSA 2020 Sales Office:

DSA EXHIBITION AND CONFERENCE SDN BHD (423338-H)

Suite 5-01, Level 5, Sunway Visio Tower
Lingkaran SV, Sunway Velocity
55100 Kuala Lumpur, Malaysia
Tel: +603 9771 2688
Fax: +603 9771 2799
E-mail: enquiry@dsaexhibition.com

MALAYSIA & ASIA SALES
EZWAN EFFENDY
E-mail: ezwan@dsaexhibition.com

HAZDI HASRUL
E-mail: hazdi@dsaexhibition.com

WORLDWIDE SALES
SHAUN WHITE
E-mail: swhite@dsaexhibition.com
Tel: +44 20 7560 4040

SPONSORSHIP / BRANDING
PETER MCKENNA
SPONSORSHIP PRODUCER
E-mail: info@official-events.net

www.dsaexhibition.com

Defence Services Asia | @DSAMalaysia | Defence Services Asia | dsamalaysia

**Open to related industry professionals and trade visitors only.*

Furthermore, a distributed ledger can grow organically if OEMs add newly built parts to it—especially if existing parts and their histories are added during maintenance events. To that end, PwC advocates for technicians' certification information and parts traceability as prerequisites to including a part in a blockchain.

LUFTHANSA TECHNIK

Not all organizations that touch a part need to be on the blockchain: gaps in a service history can be filled when the part is handled by a company that does have access.

PARTICIPATION

Within an aviation aftermarket application such as parts-tracking and record-keeping, the usefulness of a distributed ledger increases in step with the number of parties that adopt it.

"The unique selling point of this technology is creating trust between multiple organizations without significant interaction between them," says Will Alete, counsel and aviation lawyer for Norton Rose Fulbright. "And to achieve this may require a significant part of the industry to be utilizing the technology to demonstrate that the benefit is actually being realized."

Alete's point is echoed by many within the aviation industry who argue that limited participation in blockchain offers little value if the goal is to provide complete back-to-birth records. However, while PwC agrees that the best blockchain is one with many participants, it still sees benefits for early adopters. "Simply put, the data does not have to be 100% populated—or even 5%—for early adopters to gain value from a blockchain-based solution," Sealy says.

She gives the example of an MRO company that repairs a part without loading the repair event on the blockchain. Later, the part is installed by an airline that is party to the ledger, which records that event as a link in the chain as well as any missing history.

"Blockchain ledgers are self-healing in that if a part record gets updated a day, a week or even a month later, that 'dark' portion of its history is now 'enlightened,'" Sealy says.

"Certainly, shared ledgers are of most value if every entity in a chain of custody or a chain of ownership is part of the consortium running the ledger," McBurney says. "However, even if everyone in a chain is not signed up, others may find value in sharing their data and coordinating their actions over that data."

DATA SHARING

Greater collaboration between airlines, OEMs and maintenance providers is viewed as a long-term benefit of blockchain, but those parties will want to keep certain information off of a distributed ledger. The cost of equipment and maintenance tasks is one example; another is data that feeds into the predictive maintenance models that OEMs and MROs are increasingly using to enhance their customer offerings.

"MROs can keep the data that could reveal methods and metrics from the rest of the chain participants," says Sealy. "Further, the data from the actual MRO task cards does not need to be loaded, unless there is value to be gained by doing so." Instead, PwC argues that the most useful data is that which shows the intersection of "planes, parts, people and places."

However, delineating data in this way is not always simple, with the value of certain information changing according to the party that sees it.

"OEMs are extremely protective of the data applicable to their equipment and are particularly sensitive to third-party providers using that information to compete," says Alete. "Equally, operators do not want to find that key information on how their fleet is managed or performing is becoming available to competitors."

Alete also observes that many existing copyright and trade secret regulations were not devised with technologies such as distributed ledgers in mind. "Until a party has clarity on this, it will always be reluctant to put its valuable information at risk," he says.

Another technical issue concerns revocation of access rights, the granting of limited-duration access and the ability to assign those rights to others. "Managing dynamic access rights in decentralized systems is still a challenging problem in computer science, and standard, proven frameworks for this area are still under development," McBurney says.

FUTURE CONSOLIDATION

In addition to the GE system outlined above, other OEMs and information technology companies are developing distributed ledgers for the aviation aftermarket. However, the nature of the technology lends itself to collaboration—not competition. That means industry partnerships are widely viewed as the way forward for blockchain.

"There is a rush of one-off blockchain providers developing solutions," says Sealy. She believes that over time there will be consolidation among blockchain providers in the aftermarket, with the most trusted parties from a data quality perspective emerging as the likeliest winners.

"The winning companies, and there will be more than one, will be the ones that design to leverage the advantages of automating trust without being perceived as tipping the scales in their [own] favor," Sealy says.

In the interim, there may still be value in disparate ledgers due to the interoperability of data, McBurney notes. And it is already possible to transfer data between different blockchains or shared databases, he adds.

"The technology platforms underlying distributed ledgers are still immature and hence quite fluid," he says. "The major platforms are working with one another to facilitate automated data transfer between different ledgers."

For now, it appears that an industry-wide blockchain system is still some years away.

AVIATION WEEK
Fleet&MRO
FORECASTS

DISCOVER
ANALYZE
PLAN
FORECAST

Predictive Intelligence to Drive Results

With Aviation Week Network's **2020 Fleet & MRO Forecast**, gain a 10-year outlook to **minimize risk** and **maximize revenue**.

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

Take your business to the next level.

For more information, visit
aviationweek.com/forecasts
or call 866.857.0148
or +1.847.763.9147

Available for:
COMMERCIAL
MILITARY
BUSINESS
HELICOPTER

AVIATION WEEK
NETWORK

Casting About for Change

Aerospace customers know little about casting giants Arconic and PCC besides their rising prices, turning attention toward a new competitor

Michael Bruno Washington

Before production of Boeing's 737 MAX was halted and the aircraft type grounded, aerospace manufacturing had only one real bogeyman: investment casting, the metal-forming for engine blades and other aircraft parts.

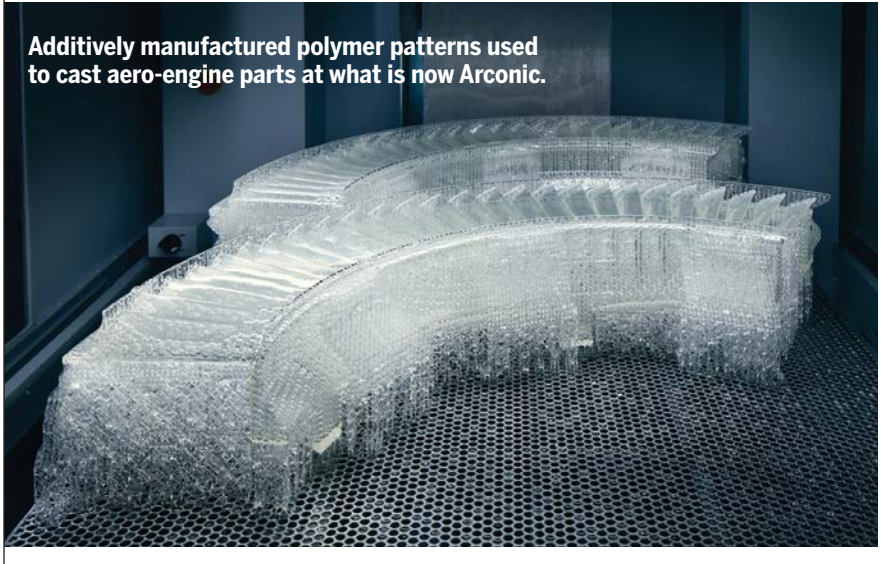
A casual search on YouTube finds numerous videos showing the complexities of castings, whether using the investment or sand processes. The practices require skilled labor experienced both in the science of the 5,000-year-old process as well as the art of applying it to new aerospace programs such as next-generation engine programs.

The learning curve is enormous. On a mature product line, even a high-performing process can see 5% of a production yield thrown away. On new programs, it is not unheard of for half to be discarded in the beginning.

Barriers to entry in the business are high, and industrial capacity remains limited due in part to capital-intensive demands. Castings have been a well-known choke point for growth in commercial aircraft manufacturing and the aftermarket business for years. Some industry executives and advisors have thought that with the MAX slowdown, there might be some relief from recent castings issues. So what has happened?

"Those challenges remain," says Glenn McDonald, a senior associate at AeroDynamic Advisory, a consulting firm focused on the global aerospace and aviation industries. "It does seem to still be an issue." Relief for the rest of industry is not expected in the near term; in fact, the situation might become harder for casting customers.

The aerospace castings sector, a roughly $10 billion industry, is dominated by two leading providers: Arconic and Precision Castparts (PCC). There are smaller companies, one of which—Consolidated Precision Products (CPP)—is seen as an up-and-comer. But each has had its own issues, according to industry sources, and are expected to continue to face challenges in meeting demand. At the same time, they also are enjoying their oligopoly positions and raising prices.



Additively manufactured polymer patterns used to cast aero-engine parts at what is now Arconic.

ARCONIC

For one thing, industry sources say public communication from market leaders Arconic and PCC has become almost nonexistent in recent years. "The communications have shut down on both companies," says one industry advisor. "It's hard to get anything."

PCC was acquired by Berkshire Hathaway, the giant investment group led by Warren Buffett, in January 2016, essentially turning it from a publicly traded and publicly accountable company to a private asset.

Arconic, meanwhile, has been suffering corporate turmoil. In November 2016, Arconic split off from Alcoa but then saw three CEOs in as many years due to disappointing financial results, in part from a failed acquisition, as well as a spat with an activist investor and continued divestitures and restructuring. On Jan. 27, Arconic announced it expects to split into two companies on April 1, an aluminum rolling company and a mostly aerospace-focused business to be called Howmet Aerospace, an homage to the former Howmet Castings bought by Alcoa in 2000.

Yet additional layoffs are possible because of the MAX production halt, according to Arconic Chairman and CEO John Plant. "My expectation is that we will actually be reducing head count," he told an earnings teleconference, also citing other actions such as partially paid vacation for workers and production shift changes. More information is likely to be forthcoming at a Feb. 25 investor briefing for the new Howmet and Arconic.

Indeed, according to AeroDynamic Managing Director Kevin Michaels, Tier 4 raw material and forging and casting suppliers all will be affected by the MAX halt. Moody's Investors Service surmised PCC derives more than 10% of its revenue from the MAX.

While PCC's financial results are unknown, as they are no longer publicly reported, Arconic's 2019 financial results also are nebulous because there are "lots of moving parts" in the company, executives admit. Still, the to-be Howmet aerospace division reported revenue of $1.7 billion for 2019, up 1% year-over-year. Organic revenue was up 2%, driven by aerospace growth.

A major reason behind the growth

is that Arconic continues to raise prices for its products, particularly for aerospace customers. In 2019, the aerospace division—currently called Engineered Products and Forgings—tallied $78 million in price increases compared with 2018.

"We expect favorable pricing to continue," says Arconic Chief Financial Officer Ken Giacobbe. At the same time, the company finished investing in expansion of aerospace rings and forged wheel production capacity and now expects a return on those investments.

Industry sources say PCC is also raising its prices, yet both companies continue to be challenged delivering to aerospace customers such as engine OEMs. "[There are] the usual things about poor delivery performance and quality issues from Arconic, with all the struggles and operational issues they are going through," says one source. PCC, meanwhile, is restrained by capacity and "struggling to meet the ramp-up in delivery targets," particularly for narrowbody engines.

Not surprisingly, the aerospace industry is hungry for more castings providers to both disrupt the top two suppliers and also meet long-term commercial aircraft demands. In turn, many industry observers see hope in CPP, the private-equity-backed Cleveland company that is rolling up sand casting and other assets and working on newer directionally solidified (DS)/single-crystal castings technology.

Founded in 1991, CPP now comprises 19 global facilities manufacturing products for the aerospace, defense and industrial gas turbine markets. CPP makes engine housings, gearboxes, front frames, shrouds, panels, fairings, blades and vanes. Its defense work also includes missile bodies and other structural components to support munitions.

The company was majority-owned by Warburg Pincus from 2011 until last June, when it sold a stake to Berkshire Partners (which is not connected to Berkshire Hathaway). While terms of the deal were not disclosed, Moody's says CPP is now majority-owned in equal parts by Warburg and Berkshire.

The company is believed to have hit the $1 billion revenue milestone. Commercial aerospace is responsible for two-thirds of annual sales, and the company continues to expand.

"Notwithstanding the company's small size, we believe there continue to be growth opportunities for CPP (as evidenced by recent business wins and a growing backlog), driven in large part by ongoing engine OEM efforts to minimize and diversify supply chain risk by using dual or triple-sourced suppliers," Moody's says in a Dec. 27 report.

CPP further has made "considerable" investment in manufacturing capabilities, particularly around DS/single-crystal technologies, according to credit rating analysts. "We view these investments as having facilitated meaningful content wins on next-generation engine platforms, and the acquisitions of Selmet and Pacific Cast Technologies (both of which add titanium to the company's product capabilities) are deemed to have helped further improve its competitive standing and support future business wins.," says Moody's.

Last July, CPP announced a new advanced manufacturing facility in Euclid, Ohio. It will result in a new 135,000-ft.^{2} facility and 120 new manufacturing and engineering jobs, according to representatives.

Like Arconic and PCC, CPP holds its proverbial cards close to its vest. But based on what is being said publicly, more competition can be expected. "Our new relationship with Berkshire Partners and ongoing partnership with Warburg Pincus will enable us to further build upon the success we have achieved," says CPP CEO James Stewart. "Both firms are growth-oriented and have deep expertise in the aerospace and defense sectors."

ARCONIC

HOWMET AEROSPACE

What was Alcoa and then Arconic will be Howmet Aerospace starting April 1. Its logo is inspired by the two halves of a forging die and the cavity of an investment cast mold.

The Trent 900's Future

Trent-powered A380s will round out the model's 20-year production run and generate steady MRO demand

Sean Broderick Washington

The imminent end of Airbus A380 production combined with a soft secondary market sets up an interesting product-support story for suppliers. While some operators are cutting back, others plan to keep flying the A380s they have, which will create ongoing demand for maintenance. But the absence of second-hand demand means parked A380s will be used to support the in-service fleet, which is expected to reduce demand for new parts.

The market is particularly murky for the A380's two engine suppliers: Engine Alliance (EA), the GE-Pratt & Whitney joint venture, and Rolls-Royce. Engine Alliance is in product-support mode, as the last GP7200-powered A380 was delivered in early 2018. As of Feb. 1, Rolls had the remaining backlog of nine A380s—they are being built at the rate of six per year. The in-service fleet's breakdown indicated 108 Rolls-powered aircraft, compared to 129 with EA engines, Aviation Week Fleet Data Services show.

Both engine OEMs are seeing retirements. Singapore Airlines has returned five Trent-powered A380s to lessors. Four belonged to Dr. Peters—two are being parted out, and two more are in storage. The fifth, owned by Doric, is on lease to charter specialist Hi Fly.

Air France is phasing out its 10 EA-powered A380s by 2022, citing the outsize challenge they present in scheduling as well as reliability issues as primary drivers. Air France-KLM CEO Ben Smith also cited investments that European competitors British Airways and Lufthansa have made in their A380 interiors as a factor. Air France faced costs of about $4 million per A380 to bring them up to the airline's current standard—money it ultimately decided to spend elsewhere.

Emirates, which operates 114 of the 240 A380s in service or storage, including 25 Trent-powered ones, will retire some of its double-decker airliners and invest in others. Cabin upgrades are in the cards, and a new premium-economy class is expected to make its debut on an A380 delivered later this year. Emirates plans to keep its A380 fleet stable for several years before allowing it to decline to around 100 aircraft. The plan means its long-term fleet will be a mix of both engine types.

Qantas, another Trent 900 operator, debuted its upgraded A380 cabin last fall and plans to have all 12 refurbished and flying by 2021.

While no more A380s will be delivered after Emirates takes its final eight and All Nippon Airways takes one by mid-2021, investments made by several operators combined with having nearly two years of production to itself means Rolls faces perhaps two decades of ongoing support. High-pressure turbine blades have been redesigned to provide better durability, with further enhancements—including "design changes and manufacturing improvements"—slated to be introduced this year, the OEM says.

Rolls also made the best of the idle ex-Singapore airframes, leasing all 16 engines from Dr. Peters to help support the in-service fleet. Despite the two stored airframes having been idle since June and October 2018, respectively, Dr. Peters has not given up hope. "We are still exploring all available options to successfully place those two aircraft in the market [and] looking at the best value proposition for our investors," a Dr. Peters representative says.

Even if the airframes do not move, their powerplants should see plenty of work. Aviation Week's MRO Prospector projects 144 Trent 900 overhauls will be conducted across the 10-operator fleet over the next three years, roughly divided evenly within each 12-month period. Information from Aviation Week Fleet Data Services indicates that the average Trent-powered A380 is just more than six years old (see table), suggesting many have not undergone their first engine shop visits, which take place every 6-7 years, depending on an operator's mission profile.

Even factoring in early retirements—Air France's fleet will average slightly more than 10 years of age when the aircraft are parked—the A380's fleet profile suggests many shop visits remain, particularly for the Rolls-powered fleet.

Rolls-Royce-Powered A380 Fleet at a Glance

Operator	In Service	On Order	Average Age
All Nippon Airways	2	1	0.8
Asiana Airlines	6	0	4.8
British Airways	12	0	5.8
China Southern Airlines	5	0	8.2
Emirates	25	8	2.4
Hi Fly Malta	1	0	13.2
Lufthansa	14	0	8.3
Malaysia Airlines	6	0	7.7
Qantas Airways	12	0	10.4
Singapore Airlines	19	0	7.7
Thai Airways	6	0	7.2
	108	**9**	**6.4**

Note: Lessor Dr. Peters has two Rolls-powered A380s in storage and is parting out two others.

Source: Aviation Week Network Fleet Data Services

AVIATION WEEK

MRO AUSTRALASIA

March 11-12, 2020
Sofitel Brisbane
Queensland, Australia

MRO IN AUSTRALASIA IS TAKING OFF – GRAB YOURSELF A SEAT!

Examine the maintenance, repair and overhaul landscape for all fixed wing aircraft; commercial, business, general and regional aviation and rotorcraft at the two-day conference in Brisbane.

Discover more at mroaustralasia.aviationweek.com

Hear from regional experts including:

Chor Chee Hoe
Head of Maintenance Support & Services
Firefly Airlines

Paul Crawford
Head of Base Maintenance – Qantas Engineering
Qantas

Robin Furber
Head of Engineering
Tiger Airways Australia

Sandra James
Senior Manager of University Relations and STEM
Boeing Australia

Toby Koch
General Manager, Engineering
Alliance Airlines

Andrew Sanderson
CEO and MD
TAE Aerospace

Host Sponsor

Queensland Government
Australia

Facility Tour

Visit the Qantas Engineering Base Maintenance facilities located at Brisbane Airport

For more information visit:
mroaustralasia.aviationweek.com/tour

Official Airline Partner

QANTAS
Spirit of Australia

Sapphire Sponsors

AIRBUS · AJW · BOEING · Fokker · HEICO · HESTON MRO · Lufthansa Technik · MED-CRAFT, INC · ottobock. · StandardAero

Sponsors

AIRCRAFTERS, INC. · AJ Levin · Aviation Australia · STS Aviation Group

Apps for the Aftermarket

Lindsay Bjerregaard Chicago

1. Logging Cabin Damage

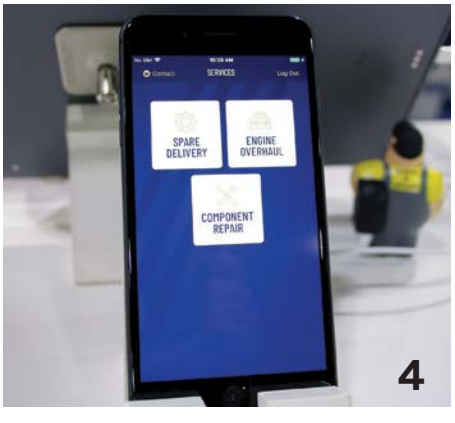
Product: Interior Inspector
Specifications: Magnetic MRO's Interior Inspector app was created to help cabin crew and maintenance teams log and share data about passenger-cabin damage on mobile devices such as smartphones or tablets. The app connects found damage such as stains or broken seat recliners with pictures or notes that cite a specific location within the cabin. Magnetic MRO released the app last year as a service to customers and to help improve it is collecting data on how airlines are using it. One of the latest adopters is Latvian carrier SmartLynx Airlines.
marketplace.aviationweek.com/product/magnetic-mros-interior-inspector-application

2. Salesforce Simplicity for MRO

Product: AvSight
Specifications: Built on the Salesforce platform with efficiency and mobility in mind, AvSight's cloud software combines a variety of aftermarket functions within one platform. With the AvSight mobile app, technicians are able to check the status of work orders, parts, labor and invoicing on the go. AvSight just released its Quote 360 module for high-volume aviation quoting, which integrates with sources such as ILS and PartsBase while enabling teams to view and perform actions on all incoming RFQs.
marketplace.aviationweek.com/product/simplify-your-mro-and-work-order-business-avsight

3. Supply-Side Predictive Analytics

Product: FlightDeck
Specifications: Beep Analytics' FlightDeck platform combines a machine learning-based analysis engine with MRO simulation data to provide supply-side predictive analytics. FlightDeck is able to integrate with companies' legacy systems, and Beep says it is in talks with what it calls "several major first-tier OEMs" to build extended market mapping and predictive analysis solutions for LRU and spare-parts portfolios. Beep says this will enable customers to "obtain a precise, near-real-time tracking capability of their entire aftermarket commercial operations, including market share, competitor activity and much more."
marketplace.aviationweek.com/product/flightdeck-platform



LINDSAY BJERREGAARD/AW&ST

4. Real-Time Engine MRO Data

Product: Pratt & Whitney Track
Specifications: Pratt & Whitney is piloting a new app called Track with customers to "put real-time data in the palm of their hands." The app provides access to data about spare parts, orders, component repairs and engine overhauls, which can be filtered and searched as needed. According to Pratt & Whitney, Track will be available in app stores once the trials have been completed.
marketplace.aviationweek.com/product/pratt-whitney-track

5. MRO Management Modules

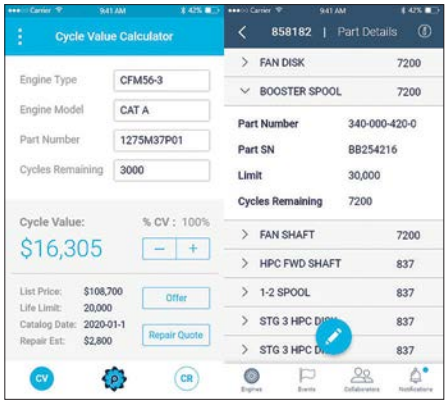
Product: Quantum Control
Specifications: Component Control's Quantum Control platform is composed of a wide range of modules designed to support key aftermarket processes such as managing inventory, resources and MRO tasks. The company continues to advance the platform's capabilities, including the addition of a new MobileTech app for mobility across shops and worldwide locations and a Quantum Analytics module for data on parts distribution, inventory, job performance and more. Quantum Control was recently selected by TP Aerospace as part of its goal to go paperless by 2020.
marketplace.aviationweek.com/product/quantum-control-mobility-suite

6. Life-Limited Parts Management

Product: Power Werks Aviation Apps
Specifications: Aviation software specialist Power Werks has developed several apps for suppliers, airlines, MROs and lessors.

*Go to **MROLinks.com** for more information.*

Engine Manager was created for operators to manage their fleets and track engines off-wing through 24/7 access to detailed engine and life-limited parts (LLP) data, including LLP market availability and collaborative event reporting, which Power Werks says can streamline decisions and turn time for aircraft and engine events. The Cycle Value Calculator app is used by engine shops, lessors and airline powerplant personnel to quickly calculate cycle value for LLP in commercial engines.
marketplace.aviationweek.com/product/aviation-apps



6

7. Step-by-Step Task Guidance

Product: FieldLogs
Specifications: Recently adapted for the aviation industry, FieldLogs seeks to revolutionize digital task cards by diving much deeper than PDF-based instructions, instead providing step-by-step intelligent guidance that combines OEM instructions, experience-based knowledge, sensor data and more. The app enables videos and photos, digital signatures, and time- and GPS-stamping of actions taken. According to FieldLogs, the app helps MROs increase efficiency and technicians' compliance while enabling faster training and better knowledge-retention.
marketplace.aviationweek.com/product/fieldlogs-digitalization-platform

7

LINDSAY BJERREGAARD/AW&ST

8. Optimizing Spare Parts

Product: SPM Studio
Specifications: Gordian's SPM Studio is a spare parts optimization tool that enables what it calls tactical spare parts planning decisions through key features such as demand forecasting, advanced inventory models and a KPI (key performance indicator) dashboard. Gordian says SPM Studio can be used to distinguish between "cheap fast-movers" and "expensive slow-movers," simulate parts performance and formulate actions for improvement. The tool, which is being migrated to a web-based cloud format, is used by aviation clients such as Proponent and KLM Cityhopper.
marketplace.aviationweek.com/product/spm-studio

By CRAIG GOTTLEIB

Craig Gottlieb is the managing director in Accenture's aerospace and defense practice, focused on innovation in aftermarket services.

Applying AI to Customer Service

"Airlines like you have also ordered . . . "

It is no surprise to readers of these pages that the aerospace and defense (A&D) aftermarket is burgeoning with investment, much of which targets new business models and services to improve aircraft availability and operator value. Aftermarket providers must prove how these new services will create value for customers, assets and their own bottom lines. Among other factors, this requires mastering a discipline that has not always been favorably associated with MRO or the aviation aftermarket—customer service.

Customer service has grown in stature as businesses, including aviation, have moved "beyond the product sale" to capture the customer lifetime value that can be created with services. Securing lifetime value, the cumulative revenue stream of a customer, requires a consistent, predictable, engaging and personalized customer experience. Getting that experience right is the new mandate of the customer service function. With the lifetime value of an aviation customer measured in decades, aftermarket providers are investing in a range of tools to craft compelling experiences. Among these is artificial intelligence.

As AI gains access to more fleet, service-bulletin and other data, the applicability, efficacy and confidence in these systems can grow.

AI is not new to our industry. Indeed, our research at Accenture shows that A&D companies have adopted AI at a higher rate than the global corporate average. Most AI deployments within A&D have been in product service or of high-value aftermarket products such as predictive analytics. The notion of employing AI to drive customer service outcomes is emergent but promising.

There are more aircraft in service, more aftermarket contracts based on aircraft availability and more data available about both assets and their operators. Amid this bounty, however, there is a dearth of humans who can deliver customer service at scale. AI can fill that gap through listening to where customers need help, brokering their path to customer service, diagnosing their problems, resolving their issues, responding to gather feedback and anticipating future needs.

Using AI to monitor customer service needs originates in the consumer realm, where social media monitoring can help target customer service responses. In aviation, this translates into an omnichannel service desk where AI-enabled monitoring can capture and acknowledge requests by SMS, phone, internet or other channels and rapidly induct them into the service broker engine.

AI for brokering can help guide customers to the right channel and service to resolve their need quickly and effectively. For example, a chatbot could be used for a line-maintenance inquiry, natural language processing for a field representative phone call or a direct instant-message conversation for airline operations to help resolve an aircraft-on-ground (AOG) event.

By combining AI-driven insights into customer profiles and known problems with information from product life-cycle management and MRO systems, operators can unlock new channels such as interactive voice or online self-service tools to help diagnose and resolve issues. This approach not only can accelerate issue resolution but also free up in-demand experts to focus on AOG and other critical needs.

As AI gains access to more fleet, service-bulletin, configuration and other data, the applicability, efficacy and confidence in these systems can grow. Indeed, this kind of iterative "prove-it-to-me" approach will be needed to gain regulatory and compliance approvals for more critical maintenance processes.

Customer service must also manage customers' ongoing experience and perception of service. While aftermarket providers use focus groups and other tools, AI can automate and more effectively organize feedback. Text analytics and other tools can aggregate views of operator sentiment that might previously have been lost in spreadsheet analysis of multiple-choice surveys. These insights and other service-event analytics can help drive actions that anticipate operator service needs, from technical publication updates to training refreshes to part removals. These actions can create long-term customer engagement and value.

New aircraft deliveries, greater data availability, new service models and workforce pressures are driving the need for new approaches to customer service. But this is not just a volume problem. Operator expectations of the value of availability-based services and aftermarket provider expectations of the value they will create from delivering those services are increasing. When increased expectations meet growing constraints, it does not take an algorithm to determine new methods are needed. AI is one such solution for aftermarket customer service.

MRO Links is an online service that connects **buyers and sellers** in the MRO industry. *Become an MRO Links power user by registering at mrolinks.com/register. Registration is FREE, enabling you to find hundreds of products like the ones featured below and to connect with more than 8000 companies. You can create a personalized save list, learn about companies' specialties, get contact details and request information at mrolinks.com.*
To advertise in MRO Links, contact **Elizabeth Zlitni at 913-967-1348 or elizabeth.zlitni@aviationweek.com.**

MRO MIDDLE EAST
Organised by AVIATION WEEK NETWORK
Tarsus

MRO Middle East takes place in Dubai from 24-26 February 2020, gathering the commercial aviation aftermarket for three days of big business in the region. Co-located with AIME, the leading aircraft interiors event for the region, the whole industry is represented, with airlines, OEMs, MROs, lessors and suppliers in attendance to network, test the latest technology and discover emerging opportunities in this booming market. The event opens on 24 February with a one day summit at the Conrad Dubai (paid event) where expert speakers will guide 150+ delegates through the latest challenges and trends of the regional MRO market. The exhibition takes place on 25-26 February at the Dubai World Trade Center, free to attend for all trade professionals. More information can be found at **mromiddleeast.aviationweek.com**

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

ABLE AEROSPACE SERVICES, INC.

YOUR NEW SINGLE SOURCE FOR BOEING 737NG LANDING GEAR MRO

Able is now offering landing gear modifications, upgrades and sales for the B737-700/-800/-900.

Count on Able – and our decades of commercial aircraft experience – as your single source for B737NG landing gear MRO.

Also Coming Soon from Able: B737 Landing Gear Exchanges!!

www.ableengineering.com
https://marketplace.aviationweek.com/product/your-new-single-source-boeing-737ng-landing-gear-mro

Maintenance, Repair & Overhaul • Engines/ Engine Systems

AEROXCHANGE

E-Commerce Supply Chain Solutions

Created by 13 major global airlines, Aeroxchange provides secure electronic solutions that drive asset optimization and maximize efficiency across the aviation supply chain. Backed by airlines and trusted by OEMs, our tailored solutions offer a seamless e-commerce experience between trading partners.

www.aeroxchange.com
https://marketplace.aviationweek.com/product/e-commerce-supply-chain-solutions

Technology • Software

AIRMARK CORPORATION

NATIONAL LEADER IN AIRCRAFT MARKING SYSTEMS

Your partner for stenciling and labeling in the aerospace industry. AirMark printing and cutting systems offer innovative solutions for all interior and exterior aircraft graphic applications.

www.airmark.com
https://marketplace.aviationweek.com/company/airmark-inc

Tools & Equipment

AIRWORTHY, INC.

Floor to Ceiling - Complete Interior Solutions

Airworthy, Inc. specializes in manufacturing and repair of aircraft interiors including flooring, side walls, overhead bins, bin doors, monuments and lav doors. As we celebrate 20 years of service, we continue to meet the MRO's demanding requirements of quality, service and quick turn times.

www.airworthy.aero
https://marketplace.aviationweek.com/product/floor-ceiling-complete-interior-solutions

MRO Americas • Consulting Services • Maintenance, Repair & Overhaul • Cabin Interiors/ InFlight Entertainment

Go to mrolinks.com for more information.

ALIGN AEROSPACE LLC

Supporting Major OEM and Aftermarket Customers

Our Products are LTA Contracts, Kitting Solutions, VMI Min/Max, Bin Management DLF, 3PL and Integrated Solutions.

We are fully franchised for the following distributors: Arconic, CAM, PCC, TriMas Aerospace, Lisi Aerospace and the Novaria Group.

Airframes ▪ Connectors/Fasteners ▪ Electrical ▪ Engines/ Engine Systems

alignaero.com
https://marketplace.aviationweek.com/product/supporting-major-oem-and-aftermarket-customers-0

AMBRY HILL TECHNOLOGIES

A smarter way to work RFQs.

Vista-Quote, a cloud-based application designed to automate your RFQ gathering and quote sending workflow. Sales teams use VistaQuote to manage their RFQ and quote activities, accompanied by real-time inventory data, all inside one intuitive platform.

Technology ▪ Software

www.ambryhill.com
https://marketplace.aviationweek.com/product/smarter-way-work-rfqs

AMERICAN ALUMINUM CASTING CO.

SAND, DIE AND PERMANENT MOLD ALUMINUM CASTINGS

American Aluminum Casting Company is a privately-held, family-owned-and-run metal casting business located in Irvington, NJ. The Company provides high-integrity and commercial non-ferrous castings to a wide variety of industries, with an emphasis on high-quality cast aluminum parts.

Manufacturing & Distributing ▪ Avionics/Instruments ▪ Cabin Interiors/InFlight Entertainment ▪ Electrical ▪ Lighting ▪ Parts

americanalum.com
https://marketplace.aviationweek.com/product/sand-die-and-permanent-mold-aluminum-castings

AMERICASE, LLC

Providing Practical Solutions to Complex Problems

Americase, an ISO9001/AS9100 company designs and manufactures commercial duty carrying cases for any kind of transport. With in-house engineering and production environments, Americase is uniquely adept in providing high quality, custom fabricated solutions to various industries.

View this product at americase.com

Manufacturing & Distributing ▪ Aerospace Materials

www.americase.com
https://marketplace.aviationweek.com/product/providing-practical-solutions-complex-problems

AOG ACCESSORIES

Customer Service, Quality, on Time Delivery

AOG Accessories specialize in providing repair services covering equipment manufactured by many of the galley equipment and interior parts for major OEM's. AOG is able to provide repairs from our FAA Part 145 and EASA approved repair station and has capabilities for dual release on equipment within ATA Chapters 21, 24, 25, 26, 27, 29, 30, 32, 33, 35, 36, 37, 38, and 49.

Maintenance, Repair & Overhaul

www.aogaccessories.com
https://marketplace.aviationweek.com/product/customer-service-quality-time-delivery

A PROFESSIONAL AVIATION SERVICES

FAA/ EASA 145 Certified Repair Station with a state of the art facility.

With a vast capabilities in:
Structures
Composite
Electro Mechanical
Hydraulics
Pneumatics
Fuel
Wheels and Brakes
AOG Support
Providing commercial and military services around the globe to the aviation industry.

Maintenance, Repair &Overhaul

www.apas1.com
https://marketplace.aviationweek.com/company/professional-aviation-services

Go to mrolinks.com for more information.

AQUARESE BY FLOW

Ultra high-pressure Waterjet Stripping Solutions

Aquarese ultrahigh-pressure Waterjet Stripping Solutions remove TBC coatings with ease. Waterjet stripping is an eco-friendly process; no chemicals and no pollutants. Up to 10 times faster than chemical removal processes; a cost-efficient solution for combustors, vanes, boosters, blades, and more.

www.flowwaterjet.com

https://marketplace.aviationweek.com/product/ultra-high-pressure-waterjet-stripping-solutions

Aerospace Materials

ASSOCIATED INDUSTRIES INC.

Advanced Material Distribution

Associated Industries is the premier Advanced Material Distributor for the Aerospace, MRO and Defense markets. Offering premium brands that supply vacuum bagging materials, adhesives, sealants, pre-preg, carbon fiber, fiberglass, core, surface treatment chemicals, tapes, abrasives and much more.

www.associatedindustriesinc.com

https://marketplace.aviationweek.com/product/advanced-material-distribution

Maintenance, Repair & Overhaul ▪ Painting/Coatings ▪ Consumables/Supplies

ATEC, INC.

PHOENIX MODULAR FACILITIES

Atec, Inc., provides high quality products and services for Aerospace and Energy. Our 65 years of experience in design, manufacturing, construction, procurement, maintenance, and field service offer confidence and value to our customers worldwide. We provide harsh environment solutions for medium volume requirements involving engine test, aero support equipment, constructed facilities, space flight components and energy service products. Celtech Corp., the global leader in fabrication of Jet and Turboprop Test Stands, bolsters our reach and capabilities for heavy production. Vital Link, Inc. brings the world's leading noise suppressor & hush house firm to our corporate family.

www.atec.com

https://marketplace.aviationweek.com/product/phoenix-modular-facilities

Manufacturing & Distributing

CAVU AEROSPACE, INC.

CAVU Aerospace Inc offers the most efficient solutions to aircraft disassembly and asset management by offering our R.A.M.P.(Recycling & Asset Management Program) and CAVUSmartTags' programs

The R.A.M.P.(Recycling & Asset Management Program) and CAVUSmartTags' an effective solution to efficiently manage their end of service aircraft. Providing a solution that liquidates the surplus material and brings you the MOST value in the shortest amount of time for our consignors.

www.cavuaerospace.com

https://marketplace.aviationweek.com/product/ramp-and-cavusmarttags-efficient-disassembly-and-asset-management-solutions

Aftermarket Services

CEE-BEE AVIATION

Cee-Bee Aviation & Met-L-Chek

For more than 75 years, Cee-Bee® aviation products have helped commercial airlines, military, aerospace, and original equipment manufacturers meet the demanding requirements of the aviation industry. Met-L-Chek® is an approved manufacturer, qualification laboratory, and supplier of liquid penetrant inspection materials.

www.mcgean.com

https://marketplace.aviationweek.com/product/cee-bee-aviation-met-l-chek

Maintenance, Repair & Overhaul ▪ Engines/Engine Systems ▪ Landing Gear/Wheels/Brakes ▪ Military Maintenance

DCI INDUSTRIES

DCI - Industries "The Future Is Bright"

DURACOATINGS "The Future is Bright" DuraCoatings has a limited rating for Airframe, Landing Gear, and Accessories. Our core business is built around our Hard Chrome Plating and Thermal Spray Processing with the ability to handle large components.

duracoatings.com

https://marketplace.aviationweek.com/product/dci-industries-future-bright

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

Go to mrolinks.com for more information.

EASTMAN AVIATION SOLUTIONS

Trusted on the ground. Proven in the air.

Found in approximately 24,000 engines in use today—completing billions of flight hours, Eastman turbo oils and Skydrol™ aviation hydraulic fluids have been tested, proven, and trusted aviation solutions for more than 50 years.

Aerospace Materials ▪ Advanced Materials/ Composites ▪ Chemicals ▪ Fuel/Lubricants

www.eastmanaviationsolutions.com
https://marketplace.aviationweek.com/product/trusted-ground-proven-air

GLOBAL AEROSPACE CORPORATION

Global Aerospace Corporation - Keeping you flying!

Established in 1993, Global Aerospace Corporation is a leading Canadian provider of landing gear, air cycle machine, pneumatic and hydraulic aircraft component MRO, including loan and exchange services for commercial and regional aircraft.

MRO Americas ▪ Maintenance, Repair & Overhaul

www.globalaerospace.com
https://marketplace.aviationweek.com/product/global-aerospace-corporation-keeping-you-flying

GLOBAL AVIATION CO

SERVICE IS OUR BEST PART

Global Aviation Co. provides customized supply chain solutions and spare parts distribution services for commercial airlines, helicopter operators and MROs. Global provides customers with prompt fulfillment from distribution centers located in Atlanta, Dallas, Singapore, and Amsterdam.

Manufacturing & Distributing ▪ Consumables/Supplies

www.globalaviation.aero
https://marketplace.aviationweek.com/product/service-our-best-part

GREEN WORLDWIDE SHIPPING LLC

Green Worldwide Shipping, as partner in the Aviation Logistics Network (ALN), provides best-in-class aerospace and Aircraft-on-ground (AOG) services to the aviation community. With our 10 USA offices, Airfreight specialist staff and 365/24/7 coverage, we can ensure you the highest level of service and solutions. Green is the exclusive USA member of ALN (Aviation Logistics Network), with over 350+ stations around the world, all specialist in Aerospace/AOG.

Aftermarket Services

www.greenworldwide.com
https://marketplace.aviationweek.com/company/green-worldwide-shipping-llc

HURRICANE AEROSPACE SOLUTIONS

Hurricane Aerospace Solutions

Hurricane Aerospace's commitment to our customers and associates is to continually strive for excellence in these and other areas required to assure their own success.

Manufacturing & Distributing ▪ Cabin Interiors/InFlight Entertainment ▪ Consumables/ Supplies ▪ Lighting ▪ Parts

HURRICANEAEROSPACE.COM
https://marketplace.aviationweek.com/product/hurricane-aerospace-solutions

TITAN TOOL SUPPLY, INC.

Videoscope Records Video & Still MRO Inspections

Titan Tool Supply's Model TVSG Videoscope enables visual inspections at remote MRO sites to be recorded in both still images and video. Models are available in 4.5 mm or 6.4 mm diameters and 1.5 m or 3.0 m lengths. Full 360° joystick articulation control. Engineering * Ground Support Equipment * Hangars & Equipment * Test Equipment * Tools

Tools & Equipment ▪ Test Equipment ▪ Ground Support Equipment

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

Go to mrolinks.com for more information.

SANAD AEROTECH

The globally pioneering engine MRO

The world's first independent GEnx™ MRO, and the world's only independent Trent 700 MRO & AMC - Sanad Aerotech is a globally pioneering engine MRO service provider.
Sanad Aerotech performs complete MRO servicing of engines installed on A/C such as Airbus A330, A320, Boeing 787 and 747.

www.sanad.ae

Components ▪ Engines/Engine Systems ▪ Test Equipment

https://marketplace.aviationweek.com/product/globally-pioneering-engine-mro-0

SATAIR, AN AIRBUS SERVICES COMPANY

Your partner for more than parts

With more than 200,000 different part numbers in stock, Satair is one of the global leading providers of aftermarket solutions for the civil aerospace industry, offering parts management and services as well as parts support for all types of aircraft platforms as the preferred aftermarket integrator.

www.satair.com

Parts ▪ Aftermarket Services ▪ Training ▪ Supply Chain/Logistics

https://marketplace.aviationweek.com/product/your-partner-more-parts

MB AEROSPACE

Industry-leading repair services

MB Aerospace is committed to engineering excellence supporting repair operations with OEM's, MRO's and other aviation entities across multiple engine platforms. Our world class quality and TAT, together with our customer service team ensures 100% quality delivery, on time, every time.

www.mbaerospace.com

Components ▪ Heat Coating/Brazing ▪ Military Maintenance

https://marketplace.aviationweek.com/product/industry-leading-repair-services-0

b2b-aero.com GmbH

b2b-aero.com - THE AVIATION MARKETPLACE

DRIVING DIGITAL TRANSFORMATION
b2b-aero.com — THE AVIATION MARKETPLACE — is the industry's benchmark for electronic supply chain transactions and database solutions. b2b-aero.com offers low cost electronic interaction and data exchange (EDI) services between MRO buyers and suppliers.

www.b2b-aero.com

Aftermarket Services ▪ Technology ▪ Manuals/Repair Documentation/Records ▪ Software

https://marketplace.aviationweek.com/product/b2b-aerocom-aviation-marketplace

USA BORESCOPES

USA2000J 6mm Portable Joystick Articulating Videoscope

The USA2000J-6-2000 6mm portable joystick articulating videoscope features:

Excellent Image Quality with Optimized Optic System & HD CMOS Sensor
High Resolution Picture/Video LCM Output System
Smooth Joystick Control and Lock System
Tungsten Tube
Temperature Warning
7" LCD Monitor

www.usaborescopes.com

Tools & Equipment ▪ Test Equipment

https://marketplace.aviationweek.com/product/usa2000j-6mm-portable-joystick-articulating-videoscope

CO-OPERATIVE INDUSTRIES AEROSPACE & DEFENSE

Electrical Wiring Harness Repair Services

If your organization is looking for reliable wiring harness repairs, you can trust in CIA&D (Co-Operative Industries Aerospace & Defense) to deliver the results you need. With quality workmanship and responsive turn-times, our repair center offers cost-effective repair options to airlines and MROs.

coopind.com

Maintenance, Repair & Overhaul ▪ Components ▪ Electrical ▪ Engines/Engine Systems

https://marketplace.aviationweek.com/product/electrical-wiring-harness-repair-services

Go to mrolinks.com for more information.

Go to mrolinks.com for more information.

TRUEngine.™
Protect your asset.
Think outside the box

Optimum performance isn't just about individual parts. It's about the entire engine system. TRUEngine qualification is available for CFM engines maintained to our precise standards. This assures expedited technical support, 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.

Take part now at www.cfmaeroengines.com/services

*Based on CFM, GE and independent third-party research.

CFM International is a 50/50 joint company between GE and Safran Aircraft Engines

Unmatched Experience | World-Class Support | Exceptional Value


TECHNOLOGY PROVIDES
A LEADING EDGE.
INGENUITY
MAKES THE DIFFERENCE.
Visit us at Singapore Airshow and MRO Middle East
The history of aviation began with making the impossible possible. This spirit still inspires our work at Lufthansa Technik today. Ingenuity is the basis on which we create exceptional solutions for an industry in motion. Each and every day, we combine imaginative engineering and the best in design and technology to bring excellence to all of our customers and partners. Together we challenge the status quo as we create new and better ways forward.
CHRISTOPHER PETERMANN • ENGINEER INNOVATION & RESEARCH
Excellence in Motion
Lufthansa Technik

What Does Brexit Mean for Aviation?

Helen Massy-Beresford Paris

Three and a half years after the UK voted to leave the European Union, and after many political twists and turns on the way, the UK left the EU on Jan. 31. A transition period, during which existing rules and terms apply, is scheduled to last until the end of 2020.

What will change for airlines? In the short-term, not much. An 11-month transition period ensures the status quo will last until Dec. 31, 2020, with a target for an agreement on the future relationship to be signed by Jan. 1, 2021.

Once the transition period begins, negotiations on the UK's future relationship with the bloc will get underway. The UK will have the same rights and obligations as the remaining member states until the transition period ends.

JOEPREISAVIATION.NET

Ryanair has warned about the economic impact of Brexit.

What are airlines most worried about after that? The transition period buys them some breathing space, but airlines still want clarity on their future. In other words, they want to understand how Brexit will affect everything from airline ownership rules to safety regulations, traffic rights and immigration processes at airports.

The UK Chancellor of the Exchequer Sajid Javid's recent comments that the UK may not align itself on European rules rang alarm bells for a highly regulated sector, but Javid later sought to calm the debate by saying there would not be divergence from European standards for the sake of it.

What can UK and EU airlines expect after December 2020? For now, no one really knows. Teams of negotiators from the UK and the EU will spend the coming months thrashing out the minutiae of the two sides' future relations, including the air transport sector.

A document released Jan. 15 by the European Commission's Task Force for Relations with the United Kingdom noted the baseline scenario in which the UK ceases to be part of the fully liberalized EU aviation market. All current EU law-based rights, obligations and benefits cease, as do traffic rights and ownership and control rules. There is no fallback on the World Trade Organization rules.

The European Commission Task Force's document highlights European Council guidelines from 2018 stating: "The aim should be to ensure continued connectivity between the UK and the EU after the UK withdrawal . . . while ensuring a strong, level playing field in highly competitive sectors." But it also warns: "There can be no 'cherry picking' through participation in the single market based on a sector-by-sector approach."

The negotiators will also be looking at the effect of the UK's departure from the EU on areas such as operational and commercial flexibility, including codesharing.

What will the UK's relationship with the EU and U.S. air transport markets look like post-Brexit? The future of the UK's relationship with the air transport markets in the EU is one of the most important points negotiators will be trying to define as negotiations begin. In an October 2019 revised political declaration setting out the framework for the UK and the EU's future relationship, the European Commission said a comprehensive air transport agreement would be needed to ensure passenger and cargo air connectivity. That agreement would include provisions covering market access and investment, aviation safety and security, air traffic management, and provisions to ensure open and fair competition, including appropriate and relevant consumer protection requirements and social standards.

The two sides should make arrangements to enable cooperation with a focus on high standards of aviation safety and security, including close cooperation between the European Union Aviation Safety Agency (EASA) and the UK's Civil Aviation Authority (CAA), the council said in its October 2019 statement.

Post-Brexit, the UK will also cease to be part of the EU-US Open Skies, an agreement signed in 2007.

In November 2018, the UK signed a new open skies air services agreement with the U.S., a move that International Airlines Group (IAG) CEO Willie Walsh said at the time was "a significant positive development." He added: "It's critical that Britain maintains full access to international aviation markets so it can continue to develop its global trading links."

Virgin Atlantic says the open skies agreement between the U.S. and UK, as well as existing bilateral air service agreements with other key markets, will ensure that flights will continue to operate as normal, regardless of the future relationship agreed to between the UK and EU. "In the meantime, we welcome the status quo transition pe-

riod until Dec. 31, 2020, which ensures that customers can continue to travel with confidence as the UK leaves the EU on Jan. 31," the company says.

Virgin says its joint-venture plan—a transatlantic joint venture with Delta Air Lines and Air France-KLM that involves cross-shareholdings spanning the U.S., the UK and the EU—is unaffected by Brexit.

What will be the impact on airline ownership? Airlines have been taking action to ensure their ownership satisfies EU ownership and control rules to maintain their continued right to fly post-Brexit.

For example, IAG says its airlines (British Airways, Aer Lingus, Iberia, Vueling and Level) submitted plans on ownership and control to the national regulators in Austria, France, Ireland and Spain, all of which confirmed that the plans would satisfy EU rules in the event of a no-deal Brexit.

What about operating licenses? Airlines based in the UK and operating to European destinations, or vice versa, have been preparing for Brexit for years.

In July 2017, a year after Britain voted to leave the EU, EasyJet set up Vienna-based EasyJet Europe. The move protected its rights to fly to European destinations through its Austrian air operator's certificate (AOC).

Dublin-based Ryanair will have no problems continuing to operate in Europe post-Brexit. In January 2019, the airline secured its UK AOC to allow it to continue operating domestic UK and UK-to-non-EU flights after the transition period ends. Budapest, Hungary-based Wizz Air set up its UK subsidiary and obtained its UK AOC in 2018.

What will happen to the EU261 passenger compensation scheme after the transition period? Air passengers on a flight departing the UK will have the same passenger rights that apply today, both during and after the implementation period. The UK government plans to adopt EU261 rules into UK law when it leaves the EU.

What other effects will Brexit have on the airline industry? The economic impact of Brexit is already taking its toll on airlines. How that will evolve is hard to predict. In its annual report published July 26, Ryanair said Brexit would have less of an effect on its operations than on those of UK-based airlines. "But we still expect adverse trading consequences," the airline stated. "Brexit is causing considerable political uncertainty in the UK; it has damaged investment, economic activity, and consumer confidence and has been a major contributor to the weakness of air fares and consumer demand for flights from/to the U.K."

Thomas Cook's collapse in September and UK regional carrier Flybe's recent financial difficulties and subsequent rescue were not solely due to Brexit, but the effect of currency swings and consumer uncertainty since the 2016 vote certainly heaped extra pressure on already struggling businesses.

Virgin Atlantic says its joint-venture plans are unaffected by Brexit.

JOEPREISAVIATION.NET

Are negotiators sure they will reach full agreement in the allotted time? No. The EU's chief Brexit negotiator, Michel Barnier, has warned that while the withdrawal agreement guarantees continuity and free movement of people, goods and services until the end of the year, 11 months is a short period in which to negotiate an extremely complex new relationship after what he described as "a kind of divorce" in a Jan. 9 speech. "The UK will automatically, mechanically, legally, leave 600 international agreements. And we will have, together—EU and UK, and the UK for its part, alone—to rebuild everything," Barnier said in the speech.

If negotiating the transport clauses requires more time, the EU would fall back on international agreements for aviation or its "no-deal contingency plans" developed in 2019, the Airlines for Europe (A4E) industry lobby group warns.

"This is the worst-case scenario for EU aviation. These contingency plans are far from all-encompassing, and a series of practical issues will arise on Jan. 1, 2021, if the EU-UK agreement does not cover the aviation sector," A4E says.

Member airlines—which include Air France-KLM, EasyJet, Finnair, IAG, Norwegian and Ryanair—are concerned about the transfer of passenger data once the UK is no longer covered by General Data Protection Regulation (GDPR) legislation, the association says.

"Similarly, the transfer of spare parts for aircraft maintenance from the EU to the UK might fall under different customs rules in the future, creating administrative burden and higher costs for airlines," it adds. A4E says it is in regular contact with the European Commission and lobbying for transport clauses to be included in the future EU-UK agreement.

What does Brexit mean for the UK and EASA? The baseline scenario is that the UK will cease to be part of EASA after the transition period, but industry insiders believe a way around this will be found, as leaving EASA and setting up a UK equivalent would be costly, complicated and could give European competitors the edge.

Given the UK's significant aerospace manufacturing and aviation interests, ongoing UK membership of EASA is also seen as important for the EU.

For now, EASA says the UK's exit will not alter its mandate, aims or operations, but it is too early to say what ultimate impact Brexit will have on EASA or its European stakeholders or on the UK itself.

"The withdrawal will significantly alter EASA's cooperation with UK authorities and will not leave EASA's stakeholders untouched," the agency says.

第13届中国航展
AIRSHOW CHINA
2020.11.10-15 ZHUHAI·CHINA

第十三届
中國國際航空航天博覽會
The 13th China International Aviation & Aerospace Exhibition

引领亚洲巨大的航空市场
LEADING TO THE LARGEST AEROSPACE MARKET IN ASIA

珠海航展有限公司
ZHUHAI AIRSHOW CO., LTD.
WWW.AIRSHOW.COM.CN

EXHIBITION
Mr. Jimmy Sum
Tel:+86-756-337-6304
Email:jimmysum@airshow.com.cn

TRADE VISITOR & AIRCRAFT EXHIBITION
Mr. Aaron Huang
Tel:+86-756-337-6111
Email: aaron@airshow.com.cn

LEONARDO'S KOPTER COUP

> SH09 WILL "COMPLEMENT" LEONARDO'S AW119 KOALA, SAYS KOPTER CEO

> AIRCRAFT CERTIFICATION PLANNED FOR 2020

Tony Osborne Los Angeles

Through its $185 million takeover of the fledgling Kopter Group, Leonardo Helicopters has captured a new product for a fraction of the half-billion-dollar price tag normally associated with such a development.

The surprise, bargain-basement deal announced at this year's Helicopter Association International's Heli-Expo conference in Los Angeles also secures what could soon be a sizable chunk of the single-engine helicopter market for Leonardo—a business that the Italian OEM has largely ignored for a decade by focusing on the medium, twin-engine segment.

And although Kopter will remain an autonomous entity, Leonardo's backing should help finalize the development and certification of Kopter's SH09, as well as provide significant marketing, supply chain and distribution clout from its larger parent.

"This is the highlight in the history of Kopter," Kopter CEO Andreas Lowenstein says. "We are convinced this will be the market leader that will change the game in the light helicopter segment."

Leonardo Helicopters CEO Gian Piero Cutillo told Aviation Week: "I believe all the ingredients are there to come into this segment with a really great product. It will really open the door for a lot of opportunities."

The 2.85-metric-ton (6,280-lb.) SH09 is the first new design of a single-engine light helicopter for the long, light-single market in more than 30 years *(AW&ST*, Jan. 27-Feb. 9, 2020, p. 42). It has been designed to take on Airbus' H125 AStar/Ecureuil and Bell 407 and compete with small, twin-engine models, including the Airbus H135 and the Bell 429.

As the former owner of the SH09, holding company Lynwood had ploughed some $350 million into the development of the aircraft type since it emerged out of Marenco Swisshelicopter in 2009. Leonardo will likely need to spend at least $100 million to complete development, industry watchers say. Additional payments linked to certain milestones over the life of the program could also be earned by Lynwood.

"This is a hell of a bargain for Leonardo," says Mike Hirschberg, executive director of the Vertical Flight Society. "If they were to develop an aircraft independently, they would have spent at least half a billion dollars and five years to develop it."

Leonardo's initial interest in the program extends back at least four years, before Marenco transitioned into the Kopter Group in February 2018 under the management of Lowenstein. In 2018, Kopter had already started a hunt for new shareholders to complement Lynwood's investments. Several investors had expressed a strong interest in taking a stake in Kopter, including other helicopter OEMs, but a full buyout was never in the cards until the Leonardo offer came along. Leonardo CEO Alessandro Profumo admitted he was skeptical of the deal

The SH09's Updated Configuration

2 | New Rotor Head and Main Rotor Blades

The new rotor head combined with a new main rotor blade—fitted with large trim tabs—has increased stability and improved the smoothness of the ride, reducing pilot workload.

3 | Resculpted Cowlings

The cowlings reduce the amount of turbulent air flowing around the back of the aircraft and have the impact of reducing drag and ultimately fuel consumption in cruise.

4 | Endplates

Although these components are pictured, the aim is to eliminate the need for them on the horizontal stabilizer.

KOPTER GROUP

1 | New Avionics Suite

The prototype P3 is using a Sagem-developed avionics suite, but production aircraft will use the Garmin G3000H system, which will ready the SH09 for single-engine instrument flight rules (IFR) operations.

5 | New Fuel Tank Configuration

The SH09 will receive new fuel tanks that use concertinaed fuel lines capable of coping with a high-sink-rate impact.

at first, but the management of his helicopter business won him over. The new aircraft not only provided a leg up into the busy light helicopter market but also produced a steppingstone to new technologies such as hybrid propulsion and unmanned systems, Cutillo notes.

Leonardo has several new single-engine helicopter studies underway, and the purchase was a "unique opportunity," Cutillo says. "We have the chance to shortcut the time to market," he adds.

The SH09 will join Leonardo's AW119 Koala as part of the company's single-engine product lineup. The AW119, which is nearing the end of its development cycle, will likely become a niche product for key missions such as military training, having recently secured the tender as the U.S. Navy's TH-73 rotary-wing trainer.

Keeping Kopter's autonomy from the Leonardo mothership appears to be a priority for both Cutillo and Lowenstein.

However, recent acquisitions—such as Sikorsky's purchase of Schweizer and PZL Mielic and Leonardo's purchase of PZL-Swidnik—show that separation could be difficult to sustain.

"We should leverage this agile way to do things," Cutillo says. "We don't want to go and change the way they are doing things. For the time being, I don't see any need to merge."

"It is very important in this segment to be different from those working on bigger helicopters," Lowenstein says. "You need to decide quickly, be cost-aware and [remain] agile with product support."

The takeover was announced just as Kopter began taking major investment decisions to support the production of the aircraft and build-up of its international distribution network. The company is planning a new factory at its headquarters in Mollis, Switzerland—a 24,000-ft.^{2} plant that will bring the company's geographically separated facilities together under one roof. The site is due to be operational in 2022, ready for an expected ramp-up in production. The company has also secured facilities in Lafayette, Louisiana, where it will serve the U.S. market with a final assembly line.

Lowenstein says the company needs to assess the impact of Leonardo's takeover on Kopter's recent agreements with Korea Aerospace Industries (KAI). Those agreements could see the pair cooperate on marketing, sales and potential assembly of the helicopter in South Korea.

Kopter has been testing its third prototype SH09 in Sicily. Over the coming months, it will be modified in line with the new configuration.

TONY OSBORNE/AW&ST

Kopter is also making significant changes to the SH09's dynamic systems and aerodynamic configuration, as engineers close in on the production configuration of the aircraft. The changes resculpt the cowlings around the main gearbox and the Honeywell HTS900 engine and introduce a new main rotor head and main rotor blades.

The company retrofitted the head and blades onto the only flying prototype (P3) in December, paving the way for the first flights with the new configuration in January.

The new rotor head introduces a new damper, whereas the previous rotor-head dampers provided damping to the cyclic inputs—but not collective inputs—making the aircraft movements sensitive to updrafts, downdrafts and turbulence. The old dampers would cause the aircraft to occasionally "fishtail," says Michele Riccobono, Kopter's chief technical officer and head of flight operations.

"This new architecture of damper is maintenance-free and provides the opportunity for on-condition maintenance, and the collective damping has improved the ride-quality and stability of the aircraft significantly," Riccobono says.

The new rotor blades introduce several large trim tabs along the trailing edge to provide more stability. The improved stability was demonstrated when test pilots were able to leave the flight controls unattended for 20 sec. and the aircraft would "stay in trim," Riccobono says.

The new cowlings have been designed to reduce the amount of turbulent air along the tail boom and to reduce drag by around 10% by sending air down underneath the tail boom.

Riccobono says the aim is to eliminate the need for endplates on the tail boom's horizontal stabilizer. Aerodynamic adjustments have also been made to the vertical stabilizer.

P3 will test these changes with a series of retrofits planned for the spring and summer during flight trials in Sicily, Italy.

Other changes in production models will see the SH09 adopt a Garmin-developed avionics suite, which the company says will pave the way for the aircraft to be certified for single-engine instrument flight rules (IFR) operations. Work on a new four-axis digital autopilot to support IFR flight is also underway.

Kopter continues to target certification in 2020, but rather than wait for European Union Aviation Safety Agency approvals and then validation by the FAA later, Kopter wants to try to secure a concurrent approval from both regulators. The company says the move reflects the importance of the U.S. market. Kopter has already secured more than 70 firm orders for the SH09 as well as 120 letters of intent (LOI) for the aircraft, Lowenstein says. About 70% of the LOI will likely convert into firm orders, he adds.

During Heli-Expo, an additional six firm orders were received from U.S. and Asian operators. Kopter officials say they are close to signing up a major fleet operator for the type, targeting a baseline aircraft price of $3.3 million at 2019-20 prices.

— With Guy Norris in Los Angeles

Improved Air Crane Could Fight Fires Autonomously

- ERICKSON WANTS MODERN FADEC-EQUIPPED ENGINES FOR S-64+
- AIR CRANE MATRIX DEMONSTRATION ENVISAGED FOR 2021

Tony Osborne Los Angeles

International demand for firefighting aircraft and the growth of complex urban engineering projects is prompting Erickson to make investments for the future of its distinctive Air Crane heavy-lift helicopter.

The Oregon-based company wants to transform the Sikorsky-designed machine's performance. The proposed S-64F+ Air Crane will be equipped with modernized engines, composite rotor blades and advanced avionics, including Sikorsky's Matrix autonomous technology, potentially enabling it to fly hazardous firefighting missions without endangering the crew.

ERICKSON

"We will build the world's most advanced heavy-lift and heavy aerial [fire]-attack platform," Erickson CEO Doug Kitani told journalists as he announced the launch of the program here at Heli-Expo 2020.

He said the work would draw on the company's now decadelong composite rotor blade program, which is nearing its conclusion, with the FAA expected to certify the blades in the coming months.

The first step in the modernization is a planned demonstration of the Matrix technology, in which the aircraft will likely perform an autonomous firefighting mission collecting water and dropping it on a fire in 2021.

"We are not talking about taking the crews out of the Air Crane but augmenting them, to enable them to take on these high workload-demanding missions and do it safely over and over," said Chris van Buiten, vice president of the Sikorsky Innovations research organization. Installation will be invasive: On top of the Matrix processing units, containing digital terrain and obstacle databases, the aircraft also will be fitted with lidar and cameras that will link to a fly-by-wire system with servos and clutches that drive the existing mechanical flight controls in response to commands from the management system.

"We are seeing fires intensifying. We need to be able to fight them at night and in reduced-visibility conditions," added Hayden Olson, general manager for Erickson Aerosystems. "No matter how old the asset is, we can continue to apply that technology and potentially make one of the best tools for that mission."

Along with the arrangement with Sikorsky, Erickson has selected Piasecki to act as a consultant to the S-64+ program, supporting the engine selection process to replace the 1950s-era 4,500-shp Pratt & Whitney JFTD12-4A (T73-P-1). Erickson wants a powerplant with full-authority digital engine control (FADEC) for the S-64F+. Options could include the Honeywell T55 engine from the Boeing CH-47 Chinook or the General Electric T64 from the Sikorsky CH-53 Stallion family. The company is still finalizing the specifications for the new composite blade, which has been in development since 2010, but flight trials have shown a 13% improvement in efficiency compared to the previous blade as well as reduced fuel burn of around 3-5%.

Other partners for the work will be announced in the coming months.

Erickson has owned the type certificate for the Sikorsky-designed S-64 Skycrane—known to the U.S. Army as the CH-54 Tarhe—since the early 1990s and today owns and operates 20 of the machines for the firefighting, precision construction and aerial lift missions. They regularly deploy worldwide during the fire seasons to both the Southern and Northern hemispheres. Six of the Erickson-owned machines helped fight the devastating forest fires in Australia.

Sikorsky's Matrix technology could allow the Air Crane to fly hazardous firefighting missions unmanned.

Other Air Cranes are owned by government forestry agencies in Italy and South Korea, and two additional aircraft were delivered to the latter in December.

New Air Cranes are being restored from existing airframe allocations using original Sikorsky data plates, but the aircraft are almost entirely built from scratch, rather like historic warbird restoration projects.

But with demand expected to grow in the coming years from sovereign customers, Erickson is gearing up to produce entirely new-build models. Kitani predicts a need for 50-100 additional S-64s in the coming years, on top of the 40-50 airframes currently in operation.

"We have seen in the firefighting mission that there is not enough aircraft to go around. . . . Where the operators used to go between the Northern and Southern hemispheres for firefighting season, that model is now breaking down," said Kitani. He believes this will be a prompt for nations to build up their own national fleets of firefighting aircraft, based in-country all year around.

The S-64F+ project comes less than three years after the company exited Chapter 11 bankruptcy protection, having struggled to make a profit since its takeover of Evergreen Helicopters in 2013. Kitani said the restructured company is now in much better shape to handle the investments required for the program. "We know existing customers want to expand their fleets, so we know the demand is there," said Kitani. He also cites the success of Erickson's new defense maintenance, repair and overhaul business for Marine Corps and Navy CH-53 Super Stallion and Sea Dragon helicopters, which will be a "key contributor" in helping to fund the S-64F+ project.

"We think we have a balance sheet and a business plan that will allow us to execute this," Kitani said.

Sikorsky Finalizes Upgrade Plans for the S-92

> S-92A+ AVAILABLE FROM 2023; S-92B SETS 2025 ENTRY INTO SERVICE

> MATRIX AUTONOMOUS TECH AND PHASE IV GEARBOX IN UPGRADE

Guy Norris Anaheim, California

As part of efforts to inject new life into the sluggish offshore rotary-wing market, Sikorsky is moving ahead with plans to offer a radically revamped version of its S-92 heavy-lift helicopter as well as a comprehensive upgrade package for the legacy model—which will share many of the new features.

The decision follows positive operator feedback to the plan, which was originally announced at 2019's HAI Heli-Expo in Atlanta. The upgrade is focused on boosting capability by adding initial elements of an increasingly automated cockpit, as well as improving reliability of the aircraft and reducing operating costs.

GUY NORRIS/AW&ST

The windows on the S-92B will be 20% larger, as demonstrated in this cabin mockup.

The program, which includes an S-92A+ upgrade kit for existing operators and a new set of improvements for a future S-92B model, is also designed to standardize the configuration across versions. The move will therefore enable faster reconfiguration between roles and increase commonality among the offshore, search-and-rescue and utility variants.

The S-92A+ upgrade kit, priced at $3 million, will be available from 2023, while the S-92B variant is targeted at entry into service in 2025 with an "indicative" price tag of $28.5 million, Sikorsky says. Baseline features of both developments include the recently tested Phase IV main gearbox—considered the top upgrade priority by all operators—as well as a package of weight reduction features and a higher maximum-gross-weight capability of 27,700 lb. (12,500 kg).

Audrey Brady, Sikorsky vice president of commercial systems and services, characterizes operator response to the upgrade and "B-variant" proposals over the past 10 months as: "You got it right, but when can we get it and for how much?"

The new gearbox will "actually eliminate two of the 'land immediately' flight manual requirements," Brady says. The revised gearbox design incorporates material changes to increase resistance to corrosion and fatigue. It also consists of an auxiliary lube system that includes a supplemental pump and extra lines to reuse oil that accumulates in the lower sump. Tests were conducted with the primary lubrication system deactivated and all lubrication provided only by the auxiliary system, which is integrated into the gearbox itself.

"We had our engineers testing to make sure it would surpass any requirements that would come out in the industry," Brady says. "Our tests showed the gearbox not only performed flawlessly, but—with only the auxiliary lube system—we ran it in our testbed for over 7 hr. At that point we decided to stop the test. Even with a full load, it would have run out of fuel by then." The graduation test of the new gearbox without primary lubrication simulated a 500-nm (575-mi.) flight at 80 kt. (92 mph).

The gears were "pristine" when torn down for inspection after the test, Brady says, who adds the Phase IV system has also completed more than 200 hr. of flight tests. The gear will also have an increased time between overhaul of up to 25% and, along with the rest of the A+ upgrade kit, will be certificated by the end of 2022 for availability the following year.

The S-92B will build on the baseline elements of the A+ kit with additional items including: global, real-time health and usage monitoring; advanced navigation; 20% larger cabin windows; titanium side frames; an improved cabin door; and a lightweight interior.

The upgrade also introduces the initial phase of Sikorsky's Matrix autonomous flight and landing technology, which—up until recently—has been tested only on a limited range of fixed- and rotary-wing platforms, including the company's Sikorsky Autonomy Research Aircraft S-76 and a Cessna Caravan. The system, which has been demonstrated under DARPA's Aircrew Labor In-crew Automation System program, is being tested on a UH-60A Black Hawk that is due to fly autonomously toward the end of the year.

Based on the Matrix foundation, the upgrade will also include the next iteration of the company's automated rig approach system as well as the Sikorsky Innovations Laboratory-developed SuperSearch search-and-rescue system that uses advanced algorithms to locate objects up to 30% faster. Rig Approach 2.0 will be able to operate the helicopter from takeoff until around 0.25 nm from an offshore rig, at which point the pilots assume command.

An uprated General Electric CT7-8A6 turboshaft will also be available as an option for both the A+ and the B versions.

Belgian Air Power Transformation Will Touch Nearly Every Fleet

- BELGIUM'S FIRST F-35s WILL ARRIVE IN 2023
- LUXEMBOURG'S ONLY A400M WILL BE CO-LOCATED WITH BELGIAN FLEET

Tony Osborne Brussels and Siauliai, Lithuania

By the end of the decade, Belgium likely will have completed an air force transformation that replaces almost every type in the inventory.

Along with new fighters in the form of the Lockheed Martin F-35, the Belgian Air Component will induct new airlifters, invest in and help generate a new European tanker capability, and introduce a modern unmanned surveillance capability.

It is a radical step for an air force traditionally cautious about introducing new technology.

"It is often better to learn from the first users," Col. Geert De Decker, Air Component chief of staff, told Aviation Week during an air force flight to Lithuania. "We do not have the luxury of the people or the money to go through the motions. We would rather wait a little longer and get the corrected and final version."

The approach goes some way toward explaining how Belgium ended up being the last of the Airbus A400M partner nations to receive the type, with the first expected to arrive later this year. The country was also the last of the four European Participating Air Forces that purchased F-16s during the late 1970s—with Denmark, the Netherlands and Norway—to select its replacement. Like the others, it opted for the F-35 (34 of them).

The F-35As will be Block 4, Technology Refresh 3-standard aircraft. The first aircraft will be delivered in 2023, and then more will arrive in batches of four in 2024-28 and in 2030. A batch of five will be delivered in 2029. The first aircraft will not be based in Belgium until 2025.

Belgium has chosen to split the fleet between two air bases, Florennes in Wallonia and Kleine Brogel in Flanders. Eight of the aircraft also will be stationed at Luke AFB, Arizona, until 2028.

Splitting the aircraft between the two Belgian bases will boost the operational resiliency of the fleet, noted De Decker. "In operations, you need a second base to divert to, so having this resilience and redundancy is operationally sound as well," he said.

The fleet will be the second-smallest in Europe, after Denmark's, which may indicate the air force must "adapt the level of ambition we have right now," De Decker said.

"With the numbers right now, we are falling short of the NATO targets we have," he said. "So we will have to see what we can do."

Belgium, like its neighbors in the Netherlands, has regularly punched above its weight in supporting NATO's overseas operations—with Belgian F-16s operating over Afghanistan, Libya, the Balkans and, most recently, in Iraq and Syria while also supporting air-policing missions such as Baltic Air Policing, which the air force is currently leading in Lithuania.

However, it has increasingly been able to share that burden with the Netherlands. The two nations already share the quick-reaction alert mission for national air policing. Every four months, they rotate policing the skies of both countries as well as those of Luxembourg. Agreements are in place that allow a Belgian aircraft to intervene in an incident over the Netherlands and vice versa. The two countries also share a deployment to Jordan in support of operations against the Islamic State group.

If the Netherlands sends fighters, Belgium provides the force protection, and vice versa.

The hope is that as each country introduces the F-35, the other will be able to fill in gaps, freeing up resources. "That is a work in progress," said De Decker. "But this is our way of working. With reduced numbers [of personnel] and budgets, we [European air forces] must learn and support each other; it is logical that we do that."

Belgium has already begun retiring its Lockheed C-130H Hercules fleet in favor of the Airbus A400M, the first of which will arrive during 2020.

Belgian exchange pilots are flying with the UK Royal Air Force to build experience on the A400M.

Brussels is purchasing seven A400Ms but will ultimately have access to eight airframes. Luxembourg's single A400M will be integrated into the Belgian fleet and based in Brussels, with Luxembourg providing additional pilots and ground personnel.

"We are looking forward to the A400M," said De Decker, "It is a modern aircraft with a lot of capabilities, and we are hopeful that reliability will increase by the time it arrives."

"We are doing great stuff with the C-130 [Hercules], but it is getting old, [and] the A400M is much more flexible," he added.

Another new capability being introduced is the General Atomics MQ-9B SkyGuardian medium-altitude, long-endurance UAV. The platform will replace Belgium's B-Hunter, a derivative of the Israel Aerospace Industries Hunter platform, which performs regular flights in Belgian airspace, albeit segregated from other users. With the MQ-9B fully certified, the air force is hopeful the aircraft can be operated in nonsegregated airspace. However, a capability gap is emerging between the B-Hunter withdrawal from service in 2021 and the MQ-9B's introduction in 2023, which De Decker is hoping can be addressed by sending Belgian personnel to be embedded in MQ-9 operations with France or the UK. Four MQ-9B airframes will be purchased, along with two ground control stations.

Belgium has also made investments in the Netherlands-led Multinational Multirole Tanker Transport Fleet (MMF). Purchasing 1,000 hr. a year has resulted in ordering an additional Airbus A330 tanker, bringing the fleet to eight aircraft. Buying into the scheme means the air force can now reduce its reliance on leased commercial aircraft for transport flights. Currently, the air force is leasing an Airbus A321 for its transport flights, and previously it used an A330-300. Both were leased from Portuguese operator Hi Fly.

The air force is in the process of retiring its fleet of Embraer ERJ 135 and 145 transports and will introduce Dassault Falcon 7X business jets for VIP duties.

Training is also being transformed. In January, the air force retired its last Dassault/Dornier Alpha Jet trainer, transitioning fast-jet training from Cazaux, France, to the Euro-NATO Joint Jet Pilot Training Program at Sheppard AFB, Texas. Training for multiengine types continues in France, at Avord, while helicopter training is also performed in France at Dax. The only air force flight training currently being performed in-country is the pilot screening process using the SIAI-Marchetti SF.260, one of the few types in the air force that is not being replaced—at least for now. A replacement program could emerge in the mid-2020s, De Decker has suggested.

The air force, like the rest of the Belgian Armed Forces, is also facing a complex recruitment challenge, exacerbated by aging personnel. Reports in the Belgian media last year suggested that the Belgian Armed Forces needed to recruit around 13,000 personnel in just four years to make up for an expected 11,000 personnel expected to retire by 2024. Cuts in the defense budget, working conditions, pay and competition from the private sector have all contributed to the recruitment challenge.

"We are still filling pilot slots," said De Decker. "Today, we might have five candidates for one slot; previously we would have had 35." Instead the "main choke points" are in technical staff and air traffic controllers, he adds.

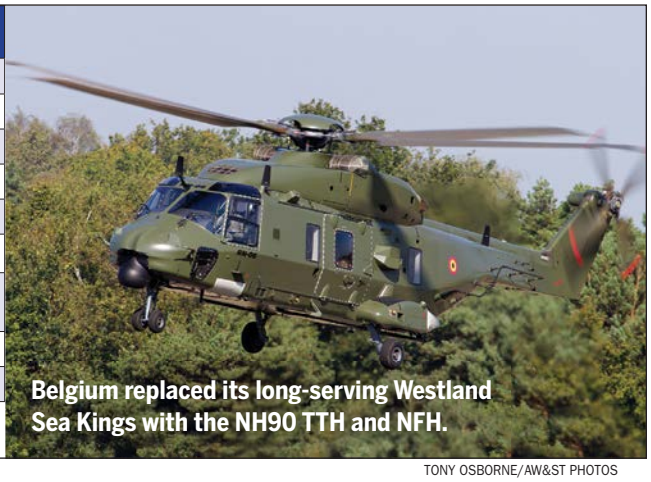
There is a hope that the new investments and technology being introduced will attract a new generation of recruits. De Decker said the introduction of types such as the F-35 will have a transformative effect not only on the air force but also on the other armed services as well.

"We need to create awareness in our defense forces," he said. "Platforms like the F-35 are a unique tool that can be used by all of the armed forces."

Belgian Air Force Inventory Transformation

Type	Replacement	First Delivery
Westland Sea King	NHI NH90 TTH/NFH	2015
Airbus A321	Airbus A330 MRTT	2020*
Embraer 135/145	Dassault Falcon 7X	2020
Lockheed C-130 Hercules	Airbus A400M	2020
General Dynamics F-16	Lockheed Martin F-35A	2023
IAI B-Hunter UAV	General Atomics MQ-9B SkyGuardian	2023
Agusta A109BA	TBD	TBD
SIAI-Marchetti SF.260	TBD	TBD

*Shared with the Czech Republic, Germany, Luxembourg, the Netherlands and Norway
Source: Belgian Air Force



Belgium replaced its long-serving Westland Sea Kings with the NH90 TTH and NFH.

TONY OSBORNE/AW&ST PHOTOS

SPACE

Commercial Space and Airlines Debate Spaceport Needs

> SPACEPORTS ENDORSED AT FAA CONFERENCE

> GEORGIA COUNTY REVISES LICENSE APPLICATION

Bill Carey Washington

How many commercial spaceports are needed in the U.S. to support what eventually could be a trillion-dollar global space economy, and how many are too many?

During the recent FAA Commercial Space Transportation Conference, spaceport operators were asked how they would respond to critics who say there are too many spaceports already, or not enough launch activity to justify the facilities that have been established.

Despite concerns over safety and air traffic conflicts raised by the aviation industry as well as cases of public opposition, the consensus among operators speaking Jan. 30 was that more spaceports will be needed to meet future launch demand.

"The key for moving spaceports forward is developing a robust network of spaceports across the nation," said Mark Lester, president and CEO of state-owned Alaska Aerospace, which operates the Pacific Spaceport Complex-Alaska on Kodiak Island. "There [are] only 11 licensed spaceports right now; only four [have] vertical/orbital [launch] capabilities. That's just not going to be enough, not for assured access to space."

The growing launch demand for communications, Earth observation and other satellites, the emerging space tourism industry and future point-to-point suborbital transporta-

tion will require spaceports with differing facilities in geographic locations other than coastal sites, operators said.

"To say there are too many implies that they are all doing the same thing, that somehow they have the same features. But they don't," said Scott McLaughlin, director of business development for Spaceport America in southern New Mexico.

"They are in different locations, they have different weather, some of them launch over water, some are over land," McLaughlin added. "The question is—what do we need to move the industry forward? We basically need those spaceports."

media reports that characterized the revision of Camden County's application as a setback."

Correspondence from the manager of the FAA's licensing and evaluation division, released due to a Freedom of Information Act filing, revealed concern that a launch accident could cause an uncontrollable fire on the connected Little or Big Cumberland Islands, which fall within an overflight exclusion zone of the spaceport. The founders of Protect Cumberland Island, an organization that opposes the facility, provided the correspondence to Aviation Week.

Launch safety is a major concern

Major Airline Flight Corridors Near Spaceports

Source: Congressional Research Service

The 11 FAA-licensed spaceports, representing about half of the overall commercial, federal government, university and private launch sites in the U.S., are located in eight states. Additional commercial sites have been proposed in Florida, Georgia, Hawaii, Texas and Michigan, according to the Congressional Research Service (CRS).

The FAA was due to issue a decision on a commercial space launch site proposed by Camden County, Georgia, in mid-December. But two days before the end of a 180-day statutory review period, the county asked the agency to "toll" or pause its evaluation and accept a revised application.

Explaining its decision, the county said it decided to refocus the operator's license application on small rockets with no first-stage return component because that is what the market demands. It described the public statement as a response to "recent

of airlines; air traffic disruption is another issue. SpaceX's historic Falcon Heavy test launch from Kennedy Space Center, Florida, on Feb. 6, 2018, closed 1,000 mi. of airspace for 3 hr., resulting in 563 flight delays and 34,000 additional miles flown by airliners, according to the CRS.

A friendly argument waged by panelists at the FAA conference, which was cohosted by the Commercial Spaceflight Federation, revealed ongoing tension between the airline and commercial space industries as the pace of launches increases.

"We're talking [about] spaceports within 5 mi. of a metropolitan area right now," said Steve Jangelis, a Delta Air Lines captain who serves as aviation safety chairman of the Air Line Pilots Association. "Eventually this will be the future."

In 2018, the pilots' union opposed establishing the Colorado Air and Space Port at the former Front Range Airport in Watkins, Colorado, which is located within miles of Denver International Airport.

"We've been insulated because we've been launching from protected areas," Jangelis argued. "We have to start looking at when we start launching from the middle of the lower 48 states, when we start launching directly across populated areas. We are going to press the FAA to make sure that it's safe. We're going to lobby hard for that."

SpaceX Senior Counsel Caryn Schenewerk countered that the commercial space industry, with 40-50 launches projected by the FAA this year, is relatively young and still working toward the safety and reliability levels of an aviation industry that conducts 16.1 million flights a year.

"Let's not yell at our kid for not being able to fly an airplane when they can barely walk," Schenewerk said.

Air traffic disruption caused by commercial space launch windows is a major concern of the airline industry.

"We're still figuring out how to walk and run in this industry. . . . Please, take a breath, make sure you understand where we are today, that we are absolutely in line with getting to a level of safety that is commensurate with yours."

While only a handful of the current commercial sites are very active, proponents believe spaceports represent an economic boon.

The New Mexico Spaceport Authority on Jan. 30 released an economic impact analysis of the state-owned Spaceport America complex. While the authority's expenditures of $270.3 million in fiscal 2008-18 exceeded the venture's revenues of $239.5 million, the report found that the state's investment in the facility has already paid off by creating new economic opportunities.

"A narrow view of the New Mexico Spaceport Authority might consider only if the cumulative private sector revenues received by the agency exceed the expenditures made to create Spaceport America," states the analysis by accounting firm Moss Adams. "This perspective ignores the private sector jobs and business activities that are facilitated by those investments of the state's resources."

Europe Outlines Plans for Reusable Launcher Demonstrators

CNES/BLACKBEAR

The Prometheus engine, a key technology brick in ESA's reusable launcher demonstration program, will undergo its first firing test in 2021.

> FRANCE'S CNES SPURS EUROPEAN SPACE AGENCY'S EFFORT

> FULL-SCALE DEMONSTRATION PLANNED FOR 2023-24

Thierry Dubois Lyon

The Themis demonstration program for a future reusable launcher garnered relatively modest funding at the European Space Agency's (ESA) ministerial council last November, but it may be a seed for a turnaround in the continent's space industry.

The in-service Ariane 5 and in-development Ariane 6, which caught most of the attention and budget in ESA's council decisions, belong to the expendable category. Senior executives at French space agency CNES would rather bet on reusable technologies for Ariane 6's successor, especially given strong competition from SpaceX. They have once again managed to morph a French-devised demonstration program into an ESA one. As a result, ESA has embarked on in a long-term effort toward the design of a reusable heavy launcher.

France has a road map for a reusable launcher for 2028-30 and hopes to bring ESA on board. "We want to be ready to launch a full development program early in 2025," says Jean-Marc Astorg, CNES' director of launchers.

To begin the technology acquisition process, four demonstrators are expected to bring reusable launcher technology to maturity.

The first program was created by CNES and ArianeGroup without another ESA member state, and the Promethee engine demonstrator was launched in 2015. It was "Europeanized" at an ESA ministerial council in 2016 and renamed Prometheus. It targets both lower production costs and reusability.

The key is throttleability. Compared to liftoff, landing with almost empty tanks requires a lower, variable thrust of 30-100% of the maximum thrust, Astorg explains. Existing European engines are not throttleable.

The 2019 ministerial council in Seville, Spain, decided to fund the liquid-oxygen/methane Prometheus program until engine qualification and deliveries for the Themis reusable first-stage demonstration program are fulfilled.

Prometheus' first firing test has been postponed to 2021. It will take place at German aerospace research center DLR's test facility in Lampoldshausen, which will be busy with Ariane 6 development until then.

The second demonstrator is the Frog minivehicle, which integrates several crucial technologies for a reusable stage. It uses a small turbofan, a Galileo receiver and an inertial measurement unit. "We are evaluating the algorithms needed to navigate back to a launchpad—including flight control, reignition and attitude control," Astorg says. Frog is now undergoing tethered trials in Bretigny, a commune just south of Paris.

The third demonstrator, now on the drawing board, is the Callisto small-scale first stage. Measuring 13 m (43 ft.) in height and 1.1 m in diameter, it will use 3.6 metric tons (7,900 lb.) of liquid oxygen and hydrogen. Callisto is a joint endeavor by CNES, DLR and the Japan Aerospace Exploration Agency (JAXA).

JAXA is contributing a throttleable engine, modified from an engine used for demonstrations in the 1990s. The 2020s version will be lighter and more powerful, Astorg says. JAXA's participation is critical, as Prometheus will not be ready in time.

Callisto's first launch is scheduled for 2022 from Europe's spaceport in Kourou, French Guiana. A speed of Mach 1.7 and an altitude of 40 km (130,000 ft.) are targeted. To test the reusability process, 10 flights are planned over a six-month period.

CNES has allotted €75 million ($82 million) for the program, while JAXA and DLR are expected to confirm their contributions in March.

The fourth demonstrator, Themis, will be a full-scale, reusable first stage. Spurred by CNES, some other ESA member states have subscribed to the program. The first ground demonstrator, Themis 1G, is now a €36 million ESA project (the amount does not include the Prometheus engines).

The prime contractor is ArianeWorks, which will see the company payroll grow to about 30 from 14. CNES and ArianeGroup created ArianeWorks last year as an "acceleration platform" for the preparation of future launchers. Other organizations have joined ArianeWorks such as French aerospace lab ONERA and propellant supplier Air Liquide. Designing Themis is the first mission for the joint team.

Themis 1G will be evaluated at ArianeGroup's Vernon facility, a commune roughly 45 mi. west of Paris. It will use one Prometheus engine. Themis 1F will also use a single engine but will fly from Kiruna, Sweden, at low altitude (1-2 km).

The complete Themis 3F, with three Prometheus engines, is slated to launch from Kourou in 2023-24. While Callisto's schedule has slipped, Themis' timeline appears increasingly aggressive, as Astorg used to refer to 2025.

Funding has yet to be obtained for Themis 1F and 3F.

ESA Struggling With ExoMars 2020 Schedule

> MULTIPLE ISSUES NEED TO BE RESOLVED OVER THE NEXT THREE MONTHS

> EUROPEAN AND RUSSIAN COMPANIES ARE HONING THEIR SPACE-VEHICLE SKILLS

Thierry Dubois Lyon, France

The European Space Agency (ESA) and the ExoMars 2020 exobiology mission's contractors are working flat out to catch up on delays and meet the planned launch window this summer.

If the window is missed and the launch postponed two years, the instruments that will eventually land on Mars will still enable significant scientific progress. Meanwhile, for the European and Russian space industries, the program entails moving up into more complex vehicle designs.

The descent module's (DM) parachutes have caused engineers headaches, but recent testing has been encouraging. ExoMars 2020 uses a two-parachute system, each with its own pilot chute for extraction. The first main parachute will be deployed while the DM is still traveling at supersonic speed.

Trials last year showed an anomaly in deployment. Both canopies were damaged, and the investigation showed the problem came from the bags. They now open like petals, explains Francois Spoto, ESA's ExoMars 2020 project manager, thus avoiding frictional damage.

Six high-speed extraction tests on the ground have been successful since October, when ESA began using NASA's Jet Propulsion Laboratory-Caltech facilities.

Next in line are two high-altitude drop tests planned for March in Oregon. In case of failure, an extensive redesign will be needed and will entail rescheduling the launch. The project's "qualification and acceptance review" is planned for the end of April.

The launch window for a 2021 arrival on Mars opens July 26 and closes Aug. 11; the next one is in August 2022.

Additional challenges for the mission emerged when it became apparent Russian prime contractor Lavochkin was late. The company delivered DM equipment in May 2019 instead of September 2018. Moreover, propulsion system testing has been delayed to February, which in case of failure, rules out the possibility of a redesign in time. Cracks in the DM's front shield had to be repaired repeatedly

Since the late Lavochkin delivery in May, Thales Alenia Space's engineers in Turin, Italy, have worked three shifts, seven days a week. The company is trying to recreate a 60-day schedule margin, says Spoto. A second avionics bench was installed to work in parallel with the original one.

The Rosalind Franklin rover, under Airbus' responsibility, is about to complete environmental trials in Toulouse.

Delivery to Thales Alenia Space is planned for Feb. 7 in Cannes, in southeast France, where it will be integrated with other modules for further tests.

There, Thales Alenia Space has already completed integration of the DM, designed by Lavochkin. It includes the landing platform, where the rover is to be fitted. The spacecraft also comprises a carrier module, supplied by OHB.

M. ALEXANDER/AIRBUS

The Rosalind Franklin rover features advanced sample-analysis capability.

Central to the rover's role is the drill, which Leonardo has designed to collect 6-ft.-deep soil samples. The onboard Analytical Laboratory Drawer (ALD) uses a carousel to distribute pulverized material to nine instruments, such as a mass spectrometer, Spoto explains. On-site analysis of deep samples in a search for organic compounds is what makes ExoMars 2020 special.

"Mars used to have a denser atmosphere, water on the surface and temperatures closer to those we find on Earth," says Spoto. As radiation has deleted potential signs of past life from the surface, the sampling depth may be key. The landing site in the Oxia Planum region is made of ancient alluvia—the kind of environment where fossils are found on Earth.

ExoMars 2020 is honing European and Russian skills. Rosalind Franklin is Europe's first planetary rover, the parachute system is the most complex designed for an ESA mission, and the ALD marks the first time European companies have created such a complex autonomous device.

For NASA's Mars Sample Return mission, ESA will contribute the Sample Fetch Rover, which will draw from ExoMars 2020, says Spoto.

ESA has learned 17 lessons from the crash of the Schiaparelli landing module in 2016, says Spoto. "The failure came from an incompatibility between the flight software and the U.S.-supplied inertial measurement unit (IMU); this time, we are using a European IMU qualified for [the] extreme mechanical environment that could result from parachute deployment."

Since its 2016 inception, the Trace Gas Orbiter (the second part of the mission) has looked for methane as a potential sign of life. It will act as a communications relay for the rover.

ESA's budget for the combined 2016 and 2020 missions stands at €1.7 billion ($1.9 billion). The Russian contribution comes in kind, as opposed to in funding. The joint ESA-Roscosmos effort hinges on a launch on a Proton-M rocket from Baikonur, Kazakhstan.

Sophisticated Clientele Drive Changes in Space-based Sensing

> FINLAND'S ICEYE LAUNCHES FIRST SERVICE

> AMERICA'S CAPELLA SPACE UNVEILS NEW SATELLITE

Steve Trimble Washington

A recent series of moves by space-based providers of synthetic aperture radar (SAR) imagery and mapping of radio frequency (RF) emissions highlights the increasing technical sophistication required to compete in one of the most challenging segments of the New Space market.

During a span of four days in late January, Finland's Iceye released a Dark Vessel Detection service for maritime security agencies, California-based Capella Space unveiled a powerful new SAR satellite, and Virginia-based Hawkeye 360 announced a partnership to fuse its RF mapping data with Airbus' SAR and optical imagery products.

The Sequoia, Capella Space's new satellite with an 8-ft.-dia. synthetic aperture radar array, is scheduled for launch in March.

CAPELLA SPACE

By emphasizing simpler—or more cost-effective—rockets and micro-sized satellites, many companies in the New Space market seek to attract the broadest possible customer base by offering dramatically lower prices for imagery and other satellite-derived products. But the recent moves in the nonoptical vertical of the New Space market show that SAR images and maps of RF emissions still rely on the most sophisticated customers.

"The commercial market is truly very difficult to capture right now," says Rafal Modrzewski, Iceye's CEO. "I do believe that the [commercial] market is there long-term. And you know we are here with that mission. But the company has to generate revenue. And we recognize that revenue can, in the short term at least, be generated almost uniquely from governmental markets."

Iceye's new service, developed with data supplied from the company's first two, 85-kg-class (185-lb.) SAR satellites in orbit, reflects the interest of the unique customer base. By overlaying SAR imagery on automatic identification system data, Iceye can identify vessels seeking to hide from coast guards and fishery patrols by turning off their transponders.

The company launched the service in January with two government agencies as the first customers. Although Iceye was founded in Europe, Modrzewski confirms the company's business model assumes about half of the market for SAR imagery is U.S.-based. To help break into the U.S. military and government market, Iceye has partnered with a Michigan-based startup called R2 Space, which plans to pair Iceye-designed satellites with an internally developed T-Link communication system for transmitting images to dedicated ground stations.

Until a month ago, Iceye's approach to satellite design stood out from its closest competitor—Capella Space. The latter entered the market in 2018 by launching the 50-kg-class Denali SAR satellite into orbit. Once the Denali satellite started generating images, the company quickly realized that a military customer base for SAR images demanded a more powerful sensor and more sophisticated control system.

For several months, Capella secretly developed a new, 100-kg-class satellite called Sequoia, which was unveiled on Jan. 21 with a scheduled launch date in late March.

"We realized that the market needs were becoming increasingly sophisticated and had evolved," the company said in a blog post. "With that, we must evolve our technology as well."

In addition to launching a new satellite design, Capella also automated the ground-based operating system for the constellation, allowing delivery of requested SAR imagery in less than 90 min.

"This is leapfrogging the entire industry and brings SAR imaging from space into a completely new era," Capella's blog post stated.

Remote sensing is seldom limited to a single phenomenology. For decades, military operators have operated satellites in multispectrum clusters, with SAR, electro-optical and RF receiver payloads orbiting in combination. A detection by the RF receiver prompts a cross-check by the optical or SAR satellite. Many New Space startups are still too small to develop a family of sensing satellites, so they have looked to develop virtual cluster networks through partnerships.

In the most significant such combination so far, RF sensing specialist Hawkeye 360 announced a partnership with Airbus on Jan. 20. The agreement allows Hawkeye customers to cross-check RF sensor data with Airbus' deployed constellation of larger SAR and optical satellites.

RESHAPING THE FUTURE

> HIGHER-SPEED NARROWBODY DESIGN ACHIEVES PREDICTED PERFORMANCE AT MACH 0.80

> HIGH-LIFT SYSTEM MEETS EXPECTATIONS FOLLOWING REFINEMENT IN TUNNEL

Graham Warwick NASA Langley Research Center, Virginia, and **Guy Norris** Orlando, Florida

ONE IN A SERIES

As aircraft developers explore unconventional configurations in search of higher efficiency and lower emissions, wind tunnel testing is playing a key role, providing data to validate modeling and fill gaps in understanding.

NASA and Boeing have now completed five wind tunnel campaigns with one ultraefficient aircraft concept, the Transonic Truss-Braced Wing (TTBW). In high- and low-speed testing in 2019, the design—with its low-drag, high-aspect-ratio wing—continued to show promise as a future 737-class airliner.

With a 170-ft.-span wing, which folds to fit airport gates, the TTBW concept was originally developed for NASA in 2010 under Boeing's Subsonic Ultra Green Aircraft Research (SUGAR) program to study new configurations for ultraefficient aircraft that could enter service in the 2030-35 time frame.

Under the fourth and most recent phase of the SUGAR program, Boeing tested both a revised TTBW design with a higher cruise speed and a high-lift system for the aircraft's slender wing, which is braced by trusses to minimize the weight penalty of its long span.

Thanks to the lower induced drag of the wing, which has an aspect ratio twice that of the 737-800, the company estimates the TTBW will have a 9% fuel-burn advantage over an equivalent-technology conventional cantilever-wing airliner on ranges up to 3,500 nm.

The truss-braced wing has a long heritage. French aircraft manufacturer Hurel-Dubois developed a series of designs in the early 1950s, and a handful of propeller-powered HD.34s, with an aspect ratio of 20:5, were produced as survey aircraft. But the idea languished until the early 2000s.

A detailed 8%-scale low-speed model was used to test the TTBW's high-lift system.

NASA and a Boeing-led team revived the concept, taking on the challenge of applying it to an advanced transonic airliner. The TTBW concept produced in 2010 was designed to cruise at Mach 0.745, slower than a 737, to reduce fuel consumption.

In 2013, a dynamically scaled half-span model of the TTBW was tested in the Transonic Dynamics Tunnel at NASA Langley Research Center. Evaluating aeroelastic behavior, this test confirmed that the structural weight penalty incurred to prevent flutter of the long, thin wing would still result in a feasible design.

High-speed tests followed in 2016 and 2018, in the 11-ft. Transonic Wind Tunnel at NASA Ames Research Center. These were focused on evaluating the wave-drag increment from interference of the truss with the

LOGO CREDITS: ARTHOBBIT/UDEFINED UNDEFIND/WASTESOUL/MARYLOO-GETTY IMAGES

NASA

wing at the Mach 0.745 design cruise speed, and they concluded the penalty was manageable.

Under SUGAR Phase 4, which began in 2017, Boeing revised the design to the Mach 0.80 cruise speed typical of today's narrowbody airliners. Wing sweep was increased and thickness modified and, to rebalance the aircraft's center of gravity, the wing root was moved forward and the strut root moved aft.

This resulted in "unstacking" of the wing and strut, with the inboard strut no longer directly underneath the wing. In addition to reducing aerodynamic interaction between the surfaces, testing at Mach 0.80 in the Ames transonic tunnel in July-August 2019 showed the change brought other benefits.

The unstacked geometry reduces compressibility drag by improving vehicle cross-section area distribution. The wing acts as a flow straightener, avoiding the need for stall protection on the inboard strut during high-lift operations. And streamwise separation of the wing-body and strut-body attachment points increases structural strength.

"The big carrot here is a dramatic increase in wing aspect ratio, which gives us a significant decrease in induced drag," says Neal Harrison, Boeing TTBW program manager. "We get efficiency from the strut-braced configuration itself, including a significant decrease in wing bending moment, which in turns leads to the potential for simplified structural attachments such as hinge joints for wing attachments."

Moving it out from under the wing allows the strut itself to carry lift loads and contribute to the aircraft's aerodynamic performance. "By unstacking, we wanted to know if we could make the strut a positive contributor to lift rather than being a parasitic structural element that just creates drag. In the end, we got significantly more lift off the strut," Harrison told the American Institute of Aeronautics and Astronautics SciTech conference in Orlando in January.

While the TTBW concept shows "potential for significant performance improvements, there is no free lunch," he says. "A lot of technology has to be demonstrated and matured, including the wing-strut join. This is dimensionally a small wingbox, and when you add the aerodynamics and structure together, you get these nonlinear aeroelastic characteristics. There are also other challenges such as certification for icing, ditching, crashworthiness and so on."

Another design change was to move the jury strut between the main strut and wing farther outboard. This allowed the outermost section of the main strut to be thinned down where it meets the wing, reducing transonic interference drag. This also raised the strength required inboard where strut thickness and chord were increased, which boosted the lift generated by the strut. "Fortunately, that also ended up being beneficial aerodynamically," he says.

High-speed testing at Ames, which used a 4.5%-scale model, assessed vehicle lift and drag, longitudinal and directional stability, and included a preliminary assessment of flight control effectiveness. A lift-to-drag ratio of 23:1 was measured at Mach 0.80, compared with around 18 for a conventional aircraft. "The measurements were within a couple of drag counts, so we are pretty pleased with that," says Harrison. "It gives us confidence the vehicle is performing as we expected transonically."

Low-speed runs in the 14 X 22-ft. Subsonic Tunnel at Langley in September-November 2019, meanwhile, marked the first high-fidelity test of a high-lift system for the TTBW. "With such a high aspect ratio, and more span to work with, there is a lot more real estate for high-lift devices," says Greg Gatlin, NASA Langley aerospace research engineer. But the long span also drove the scale of the model down to 8%, to fit in the tunnel. "The parts were so much smaller," he says, which made refining the complex high-lift geometry a challenge.

"We looked at various fixed- and variable-camber Krueger leading edges as well as a conventional slat, drooped leading edges and morphing leading edges," says Harrison. Ultimately, a full-span, variable-camber Krueger was selected to maintain compatibility with laminar flow, as a Kreuger can protect the leading edge from contamination during low-speed operations. A single-segment slotted flap was chosen for the trailing edge, plus spoilers that could be drooped and a simple flap on the strut at its root.

The leading-edge Kreuger had to be divided into nine spanwise segments to provide sufficient protection of the outboard wing, with a significant differential deflection angle from the innermost to the outermost of the outer five segments to maintain acceptable stall behavior. "On the inboard wing, we did a pretty good job, but on the outboard wing we ended up with differential rigging on the Krueger, which deflects as you go further outboard to keep that surface [flow] attached," says Harrison.

In general, the performance of the high-lift system met expectations, with stall angles and maximum lift levels in the landing configuration consistent with computational fluid dynamic (CFD) predictions. But the limitations of CFD tools in predicting high-lift performance with separated flow meant the final rigging of the Kreuger leading edge, particularly outboard, required refinement in the wind tunnel.

"We had hoped for fewer segments, but had to break it up," Gatlin says of the high-lift leading edge. The result was many small model parts, brackets, shims and spacers that had to be painstakingly removed, replaced and cataloged to investigate different combinations of deflection angles, gaps and overhangs.

"We started outboard, positioning them to optimize wing loading, then moved inboard. It was an iterative process as they influence each other," he says. "Alignment was critical when we took things apart and put them back together. There was lots of stuff in a small space."

Different axial and radial locations for strakes inboard on the engine nacelles were also evaluated. Common on nacelles today, these generate vortices that favorably interact with flow over the wing but were shown to be relatively ineffective in this configuration. One potential future advantage of the TTBW would be the ability to accommodate larger, higher-bypass engines under the high wing.

The 14-ft.-span model was mounted on an oblique ventral sting to minimize the support's interference with the wing, strut and empennage. The design of the mount enabled the TTBW model to remain in the center of the 14 X 22-ft. tunnel as angles of attack and sideslip were varied between runs.

NASA and Boeing had planned to switch the sting to a dorsal mount to

allow testing in ground effect with the landing gear attached, but they ran out of time because of the work required to refine the high-lift system. The dorsal mount could be used for potential future acoustic testing of the TTBW.

Overall, results from the two wind tunnel campaigns in 2019 showed "we have beneficial changes from going to a higher sweep angle and that the design is well-suited to efficient operations . . . [while] the low-speed performance is in line with expectations," says Harrison.

NASA

A 4.5%-scale model evaluated transonic performance of the redesigned wing and strut.

Phase 4, due to wrap up in March, also has included analysis of the aeroelastic behavior of the latest configuration with its changes to wing sweep as well as the position and shape of the main and jury struts. Structural analysis indicated total weight for the higher-sweep wing is within 100 lb. of that of the Mach 0.745 design. "On the structures side, the results of our aeroelastic analysis indicate we need to go to a higher-fidelity tool. But overall the results suggest it is feasible," he says.

Future work, under a fifth SUGAR phase expected to be agreed with NASA in the second quarter, will focus on further maturing the TTBW concept and reducing risk. Key areas of investigation will include: high-speed buffet, alternate high-lift system development, transonic tests at higher Reynolds numbers, aeroelastic analysis, detailed structural design of the wing and strut, and acoustic assessment.

Certification challenges such as bird-strike tolerance, crashworthiness, ditching characteristics and icing effects such as accretion and protection are also to be investigated. Wind tunnel testing with ice shapes to determine the impact on aerodynamics was planned for Phase 4, but time ran out, says Gatlin.

Beyond the SUGAR effort, the TTBW is acting as a "technology collector" for other potential advances. These include NASA-funded studies of a slotted natural laminar flow (SNLF) airfoil for the wing and a hybrid-electric configuration developed by Boeing with Rolls-Royce LibertyWorks and Georgia Tech.

The original TTBW designed under SUGAR Phase 1 was intended to have drag-reducing laminar flow on the wing, strut and nacelle. But the extent to which natural laminar flow can be maintained over the chord of an airfoil is limited by the need to recover to freestream pressure at the trailing edge.

In an SNLF airfoil, a slot running from the lower surface to the upper surface divides the airfoil into two elements. A favorable pressure gradient can be achieved over almost all of the forward element and most of the aft element, maintaining laminar flow over all but about 15% of the surface.

Passive and mechanically simple compared with active laminar flow control, an SNLF airfoil is being developed for the TTBW under NASA's University Leadership Initiative, by an academia/industry team of researchers led by the University of Tennessee. A 12.5% improvement in aerodynamic efficiency over the baseline fully turbulent wing is predicted, with wind tunnel tests on the TTBW planned for 2022.

Boeing looked at a range of electric propulsion options for the TTBW under Phase 1, with the SUGAR Volt concept, and again under Phase 2, with the SUGAR Freeze concept. The latter was aimed at entry into service in the 2040 time frame and used liquid natural gas as the energy source.

Subsequently, a series/parallel partial hybrid architecture for the TTBW was evaluated in more detail under NASA's Hybrid Gas-Electric Propulsion project. This uses motor/generators mounted on the underwing turbofans to produce electricity to drive a boundary-layer-ingestion fan in the tail.

The fan ingests and reenergizes the fuselage boundary layer to reduce cruise drag, while batteries are used to boost power in the climb. This allows smaller turbofans that operate closer to maximum power in cruise, improving efficiency. Boeing projects a 4.5% fuel-burn saving over a 3,500-nm mission.

The electrified propulsion study noted that "aggressive" investment in technology development would be required to meet a "challenging" 2035 service-entry target. But putting aside hybrid drivetrains or advanced airfoils for now, the latest wind tunnel tests show the TTBW continues to hold promise as a possible successor to today's narrowbodies, with growth potential that stretches well into the future.

Gallery *See a timeline in photographs of the truss-braced wing:* **AviationWeek.com/TBWTimeline**

FleetDiscovery

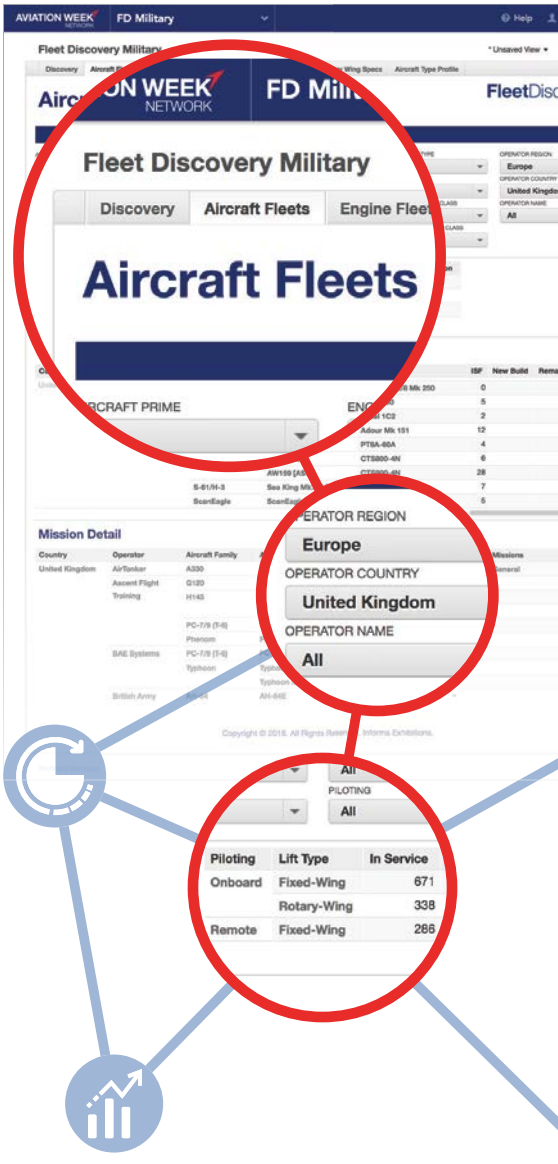
Fleet Discovery Military

Discover Opportunity with Unparalleled Tracking of Global Military Fleets

Aviation Week Network's Fleet Discovery Military Edition simplifies tracking global military aircraft and engines — piloted and unpiloted, fixed wing and rotary — so you can discover new opportunities to grow your business.

- **Featuring over 70,000 aircraft and 110,000 engines** in service with more than 400 military operators.
- **Searchable and filterable by** aircraft, engine, category, mission, lift type, weight class and more.

See for yourself how Fleet Discovery Military can help you track aircraft and engines so you never miss a business opportunity.



To learn more, go to aviationweek.com/FDMilitary

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

AVIATION WEEK NETWORK

Wuhan Virus Devastates Chinese Commercial Aviation

> THE COUNTRY'S INDUSTRY AND ROLE IN THE GLOBAL ECONOMY ARE FAR BIGGER THAN DURING THE 2003 SARS OUTBREAK

> ASIA-PACIFIC CARRIERS ARE HEAVILY EXPOSED TO TRAVEL SLUMP

Bradley Perrett **Sydney** and Adrian Schofield **Auckland**

The figures for airlines based outside of mainland China sound bad enough: On Feb. 5, they canceled 506 of their 1,145 scheduled flights to and from China. Yet this was nothing compared with the catastrophe that has overtaken airlines within the country as it struggles to contain the coronavirus that originated in Wuhan.

The mainland Chinese air transport industry, the world's second-largest, has halted fully 70% of its operations, canceling 11,642 flights on Feb. 5 alone. Three small airlines have suspended flying altogether. The outlook for international demand is so bleak that the Civil Aviation Administration of China (CAAC) has had to direct airlines not to cut services to the extent that air links with any foreign country now served would be severed.

Airlines elsewhere in the Asia-Pacific region are the next most affected by the coronavirus outbreak. Being closer to China and with economies having stronger links to it, they rely more on the Chinese market than do carriers elsewhere. Most major Asia-Pacific airlines have drastically cut back their Chinese flights or stopped them completely. Governments in the region have taken unusual steps to limit air traffic, with several—including Singapore, the Philippines, Australia, Vietnam and Indonesia—not accepting mainland Chinese passengers or foreigners who have been in the country within 14 days of arrival.

"With the larger number of carriers now flying to and from China, the level of competition is accordingly very much greater" than during the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003, says the Aviation Week Network's CAPA – Centre for Aviation. "One implication of that is that once the virus is brought under control, encouraging travelers back into the market will involve significant discounting, at least for a period of weeks," CAPA states. "As a result, the airlines involved are likely to experience prolonged financial damage."

At this early stage, there can be no precision in the outlook, since it depends on the success of disease containment, which authorities are unwilling to predict. For commercial aviation, the deep worry is that the virus may keep spreading, leading in other countries to the avoidance of travel that has occurred in China. If so, what is happening to the industry there is a harbinger for the rest.

Daily reports by Chinese consultancy Variflight track the industry's descent. On Feb. 1, mainland Chinese carriers operated 7,673 flights, just 45% of their schedule; four days later, they were down to 4,931 flights, 30% of their schedule. Genghis Khan Airlines and HNA Group's Grand China Air and Fuzhou Airlines have all of their aircraft on the ground. Okay Airlines and Jiangxi Airlines are operating at less than 10% of their schedules, while Air Travel, Guilin Airlines, Hainan Airlines, Jiangxi Airlines, Kunming Airlines, Shenzhen Airlines, Tianjin Airlines and Tibet Airlines are below 20%.

The central government's big carriers—Air China, China Eastern Airlines and China Southern Airlines—are operating at about the industry average. Foreign pilots in China are being told to take leave without pay. One source says the pilots want to leave China anyway, as so many foreigners in the country already have, and that carriers do not intend to cancel the employment contracts.

The Wuhan virus outbreak is more significant to global commercial aviation than the SARS epidemic was, simply because the Chinese industry is now so much larger. It had about 700 aircraft in 2003; now it has almost 4,000. China has become a larger part of the world economy since then, too.

Meanwhile, Chinese tourists, far richer than 17 years ago, have become common sights in Europe, North America and especially Asia. For foreign airlines, having a strong China network has become a way to boost the competitiveness of a connecting hub. Malaysia Airlines, for example, focused on increasing its flights to China as one of the key parts of a turnaround plan.

In addition to all that, the Wuhan virus is more contagious than SARS, prompting swift and decisive action

Chinese commercial aircraft are mostly idle. Xiamen Airlines canceled 77% of its flights on Feb. 4.

XIAMEN AIRLINES

AVIATION WEEK

Laureates

MARCH 12, 2020
Washington, DC

Celebrate the year's most outstanding contributors to aviation, aerospace and defense.

Aviation Week Network's Laureate Awards have recognized the extraordinary achievements of individuals and teams in aviation, aerospace, and defense for 60+ years. The tradition continues as we celebrate accomplishments that embody the spirit of exploration, innovation and vision. These are the people that inspire others to strive for progress, change and leadership in aviation and aerospace.

Category Winners Announced!

COMMERCIAL AVIATION

Platforms – Airbus A321LR
Leadership – David Neeleman, Airline Entrepreneur
Airline Strategy – Adel Ali, CEO, Air Arabia
Propulsion – Rolls-Royce
Sustainability – Boeing ecoDemonstrator
Air Traffic Management – Aireon
MRO – Donecle

DEFENSE

Platforms – Bell V-280 Valor
Best New Product – Embraer KC-390
Manufacturing – Northrop Grumman F-35 Center Fuselage Production
MRO – BAE Systems Typhoon Total Availability Enterprise
Propulsion – AFRL Medium Scale Critical Components Scramjet Program
Technology & Innovation – Kratos XQ-58 Valkyrie
Weapons – Missile Defense Agency Ground-based Midcourse Defense FTG-11

SPACE

Launch Services – Spaceflight Industries
Space Science – Chang'e 4 Moon Landing
Platforms – Mars Cube One Mission
Operations – HawkEye 360
Propulsion – Reaction Engines
Supplier Innovation – OneWeb Satellites
Technology & Innovation – RemoveDEBRIS Mission

BUSINESS AVIATION

Platform – Gulfstream G500/G600
Safety – Garmin Autoland
Propulsion – Pratt & Whitney Canada PT6E
Operations – Rega Swiss Air-Rescue
MRO – Robotic Skies
Technology & Innovation – Wing Aviation

LIFETIME ACHIEVEMENT

Robert Leduc – President, Pratt & Whitney

The Grand Laureate for Commercial, Defense, Space and Business Aviation will be announced live at the awards ceremony. The Laureate Awards will also feature Tomorrow's Leaders and the 20 Twenties.

Join the Celebration

laureates.aviationweek.com

by governments to control movement and a great reluctance in China to step outdoors, let alone take a flight. UBS, a bank, expects the disease outbreak to cut Chinese first-quarter GDP growth by 2.2 percentage points.

Suspensions of international services by local and foreign airlines evidently led the CAAC to worry that Chinese citizens could have difficulty returning home. In directing Chinese airlines to avoid general severance of air links to each foreign country, it may also be trying to limit economic damage.

"The CAAC requires that all mainland Chinese airlines, in considering service reductions in response to market demand, ensure that connections with a foreign country are not severed, except when the country has adopted a policy that stops flights," the agency says. This does not necessarily mean the Chinese carriers themselves must maintain the connection, nor does it specify minimum frequencies. Also, it seems that only one city in a foreign country needs to be served.

For the week of Feb. 3, mainland China's five largest international air travel markets, as measured by seats, were all in Asia. In order of size, they were Japan, Thailand, South Korea, Hong Kong and Taiwan, according to data from CAPA and OAG. The largest non-Asian market was the U.S., in seventh place.

The carrier outside mainland China most exposed to the country's market is Cathay Pacific's Dragon subsidiary, CAPA and OAG data show. Ranking after it in terms of traffic are Asiana, Korean Air and All Nippon Airways.

The Cathay Pacific Group, which has been recovering from a severe demand drop caused by the Hong Kong protests in 2019, will almost completely suspend its mainland China network. In a stock exchange filing, Cathay says it will be "progressively reducing" about 90% of its flights into mainland China. The carrier will also make "significant reductions" across the rest of its network over the next two months. The combined effect on the Cathay mainline and Cathay Dragon networks will be a capacity cut of about 30%, the airline says.

The reductions "are temporary for now and are driven by the [current] commercial and operational realities . . . as well as projections in short-term demand," Cathay says, stressing that its financial position remains strong.

The financial condition of mainland carriers is unclear, though they are obviously running deep daily losses. The government has so far adopted one measure to help them, suspending collection of contributions to an aviation infrastructure fund levied at 50 yuan ($7) per domestic passenger and 90 yuan per international passenger.

Amid plummeting demand, Air China has applied to replace direct services from Beijing to San Francisco and Washington with extensions on the Beijing connections to Los Angeles and New York, respectively. China Southern Airlines and China Eastern Airlines, meanwhile, have announced cuts to international operations.

The financial condition of mainland carriers is unclear, though they are obviously running deep daily losses.

ROMANOVSKYY/GETTY IMAGES

Air China's plans for U.S. services exceed the CAAC minimum, since it will maintain two routes serving four cities. But the proposal outlined in an emergency application to the U.S. Transportation Department envisages only four return flights a week on each route. The modified U.S. West Coast service will begin on Feb. 11, and the new U.S. East Coast service on Feb. 12.

There will be no other Air China flights to the U.S.

China Eastern says it will cut its Shanghai services to both New York and Los Angeles to three flights weekly, dropping all other U.S. operations from Feb. 10 until March 28. After that, U.S. capacity will be only half of the original schedule. Capacity to Canadian destinations and Amsterdam, London, Paris, Melbourne and Sydney is to be halved. China Southern, formerly active in the Australian and New Zealand markets, is dropping all services to those countries except four flights a week each to Auckland, Melbourne and Sydney.

Cathay's traffic statistics for December show its demand was already fragile as a result of the Hong Kong protests. Overall passenger numbers in December were down 3.6% compared to a year earlier, with inbound traffic about 46% lower. The mainland China, Japan and Taiwan markets were particularly weak. Before its latest move, Cathay had already decided to cut capacity by 1.4% in 2020, versus its previous plan of a 3.1% increase. The coronavirus outbreak will push the capacity cuts higher.

Governments are advising citizens to avoid China, so there is little demand for flights there, hence the widespread service suspensions. Analysts at RBC so far see travel restrictions having a limited impact on European airport traffic, however—underlining the point that the greatest industry damage is occurring in China.

Airbus has extended the Lunar New Year holidays for workers in the Tianjin plant for final assembly of A320-family aircraft, meaning the global production system for the type has indefinitely lost output of six aircraft a month, 10% of the total. Airbus China states that it is "observing Chinese government requirements for staff to work from home and is facilitating with IT equipment so employees from all locations including Tianjin do not need to travel to work where possible."

The problem is not only that workers cannot go to the plant. "With regards to the business impact, China domestic and worldwide travel restrictions are posing some logistical challenges," Airbus China says, adding that it is looking at how to mitigate the impact on production.

Safran Group is also affected in China; it has extended vacations for its 2,500 workers there. Boeing's 737 completion center in Zhoushan was already impacted by the MAX production halt.

Then there is the issue of parts supply from Avic. Most major civil aircraft makers take parts from the state group's plants, which are presumably as silent as factories in almost all industries throughout the country. Such parts include 787 rudders from Avic Chengdu and A350 elevators from a composites factory at Harbin.

—With Helen Massy-Beresford in Paris

SpeedNews CONFERENCES

Registration NOW OPEN!

Aerospace Raw Materials & Manufacturers Supply Chain Conference

MARCH 9, 2020

Beverly Wilshire (A Four Seasons Hotel)
Beverly Hills, CA

Commercial Aviation Industry Suppliers Conference

MARCH 9-11, 2020

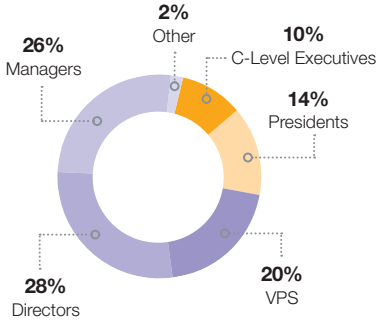
Beverly Wilshire (A Four Seasons Hotel)
Beverly Hills, CA

Join Us at these Upcoming A&D Events

Delegates at both the **Aerospace Raw Materials & Manufacturers Supply Chain Conference** and **Commercial Aviation Industry Suppliers Conference** will hear from industry experts and manufacturers on the state of the industry, material and technology advancements, and achievements. If you are interested in having a better understanding of aircraft programs and their production cycles, market forecasts and delivery updates, these are the Conferences you won't want to miss.

For more information, please visit: SpeedNews.com/conferences

Conference Delegate Profile:



AVIATION WEEK NETWORK

FIGHTER FOCUS

> INDONESIAN AIR FORCE WANTS F-16s; PHILIPPINES CONSIDERS THEM

> THAILAND'S REQUIREMENT IS MORE DISTANT

Bradley Perrett Beijing

Interest in fighter acquisitions is bubbling in Southeast Asia, even if the timing of program launches is unclear. Indonesia wants more aircraft of types that it has in service, while the Philippines aims to return to fighter operation. Thailand is expected to make a purchase during the decade, though not imminently, while Malaysia is focusing on light combat aircraft (LCA).

In each of these countries, budgeting allocations tend to be hard to predict, and major military acquisitions are often talked about long before they come to fruition—with much chopping and changing along the way. Still, prospects of fighter orders in Southeast Asia are supported by the aging of current fleets, the rising threat of China and economic growth rates generally stronger than those of developed countries.

Singapore, which tends to say little but follows through on what it does say, has begun the process of acquiring its next fighter type, the Lockheed Martin F-35 Lightning (see facing page).

Indonesia should be next in placing an order, and it has decided on the Lockheed Martin F-16. "We will buy two squadrons of jet fighters as part of our strategic plan for 2020-24," Air Force Chief Air Marshal Yuyu Sutisna said in October. "We're aiming for the latest type, the Block 72 Viper."

The air force hoped to begin the purchases in 2020, Yuyu said. The plan implies an order for 32 F-16 Block 72s, since Indonesia's practice when buying for complete squadrons is to acquire 16 fighters for each.

Two years ago deliveries were completed for 24 ex-U.S. F-16s upgraded to Block 52+ standard and called F-16IDs; one crashed, so 23 remain. Indonesia is also updating F-16A/Bs, of which it has 10. The country therefore appears to be planning to accumulate a force of more than 60 F-16s in three production standards.

It is already awaiting deliveries of 11 Sukhoi Su-35s, supplementing 16 Su-27s and Su-30MK2s. Again, the standard squadron strength suggests five more Su-35s will be wanted.

Indonesia has five Sukhoi Su-27s (pictured) and 11 Su-30MK2s.

SGT. SHANE GIDALL/COMMONWEALTH OF AUSTRALIA

The F-16V is a candidate for the Philippines' plan to restore the fighter capability it lost when it retired its last F-5 in 2005. The other possibility is the Saab Gripen, according to Defense Secretary Delfin Lorenzana.

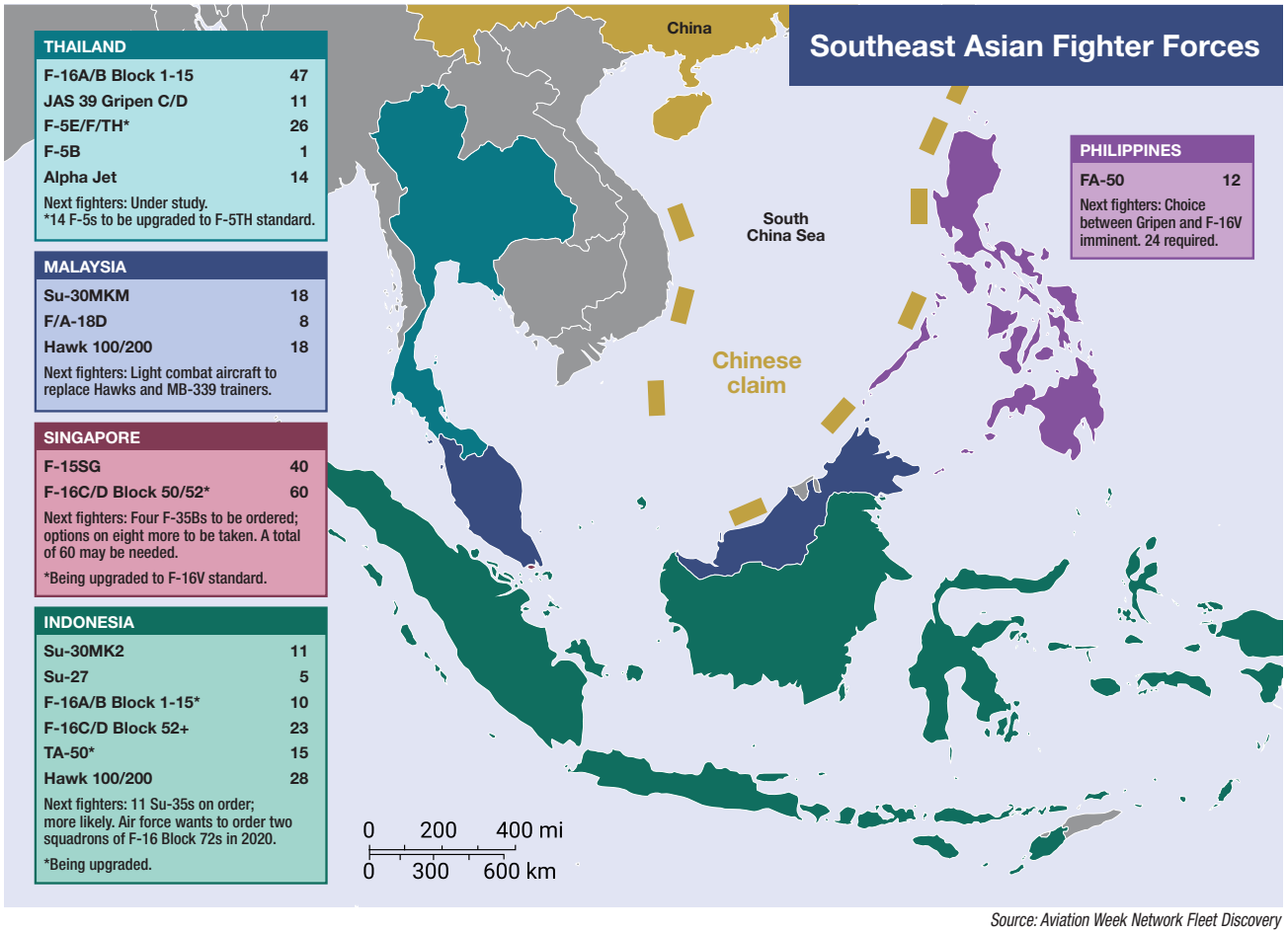
"F-16V" is the designation of an F-16 upgraded to the standard of the current-production F-16 Block 70/72, but the term is sometimes mistakenly used to refer to that new-built version. Saab has offered the Gripen C/D to the Philippines.

The Philippine Air Force has planned to buy four aircraft in this multirole fighter program in 2021, followed by eight in 2022 and 12 more later. The government has not confirmed the scale of the acquisition, however.

Twelve Korea Aerospace Industries FA-50 supersonic attack jets currently provide limited air-to-air capability for the Philippines. President Rodrigo Duterte called in 2017 and 2018 for acquisition of another 12 FA-50s, but that idea appears to have been set aside. An FA-50 order would compete with the fighter program for funds.

The Royal Malaysian Air Force (RMAF) has had to give up plans for 18 fighters to replace F-5s and Mikoyan MiG-29s now in storage; it now does not expect the government to order fighters within about the next 10 years. Instead, the service is aiming at acquisition of LCAs to replace its 18 BAE Systems Hawk 100s and 200s, survivors of 28 delivered in the 1990s.

A year ago the RMAF issued requests for information for 12 LCAs. It sought information on the FA-50, Hindustan Aeronautics Ltd. Tejas and Sino-Pakistani JF-17, addressing its request for information for the JF-17 to the Pakistan Aeronautical Complex rather than the other manufacturer of the type, Avic Chengdu. The Tejas and JF-17 are in fact fighters, but not as powerful as the types the RMAF



Source: Aviation Week Network Fleet Discovery

earlier hoped for; the Dassault Rafale had been a leading contender.

The government's attitude toward national defense is not encouraging for the RMAF. "Everybody knows: If any country wants to invade Malaysia, they can walk through, and we will not resist because it's a waste of time," Prime Minister Mahathir Mohamad said in May 2019.

The Royal Thai Air Force (RTAF) would like to buy more Gripen C/Ds to add to the 11 it has in service, but it has instead embarked on an upgrade of F-5E/Fs that includes modern radars and air-to-air missiles. The work is remarkable for such an old type: the first Northrop F-5 flew in 1963, based on the T-38, which first flew in 1959.

The service has 47 F-16s, according to Aviation Week's Fleet Discovery database, and has suggested it would like to move to replace them within five years. The project is still preliminary, reportedly at the study stage. The RTAF is emphasizing the importance of using indigenous technology, especially in software. An order to replace all the F-16s at once is unlikely, since 18 have had a midlife update to keep them in service until 2035.

F-35B Opens Basing Options for Singapore

> PLANS COVER AN ORDER FOR FOUR, OPTIONS ON EIGHT

> THE STOVL CHOICE FOLLOWS CHINA'S SOUTHWARD EXPANSION

Bradley Perrett Beijing

Lacking strategic depth, tiny Singapore has always been nervous about its runways—as it demonstrates when it practices flying fighters from roads. Now the availability of the Lockheed Martin F-35B Lightning has offered to dramatically increase the resilience of the city-state's air defenses.

The impending induction of short-takeoff-and-vertical-landing (STOVL) fighters for the country's armed forces may be all the more necessary as China expands down the South China Sea. Singapore is in easy reach of ballistic missiles, cruise missiles and tactical aircraft that China could base on artificial islands.

Singapore has asked to buy four F-35Bs and take options on eight more, the Defense Security Cooperation Agency says. Defense Minister Ng Eng Hen flagged an F-35 order in March 2019, but the choice of the F-35B was only hinted at until now. The fighters will replace Lockheed Martin F-16s.

Potentially worth $2.75 billion, the proposed order includes engines, electronic warfare systems and support systems, including the Autonomic Logistics Information System and training at a so far undisclosed U.S. location.

In principle, F-35Bs should be able to use more bases and runways than Singapore's F-16s and Boeing F-15SGs can, says airpower analyst Ben Ho of Singapore's S. Rajaratnam School of International Studies. Ho notes that as recently as 2016 the Republic of Singapore Air Force (RSAF) practiced flying F-15SGs from a road alongside Tengah Air Base.

For the exercise, the armed forces removed, in 48 hr., fixtures such as lampposts and bus stops and fitted

airfield lights and arrestor gear along the road, which measures 2,500 X 24 m (8,200 X 79 ft.). That length is abundant even for conventional takeoff and landing by fighters.

The F-35B has been designed to execute a 1,020-km (550-nm) strike mission after a 180-m takeoff run from an assault ship that provides 5 m/sec. (16 ft./sec.) of wind over the deck. So about 200 m of fixed runway should be enough, though it would not allow aborting takeoff late in the run. But that does not mean any straight, flat road of that length will do. The departure path must be unobstructed and operators must be able to fuel, arm and service aircraft there—but the potential for dispersing fighters away from main bases must still be multiplied enormously.

With F-35Bs, the main bases and civil airfields, including giant Changi Airport, could maintain operations while suffering damage that grounds conventional fighters. Shorter lengths of unbroken runway and taxiway at those locations would be sufficient for operation of F-35Bs. And F-35Bs' ability to take off vertically—an operational requirement not, as widely assumed, a mere air show trick—means they can move around a badly damaged base or escape one that is thoroughly wrecked.

Analyst Malcolm Davis, from the Australian Strategic Policy Institute in Canberra, sees China as the key factor behind the Singaporeans' decision to buy F-35Bs. "They recognize that China's growing capability in the South China Sea—driven by the island buildings and the addition of the Shandong aircraft carrier—and China's ability to use conventional precision ballistic missiles means that Singapore can't assume its airbase infrastructure will remain untouched in a conflict," says Davis.

Moreover, it could be argued that Singapore does not need F-35s of any version to face the air forces of the two countries against which it traditionally structures its armed forces, Indonesia and Malaysia. Singapore's 60 F-16C/D Block 52s are being upgraded to the F-16V standard, equivalent to the current-production F-16 Block 72. Yet Ng says the F-16s will be obsolescent after 2030. Indonesia has ordered Sukhoi Su-35s but only 11 of them.

Still, Singapore's technocratic culture would always drive its military toward the best affordable fighter, Davis adds. And the choice of F-35s provides commonality with the U.S., Australia and Japan.

The initial acquisition of only four F-35Bs with options on eight more is typical of Singapore's gradualist approach to inducting military equipment, says Ho. It usually makes a limited purchase, slowly builds up the new capability, evaluates effectiveness and integration with other systems, and only then buys more, Ho adds. This helps explain why Singapore has begun buying fighters now to replace F-16s whose gradual retirement may extend into the 2030s.

Later orders may cover the conventional-runway version of the Lightning, the F-35A, since it is cheaper, says Ho. It also has longer range.

Japan plans to buy 42 F-35Bs as well as 105 F-35As.

AVIATION WEEK NETWORK

Second Annual Urban Air Mobility Conference

Shaping the Future of Transportation for Smart Cities and Regional Connectivity

AVIATION WEEK

UAM AMERICAS

April 27-28, 2020
Dallas, TX

Manufacturers, regulators, technology innovators, municipal leaders and the infrastructure & investment community will come together to discuss on-demand aviation for smart cities and to create a new future for air transportation.

- Roadmap to Reality: What's Been Done and What's Next?
- Hybrid Electric Propulsion & Electrification
- Security: Cyber, Supply Chain, and Passenger Perspectives
- Public Acceptance: Noise, Ride Quality, and Why Are Those Things
- Infrastructure, Zoning and the Environment

SPECIAL FEATURE:
Dallas – Fort Worth Case Study

Join local leaders in the emerging UAM market for an inside look at how North Texas is leading the way as one of the first test sites for UAM operations in the United States.

From the people who know Aviation best. Aviation Week. Join us.

uam.aviationweek.com

Aviation Week is proud to welcome our Diamond Sponsor.

BELL

Growing Challenges Spur Change for SIA

> LCC SCOOT HAS MAJOR ROLE IN GROUP STRATEGY

> RAPID FLEET REFRESH MAKES NEW ROUTES VIABLE

Adrian Schofield

Although Singapore Airlines (SIA) has forged a reputation as one of the most successful carriers in the industry, it is not resting on its laurels. SIA is continuing to evolve its multipronged business model, as it seeks new partnerships and introduces advanced aircraft types to broaden its network capabilities.

SIA's moves are partly driven by a set of well-known strategic challenges. Competition on long-haul connecting markets is coming from the giant Middle Eastern carriers and increasingly from the Chinese mainland airlines. Closer to home, low-cost carriers (LCC) in Asia are continuing to ramp up their fleets with vast order backlogs. And other Asian hubs are attempting to emulate the success of Singapore's Changi Airport as a global connection point.

More recent headaches have arisen that are complicating SIA's structural and fleet changes. The grounding and delays of Boeing 737 MAXs have disrupted growth plans and the transfer of aircraft between group entities. And while SIA is still financially healthy, its profits have been under pressure from the same market forces that are hurting other Asian carriers.

SIA believes it can best compete in its markets by having different business models under its group umbrella, an approach also followed by major Asia-Pacific carriers such as Qantas and All Nippon Airways (ANA). In addition to the parent airline, SIA has SilkAir as a full-service narrowbody operator—although this brand will soon disappear—and Scoot as an LCC.

The group has been fine-tuning and streamlining its structure, and an important development is the integration of SilkAir into the parent Singapore Airlines. This process is due to continue this year, when the last of the SilkAir routes will be transferred to either the full-service parent or Scoot. SIA will then have two major entities—a full-service operation and an LCC. Scoot completed its merger with SIA subsidiary Tigerair in 2017, consolidating the LCC units.

A major part of the group reshuffle has been deciding which routes are best suited to full-service or LCC business models. SIA determined that many of the full-service routes—particularly those operated by SilkAir—would be more profitably served by Scoot. A handful of Scoot routes have also been shifted back to the full-service carrier.

In parallel with the route transfers, SilkAir was due to send 14 of its Boeing 737-800s to Scoot. However, the MAX groundings changed this plan, and the 737-800s have been retained in the full-service operation. Gaining a slew of new routes without the expected additional aircraft has caused operational challenges for Scoot, said Stephen Barnes, SIA's senior vice president of finance, during the group's most recent analyst briefing.

Scoot, launched 6-7 years ago, has an important—and increasing—role in the group's long-term strategy. The LCC's fleet has grown to 20 Boeing 787s, 26 Airbus A320s and two A320neos, allowing it to serve both long-haul and short-haul routes.

New models like the Airbus A350-900 are helping SIA replace older widebodies and increase network options.

AIRBUS

Scoot now accounts for 20% of the group's capacity as measured in available seat-kilometers and almost 30% of its passenger enplanements. Having the LCC in its portfolio means the SIA group can serve more destinations that would otherwise not be viable, SIA CEO Goh Choon Phong told analysts. For example, Scoot operates about 70% of the group's routes in the crucial China market.

Partly due to the change in the 737 plans, Scoot only grew its capacity by "a relatively moderate" 5.6% in the six months through September, said Barnes—compared to double-digit growth rates in previous years. However, Scoot's expansion is likely to pick up pace again, as the carrier has more than 45 A320neo and A321neo aircraft remaining on order.

While the LCC growth is a long-term bet, in the nearer term this part of the business is proving to be a drag on profits. The group managed to increase its net profit to S$206 million ($151 million) for the six months through Sept. 30, its fiscal first half. However, this was mainly due to the healthy performance of the parent airline.

The SilkAir subsidiary recorded an operating loss of S$19 million for the period, and Scoot dipped to a S$77 million loss. Both were wider losses compared to the previous year. While SilkAir will be absorbed into the parent carrier, SIA will expect the Scoot unit to turn around its losses and justify the group's investment. In particular, the long-haul LCC operations will need to prove they can be financially successful. Other carriers are also pursuing the long-haul LCC concept, but the jury is still out on whether this model can be sustainably profitable.

Goh admits Scoot is experiencing "transitional issues." He notes the carrier is faced with the need to build traffic and market presence on the routes it has taken over. Scoot has also been dealing with continuing operational challenges as some of its 787s have had to be grounded due to problems with Rolls-Royce Trent 1000 engines.

Singapore Airlines has enjoyed a long run of annual profits—and remarkably has never posted a full-year loss.

In addition to its Singapore-based businesses, SIA is expanding its interests in other countries. SIA helped establish Indian carrier Vistara in 2013 and holds a 49% stake. The past year has seen rapid growth, with Vistara on track to almost double its fleet size and number of weekly flights by the end of the financial year on March 31 compared to the same point in 2019.

SIA is also looking to form strategic partnerships with other airlines. Unlike markets such as Europe and the U.S., there are fewer prospects for consolidation for Southeast Asian carriers due to restrictions on cross-border ownership. There are investment opportunities, such as SIA's stake in Vistara and its minority share in Virgin Australia, but true mergers and takeovers are rarer.

Goh says he "is not holding [his] breath" over the prospect of increasing liberalization in airline ownership in the Asia-Pacific region. One of the major hurdles is that the airlines involved are often national carriers, he says. However, Goh stresses SIA can "look at other ways to cooperate" through deeper commercial relationships. "Until the regulatory environment in this part of the world allows for more liberal consolidations, this will be a good interim solution."

SIA already has joint business agreements in certain markets with airlines such as Lufthansa, Air New Zealand and Scandinavian Airlines. In two new and significant steps, SIA plans to form closer partnerships with Malaysia Airlines (MAB) and ANA. The SIA/MAB proposal was unveiled last year and is still awaiting regulatory approval. SIA and ANA confirmed on Jan. 31 they will also seek approval for a joint venture.

The Malaysia Airlines arrangement is different from SIA's other commercial partnerships because the airlines' hubs are so close together. So instead of cooperating between two widely separated home markets, the carriers will look at "what is the best way to get a win-win for two airlines in the same region," Goh says. The carriers intend to operate a revenue-sharing joint venture on flights between Singapore and Malaysia and expand codesharing on other routes.

Major changes are also underway in the SIA Group's fleet. As well as the stalled introduction of MAXs and the planned addition of A321neos in the narrowbody operation, new types are altering the widebody fleet. SIA has more than 70 widebodies remaining on order, including Airbus A350-900s, 787-10s and 777Xs.

However, these deliveries are mainly aimed at fleet replacement in the short-term. The mainline parent carrier is on track to add 16 A350-900s and six 787-10s in the fiscal year through the end of March, offset by the retirement of 17 widebodies. This will mean a net increase of just five aircraft to a total of 133 in the mainline fleet.

Goh says the carrier's strategy of "aggressive [fleet] renewal" will continue. The improved performance of the new aircraft types "gives us the capability to operate to markets [that] previously would not have been possible or commercially feasible."

A good example of this is the ultra-long-range (ULR) version of the A350-900 that SIA began receiving in late 2018. These -900ULRs have been used to operate new nonstop routes to the U.S., boosting SIA's network in that country and helping increase market share on connecting services from the U.S. to Southeast Asia, India and Australasia, says Goh. A350s are also allowing the carrier to open secondary European markets such as Dusseldorf, Germany.

SIA benefits from having its base at one of the world's premier hubs, Singapore's Changi Airport. This has helped in the development of the international connecting traffic that represents a key part of the carrier's business model.

Like SIA, Changi is looking for new ways to stay ahead of the competition. The airport has continued to pour money into new facilities, such as the centerpiece mixed-use complex called the Jewel that opened in April 2019. Expansion work begins this year on Terminal 2, with completion scheduled for 2024. A massive fifth terminal is slated to open in the early 2030s.

The SIA Group had a combined 51.1% share of total seats departing Changi for the week of Jan. 27, according to data from CAPA – Centre for Aviation and OAG. This comprised 29.3% for Singapore Airlines, 15% for Scoot and 6.8% for SilkAir. The next-highest airline was Jetstar Asia with 6%.

The group also holds strong positions in its key overseas markets. In Australia, for example, only the Qantas Group has a higher share of international seats than SIA, CAPA data shows. The three SIA Group airlines had 188 departures from Australia during the week of Jan. 27, and Australia represents SIA's largest overseas market as measured by seats.

SIA has enjoyed a long run of annual profits—and remarkably has never posted a full-year loss. Some financial results have caused concern in recent years, however. For example, a rare quarterly loss in 2017 was enough to spur the airline to launch a three-year program to reexamine many areas of its business. And in the group's most recent full financial year through March 2019, its net profit was nearly halved compared to the previous year.

The carrier reported encouraging results for the first six months of its 2019-20 financial year, with profits up by about 5%. Full-year results will no doubt come under pressure from recent events such as the decline in Hong Kong traffic due to the protest movement and the still-unfolding crisis related to the coronavirus outbreak in SIA's key China market. However, SIA has proven repeatedly that its business model is strong enough to withstand such external shocks.

Jeju Air Looks To Strengthen Its Grip on South Korean LCC Sector

> LCC AIMS TO GROW MARKET LEAD WITH EASTAR JET ACQUISITION

> DEAL MARKS AN IMPORTANT STEP TOWARD CONSOLIDATION

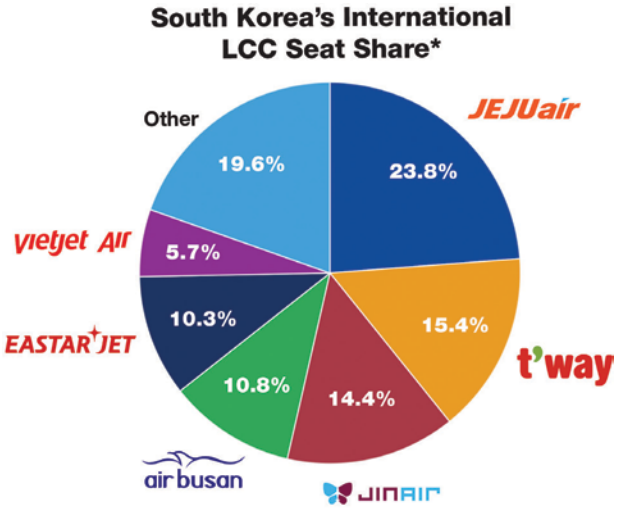
Adrian Schofield

Jeju Air's proposed takeover of Eastar Jet would give it a dominant position in South Korea's low-cost carrier (LCC) market, boosting it into the ranks of the major players in the Asia-Pacific LCC sector.

The acquisition would help Jeju break clear from what has become a congested field of LCC competitors in South Korea. While the deal has yet to close, and Jeju has not revealed its plans for Eastar, the obvious motive is to gain a scale advantage in key domestic and international markets.

The two potential partners are both committed to the Boeing 737 MAX for growth and replacement needs. Eastar ordered six MAXs, of which two have been delivered but remain out of service due to the type's global grounding. Jeju has 40 MAXs on order. While delivery timetables for the MAX remain uncertain, there is clearly scope for fleet growth.

Offshore expansion is also a possibility, as Eastar has established a joint venture carrier in Thailand. The carrier, Thai Eastar Jet, has received



*Data from week of Jan. 20, includes foreign LCCs.

Sources: CAPA and OAG

Jeju Air operates 44 Boeing 737-800s, which already represents the largest fleet of any South Korean-based LCC. Eastar Jet also flies 737s, with 21 of the -800 variant and two -900ERs, according to the Aviation Week Intelligence Network Fleet Discovery database. This means the two carriers would have good commonality, and potentially a combined fleet of 67 aircraft. A narrowbody fleet of this size would still trail Asian LCC giants such as AirAsia, Lion Air and IndiGo but would be larger than second-tier LCCs including Cebu Pacific and Scoot.

government approval and is expected to begin operations this year.

Jeju Air revealed in a Dec. 18 stock market filing that it intends to purchase a 51.2% controlling share in Eastar Jet, and the pair signed a memorandum of understanding to this effect. The deal was initially expected to close by Dec. 31, but Jeju twice extended its due diligence period and now plans to close the purchase by the end of February. The purchase is valued at an estimated 69.5 billion Korean won ($58.2 million).

There are six incumbent LCCs based in South Korea. In order of fleet size these include Jeju Air, T'Way Air, Air Busan, Jin Air, Eastar Jet and Air Seoul. Jin Air is owned by Korean Air, while Air Busan and Air Seoul are part of the Asiana group. With this many LCCs, some degree of consolidation was considered likely. The Jeju move could be a significant step in that direction.

The picture has been further complicated by the South Korean government's approval of three new LCCs last year. One of them, Fly Gangwon, began operations in November and currently operates two 737s. Aero K is set to launch by early March with one Airbus A320 and expects to add two more of the same aircraft type by the end of this year. The third of the startups, Air Premia, plans to begin operations in September and is due to receive three leased Boeing 787s this year.

Jeju Air accounts for 9% of South Korea's total international seats, behind only full-service carriers Korean Air and Asiana, according to data from the CAPA – Centre for Aviation and OAG for the week of Jan. 20. Eastar, meanwhile, has 3.9% of the international seats. Although Jeju and Eastar's combined share would still be third-highest, it would be much closer to Asiana's 14.9% share.

In terms of the LCC market, Jeju has the most international seats with a 23.8% share, while Eastar has the fifth-highest seat share with 10.3%. If they join forces, they would account for about one-third of the international seats in South Korea's LCC sector—including overseas carriers.

The two airlines have a particularly strong presence on routes to Japan. Jeju Air held a 15.1% share of seats in the South Korea-Japan market for the week of Jan. 20, ranking it third among all carriers. Eastar Jet accounted for 5.7% of seats in that period. Together, the pair's 20.8% seat share would be only slightly behind the 22% held by market leader Korean Air.

While it is very important for South Korean airlines, the South Korea-Japan market has been hit by a demand drop due to political tension between the two countries. LCCs have been particularly affected, with Jeju Air and Eastar cutting capacity in this market by 26.9% and 44.2% year-on-year, respectively, data from CAPA and OAG shows.

The two airlines have also cut ca-

Jeju Air and Eastar Jet both operate fleets of Boeing 737-800s, with 737 MAXs on order.

JOEPRISEAVIATION.NET

pacity to China due to the recent coronavirus outbreak. However, they are less reliant on China, which represents the third-largest international market for Jeju and fourth for Eastar.

Jeju would strengthen its position in the domestic market by combining with Eastar. In December, Jeju accounted for 15.1% of South Korea's domestic passenger total, while Eastar tallied 9.4%, according to data from South Korea's Ministry of Land, Infrastructure and Transport.

Any operational partnership between Jeju Air and Eastar Jet would have major ramifications for the key domestic route between Seoul's Gimpo International Airport and the island of Jeju, which is the world's busiest domestic route. Eastar has 16 daily flights from Gimpo to Jeju, and Jeju Air has up to 21 per day. Together they would have the highest number of flights and seats on this route, CAPA data shows.

Singapore Ramps Up Aerospace Parts Production

> AEROSPACE R&D IN SINGAPORE IS ALSO GROWING

> ALL THREE BIG ENGINE COMPANIES HAVE FACTORIES THERE

Bradley Perrett Beijing

A curious thing has happened in Singapore over the past decade or so: Aerospace manufacturing has moved into, not out of, the city-state's highly developed, high-cost economy. Maintenance remains the dominant aerospace activity in the city-state, but a succession of companies has announced and implemented plans to at least make parts in the Southeast Asian nation.

Sia Kheng Yok, chief executive of the Association of Aerospace Industries (Singapore), says Singapore is well positioned to sustain this trend. Along with the rise of manufacturing since the first decade of the century, aerospace research and development has widened in Singapore—moving beyond its traditional focus on supporting the country's defense forces. This may also be an area where Singapore can make further advances.

Challenges in Singapore include not only high labor costs but also land that is expensive. The problem is not so much that the tiny country has no land: The government has well-established policies to ensure that land is recycled for new uses as old industries fade. If aerospace manufacturing in Singapore is going to grow, it will have to compete with other rising sectors for available real estate.

The industry has traditionally been built on two pillars: the success of Singapore Airlines and Singapore's Changi Airport, which has supported the civil maintenance sector; and the engineering capability of Singapore Technologies Engineering, the country's main defense contractor.

Strengthening of manufacturing came after 2007, when Rolls-Royce said it would build a factory at Seletar in northeastern Singapore, Sia says. The facility, which opened in 2012, assembles and tests up to 250 civil turbofans a year. It also makes as many as 8,600 hollow, wide-chord titanium fan blades. Like Sia, Rolls-Royce notes the manufacturing expansion that followed establishment of its Seletar facility, which it calls "the runway for Singapore's aerospace industry." By the company's calculation, it accounts for 14% of Singaporean aerospace output.

Pratt & Whitney opened a plant for building fan blades and turbine disks in Singapore in 2018. A new General Electric plant in the country to make vanes for high-pressure compressors for the GE9X engine has been aiming to reach

C919 Test Fleet Complete, Mach 0.82 Reached

> SIXTH AND LAST PROTOTYPE IS IN THE AIR

> LATEST SCHEDULE IMPLIES FIRST DELIVERY IN 2022

Bradley Perrett Beijing

Comac has completed its C919 flight-test fleet, with the sixth and last unit now in the air. Flight testing has exceeded the designed cruise speed of the narrowbody airliner and reached its intended ceiling.

Elsewhere in the program, Comac and propulsion partner CFM have modified Leap 1C engines and nacelles of the six prototypes to cope with previously miscalculated loads, says an industry source. CFM has further changed the design of transfer gearboxes on the turbofans, the engine company says. According to the source, this modification has been implemented.

The sixth prototype made its first flight on Dec. 27, achieving an objective to complete the flight-test fleet by the end of 2019. The efficiency of flight testing is improving, the state company says.

The highest speed reached so far has been Mach 0.82, says that person; this compares with the design cruise speed of Mach 0.785. The highest altitude so far has been 39,800 ft. (12,100 m), says that person; that is the maximum intended for operation. The C919 is designed to carry 158 passengers in a standard two-class configuration.

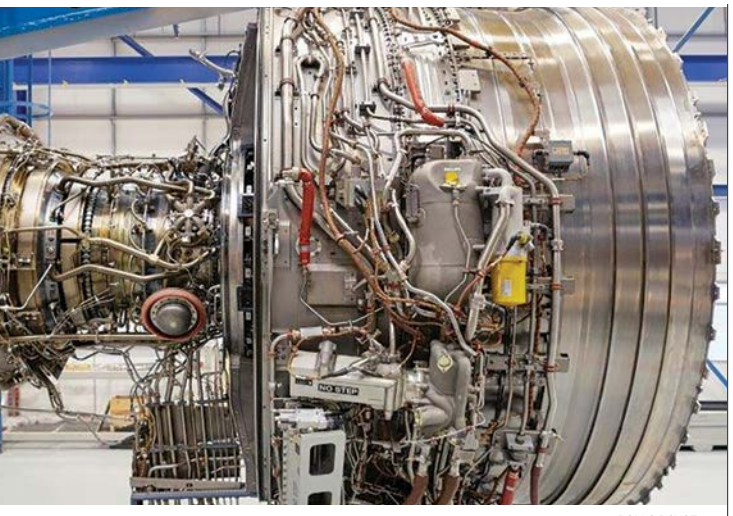
A second source confirmed that loads on the Leap 1C engines and nacelles had been unexpected. According to the first, this resulted in undesirable shuddering. "There was vibration," that person says. "But the modifications have been made."

Asked about that issue, a spokesperson for CFM says: "There is no issue with the joint design of the C919 program beyond the normal iteration between the engine manufacturer and the airframer." Reuters first reported that the issue had arisen. Comac did not respond to a request for comment sent before the annual lunar new year holiday began on Jan. 24, but the issue does not appear to be unusually serious.

The transfer gearbox has been modified to improve durability, says the CFM spokesperson. This matter was entirely the responsibility of the engine company, says the first source, who added: "All six flight-test aircraft now have the new configuration. So far, there's been no problem with it."

CFM said in June it was redesigning the bearing of the radial drive shaft of the Leap 1B, the version on the Boeing 737 MAX. This was done after five inflight shutdowns due to particles coming from the shaft, which, with the accessory gearbox and transfer gearboxes, is part of the engine's accessory drivetrain. The spokesman declined to say whether the change to the Leap 1C was related to this or any other product, however. The Leap 1C is most similar in design to the Leap 1A of the Airbus A320neo family.

The C919 program is well behind schedule, not helped by the very slow initial phase of flight testing that followed the first C919 taking to the air in May 2017. Comac said in August 2019 it



ROLLS-ROYCE

Rolls-Royce assembles Trent 1000 engines in Singapore.

employment of 100 technicians and engineers this year. Its establishment follows smaller-scale component production for GE engines that commenced in 2010.

However, these are hardly the first aerospace manufacturing operations in the country: Predecessors include Singapore Aerospace Manufacturing and operations that are now part of Collins Aerospace. Collins machines complex engine gears at one site in Singapore and castings for various aircraft systems at another.

"We have also invested in advanced manufacturing technologies to increase efficiency," says a Collins spokesperson. Machining processes and productivity have improved thanks to the adoption of automation and digital technologies.

High productivity is needed when labor and land are expensive. As offsets, Collins points to the availability of extremely high skills, Singapore's pro-business environment and the company's long-standing relationship with the government's economic development board. Sia notes that ease of doing business in Singapore is attributed to convenient movement of materials and products across its border and its proximity to suppliers in Asia.

"Industry 4.0 is changing the face of manufacturing," Sia notes, referring to a phenomenon in which intensive application of automation, information technology, sensors and artificial intelligence is expected to greatly increase productivity. "Singapore is seen as a front-runner in developing such capabilities, being one of the more advanced economies in Asia," says Sia. The large general Singaporean manufacturing sector also helps.

Aerospace research and development by local industry is extending beyond the traditional scope of support for the armed forces. Rolls-Royce has a development group at Seletar that works with universities and the government's Agency for Science, Technology and Research.

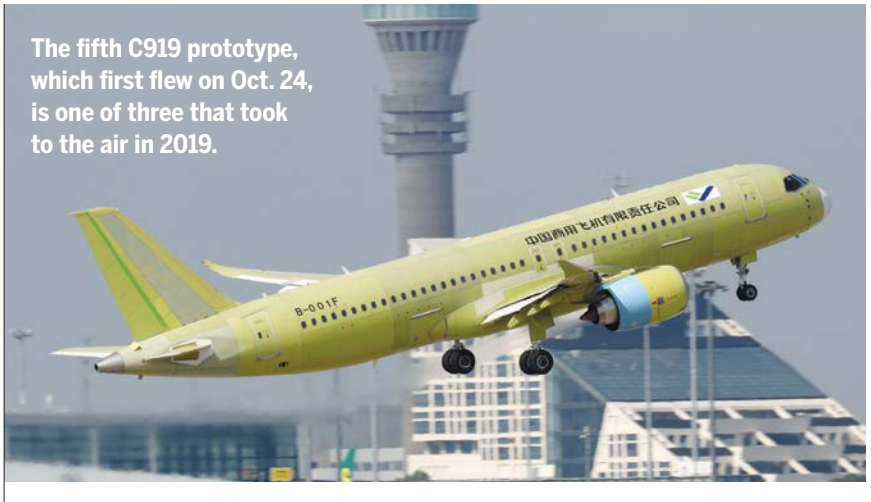
Collins said in June it would set up a research center in Singapore. "The focus will be on development, tooling and low-rate production of additive materials," the spokesperson says. The research center, which will support the company's maintenance business as well as manufacturing, is due to open by the end of March.

was aiming at achieving certification in 2021. Since it has previously expected to commence deliveries in the calendar year following that of the certification, the current schedule implies that initial customer China Eastern Airlines will receive its first C919 in 2022. When the program was launched in 2008, first delivery was due in 2016.

Comac's development problems appear manifold rather than individually large and schedule-wrecking. This contrasts to the succession of major difficulties that have each added a year or more to development of the SpaceJet, which Mitsubishi Aircraft began a few weeks before the C919 was launched.

For example, nothing in the C919 program is known to compare with the discovery in 2016 that the SpaceJet, then called MRJ, needed a significant electrical and avionics redesign that would push first delivery out by two years to mid-2020—a target that has now slipped further into 2021 at the earliest, since a prototype incorporating design changes is late in starting flight tests.

The sixth C919 prototype, No. 106, flew from Shanghai Pudong International Airport, to which it returned after 2 hr. 5 min. The objectives of the test were met, Comac says. Three test pilots and two engineers were aboard. This aircraft will be used mainly for verifying characteristics of the cabin, lighting and exterior noise, Comac says.



The fifth C919 prototype, which first flew on Oct. 24, is one of three that took to the air in 2019.

CHINESE MINISTRY OF INFORMATION AND INDUSTRY

The static strength-test airframe, meanwhile, has undergone all tests necessary for the program's certification effort. Additionally, the static fatigue-test airframe has been built. The type's normal flight control law has been verified. Comac says it, not a supplier, developed this system. Wing deicing has been tested in a wind tunnel.

Final assembly time for C919s is progressively shortening, Comac says. The flight-test aircraft are numbered 101-106. Of the static test airframes, the one used for verifying strength is 01, and the one for demonstrating fatigue life is 02. Testing on 01 was completed on Nov. 30, Comac says.

Comac said in September that manufacturing of parts for delivery aircraft had begun. The company now says it is issuing contracts for making systems and structures.

—With Guy Norris in Los Angeles

Gatwick Drone Scare Drives Countermeasures Deployments

> HEATHROW REVEALS COUNTERDRONE SYSTEM DEPLOYMENT

> MAJOR INTERNATIONAL AIRPORTS CONSIDER C-UAS SYSTEMS

Bill Carey Washington

The recent announcement that London Heathrow Airport (LHR) has installed counter-drone technology did not come as a surprise but addressed an ongoing reaction to the signature drone disruption at rival Gatwick Airport (LGW) more than a year ago.

Both of the UK airports acknowledged plans to invest in counter-unmanned aircraft systems (C-UAS) technology after a series of drone sightings forced LGW to close twice from Dec. 19-21, 2018. The holiday season disruptions caused 1,000 flight cancellations, affected 150,000 passengers, and cost airlines and the airport $64 million and $20 million, respectively, according to media accounts.

Weeks later—on Jan. 8, 2019—LHR briefly suspended departures to investigate a drone sighting. As the busiest UK airport, LHR moved 80 million passengers in 2018; LGW was second-busiest, with 46 million passengers.

The drone scare at Gatwick, located 30 mi. south of central London, served as a case study for the Blue Ribbon Task Force on UAS Mitigation at Airports (BRTF) that met last year and issued recommendations for U.S. and Canadian airports in October 2019. The FAA has cited the disruptions in regulatory documents, congressional testimony and correspondence with U.S. public-use airports.

The Gatwick event represented a peak in a yearslong trend line of drone incursions at airports. There were service disruptions blamed on drones at other major world airports in 2019, including at Newark Liberty International Airport, New Jersey, in January, Dublin Airport and Dubai International Airport in February, and Frankfurt Airport in March and May.

Israel Aerospace Industries' Elta Systems subsidiary said Jan. 27 that it has tested its Drone Guard C-UAS system at several large airports in Europe, Latin America and Southeast Asia but declined to identify them.

A multisensor system, Drone Guard uses a 3D X-band radar to detect and track targets to 4.5 km (2.8 mi.). A comint (communications intelligence) system classifies the target by its transmissions, and an electro-optical camera slaved to the radar provides target verification. Jammers disrupt radio frequency (RF) and GPS signals.

"Airport operators globally are actively seeking countermeasures to assist in handling the threat of drones around airport terminals and especially on the runways. The demand for drone management solutions has grown rapidly following the [Gatwick] incident," Elta says.

As of this January, the drone sightings at LGW in December 2018 were unsolved, and airport operator Gatwick Airport Ltd. continued offering a £50,000 ($65,000) reward for information through the Crimestoppers charity. Still, the trouble that event caused has made it a benchmark for airports and authorities considering using C-UAS systems that can detect, track and possibly intercept rogue drones.

Airports and suppliers are guarded when discussing C-UAS system deployments. The British Army initially deployed an unidentified military system at LGW, and police were seen using the commercial DJI AeroScope system, which detects the RF link between a DJI drone and its controller.

Gatwick Chief Operating Officer Chris Woodroofe acknowledged spending £5 million on counterdrone

The Anti-UAV Defense System installed at London Gatwick Airport and evaluated in the U.S. combines radar and electro-optical tracking with radio frequency "inhibition" technology.

BLIGHTER SURVEILLANCE SYSTEMS

technology in a BBC "Panorama" episode that aired last April. During the program, an executive with Chess Dynamics, of Horsham, England, described the Anti-UAV Defense System (AUDS) his company installed at LGW within days of the drone sightings.

Developed by Chess Dynamics, Enterprise Control Systems and Blighter Surveillance Systems, AUDS combines radar and electro-optical tracking with RF "inhibition" technology that blocks the control link between a drone and its operator. Used for military purposes "in the Middle East and elsewhere," the system "formed part of the solution" deployed at LGW, says Chess Dynamics.

As part of its Pathfinder research program in the U.S., the FAA chose the AUDS and C-UAS systems developed by Gryphon Sensors and Sensofusion to evaluate at U.S. airports in May 2016.

Pressed on why LGW had not installed a counterdrone system sooner, Woodroofe said on "Panorama": "There was no government-approved equipment that we could go and buy. The equipment that I have today on site is painted sand yellow because it's come straight from the military environment. This is the first time it's been used commercially."

C-UAS systems at LGW "have been expanded and consolidated into a permanent solution" since the drone scare, Chess Dynamics reports.

On Jan. 14, Operational Solutions (OSL) of Reading, England, announced that it had been chosen as the architect and integrator of a custom C-UAS system at LHR. The same day, Aveillant, a Thales subsidiary based in Cambridge, England, revealed that it is one of the manufacturers supplying technology for the system. Neither company described the system in detail.

On request, OSL provided a photo of "artificial intelligence-enabled" electro-optical and thermal cameras being tested at its C-UAS test and evaluation facility, but said they were not necessarily "representative or indicative" of the systems installed at LHR.

Aveillant specializes in holographic radar, which locates targets in three dimensions by transmitting a very-wide-angle pulse, then it forms multiple simultaneous receive beams. The company's Gamekeeper 16U radar is designed specifically to detect small drones to a range of 5 km.

THALES

Aeroports de Paris, which manages Charles de Gaulle, Paris-Orly and Le Bourget airports, uses the Thales Aveillant Gamekeeper radar.

Thales Defense confirmed to Aviation Week that the Gamekeeper radar is deployed at Paris-Charles de Gaulle Airport (CDG). But the parent company added that "we only provide the Gamekeeper to Aeroports de Paris," which manages CDG, Paris-Orly and Le Bourget airports.

Frequentis Comsoft leads a group that is developing a deployable C-UAS system at Hamburg Airport under the "Falke" research project awarded by Germany's Federal Ministry of Transport in December. Partners include air navigation service provider (ANSP) DFS, Hensoldt, Lufthansa, the German Federal Police and Helmut-Schmidt University.

On Jan. 8, C-UAS system developer WhiteFox, of San Luis Obispo, California, announced its selection with partners BlueForce UAV and EXO Tactik to conduct a yearlong drone security trial at Montreal-Trudeau International Airport. The magnitude of the trial, scheduled to run to November, is "unprecedented," WhiteFox said.

Following release of the BRTF report last October, the authority overseeing Ottawa Macdonald-Cartier International Airport (YOW) said it had partnered with ANSP Nav Canada and contractor Qinetiq Canada to test a C-UAS system there.

Qinetiq describes the Obsidian detection, identification and tracking radar mentioned in the announcement as a staring antenna array that provides 180-deg. azimuth and 90-deg. elevation coverage per radar; back-to-back units provide full 360-deg. coverage.

The goal of the testing at YOW was to determine the feasibility of the C-UAS system "to function compatibly in a civilian airport environment," the authority said.

Last October, the White House National Security Council approved a concept of operations, or strategy, that would elicit a federal response to stopping a Gatwick-like drone disruption at one of the U.S. Core 30 airports—those airports that serve major metropolitan areas with the highest volume of air traffic.

The Unified National-Level Response to Persistent UAS Disruption of Operations at Core 30 Airports designates the Transportation Security Administration (TSA) as the lead federal agency in such instances. At the local level, TSA federal security directors have completed tactical plans for the initial response, according to the American Association of Airport Executives.

It is expected the TSA will establish a C-UAS system testbed at Miami International Airport this year to evaluate technologies to detect, identify and track drones near airports. The TSA did not immediately respond to an inquiry seeking confirmation of the plan.

The FAA Reauthorization Act of 2018 requires the FAA to establish a C-UAS aviation rulemaking committee (ARC) and to test C-UAS systems at five airports this year. "A timeline has not been established yet" to activate the ARC, the agency says in response to an inquiry. It was still in the planning process for choosing pilot-site airports.

Sen. Edward Markey (D-Mass.), who has been outspoken on federal law and policy related to drones, has urged the FAA to select Boston's Logan International Airport as one of the five sites.

Well before the Gatwick drone scare, the FAA entered into a cooperative research and development agreement with defense contractor CACI International in October 2015 to test the latter's SkyTracker system, which it evaluated over five days in January-February 2016 at Atlantic City International Airport, New Jersey—the first drone detection research at a U.S. commercial airport.

The FAA and other federal agencies also have tested drone-detection systems at Denver, Dallas-Fort Worth, and New York JFK international airports as well as at Eglin AFB in Florida.

CLASSIFIED ADVERTISING

To Place Your Classified Ad Contact Steve Copley
440-320-8871
stephen.copley@aviationweek.com

ADVANCED COMPOSITE TRAINING

ABARIS TRAINING
www.abaris.com
ADVANCED COMPOSITE TRAINING & SERVICES

EQUIPMENT

Matec Instrument Companies

⇨Complete ultrasonic system integration
⇨Multi-axis gantries and immersion tanks

Northborough, MA | Banning, CA
508-393-0155 | sales@matec.com | matec.com

COURSES

Dan Raymer Wrote The Book – Come Take His Class and Get It First-hand

Aircraft Conceptual Design April 20-24
Config. Layout, Loft, & CAD April 25

crc@aircraftdesign.com
www.aircraftdesign.com

MROLinks
Visit MROLinks.com
AVIATION WEEK NETWORK
Marketplace
Where buyers and suppliers connect.

AVIATION WEEK NETWORK

Know. Predict. Connect.

Let us help you find the talent you need to grow your business!

Aviation Week Network's recruitment portfolio provides unparalleled reach into the largest, most dynamic market in the world.

Build your recruitment portfolio today!

To Learn More, Contact:

Steve Copley | +1 440 320 8871 | stephen.copley@aviationweek.com

Contact Us

President/Publisher: Gregory D. Hamilton;
+1 (212) 204-4368; hamilton@aviationweek.com

Managing Director, Global Media: Iain Blackhall (UK);
+44 (0)20 7975 1670; iain.blackhall@aviationweek.co.uk

U.S. Sales Offices

Managing Director, Americas: Beth Wagner;
(202) 517-1061; beth.wagner@aviationweek.com

Director, Commercial Sales: Tom Davis;
(469) 854-6717; tom.davis@aviationweek.com

International Regional Sales Offices

Publisher, Defense, Space & Security:
Andrea Rossi Prudente (UK); +44 (207) 182 4524;
andrea.rossiprudente@aviationweek.co.uk

Marketing Services

Director, Digital Customer Solutions: Jason Washburn;
(216) 931-9161; jason.washburn@informa.com

Sales Team Listings: @AviationWeek.com/sales-contacts

Business/Production

Senior Manager, Ad Production: Jim Heffron;
(630) 524-4552; jim.heffron@informa.com

Production Coordinator: Kara Walby;
(913) 967-7476; kara.walby@informa.com

Advertising/Marketing Services

Media Kits, Promotions or Custom Media:
www.aviationweek.com/mediakits or Elizabeth Sisk;
(860) 245-5632; elizabeth.sisk@aviationweek.com

Business and Finance Manager: Gabriel Balmes;
+44 (0) 7881-010660; gabriel.balmes@informa.com

Subscriber Service

U.S.: (800) 525-5003
Outside the U.S.: +1 (847) 763-9147
Manage Your Subscription (and Claim Digital Edition) at:
aviationweek.com/awstcustomers

Conferences/Exhibitions

www.aviationweek.com/events:

To Sponsor/Exhibit: Beth Eddy;
(561) 279-4646; betheddy@aviationexhibits.com

To Register: Virginia Gongora;
(212) 204-4202; virginia.gongora@aviationweek.com

AW&ST Mailing List Rental and Sales

Mary Ralicki: (212) 204-4284; mary.ralicki@informa.com

Reprints, Photocopies and Permissions

Custom Reprints: Brett Petillo; bpetillo@wrightsmedia.com
Wright's Media, 2407 Timberloch Place, Suite B
The Woodlands, Texas 77380
Office: (281) 419-5725
Toll Free: (877) 652-5295
Cell: (281) 853-5434
Fax: (281) 419-5712
www.wrightsmedia.com

Social Media

Join the conversation. Follow us at:

linkedin.com/company/aviation-week

Twitter.com/AviationWeek

Facebook.com/AvWeek

YouTube.com/AviationWeek

Member of Audit Bureau of Circulations and Magazine Publishers of America. Published bi-weekly, with one issue in August by Informa Markets, a trading division of Informa PLC, 9800 Metcalf Ave., Overland Park, KS 66212-2216. Periodicals postage paid at Kansas City, MO and additional mailing offices. Canadian GST #R126431964. Title reg.® in U.S. Patent Office.

Postmaster: Send address changes to *Aviation Week & Space Technology*, Attention: Subscription Services, P.O. Box 1173, Skokie, IL 60076.

Aviation Week & Space Technology
605 Third Avenue, New York, NY 10158
February 10-23, 2020 VOL. 182, NO. 03
(ISSN 0005-2175)

Aerospace Calendar

To submit Aerospace Calendar Listings
email: aero.calendar@aviationweek.com

Feb. 25-26—Paris Space Week. Air and Space Museum. Paris. See paris-space-week.com

Feb. 26-April 2—RTCA Plenary Sessions. Various locations. See rtca.org/content/upcoming-committee-meetings

Feb. 25-26—AIME-Aircraft Interiors Middle East. Dubai World Trade Centre. Dubai. See aime.aero

Feb. 25-28—Aerospace Europe Conference (AEC2020). Bordeaux Congress Center. Bordeaux, France. See aerospace-europe2020.eu

Feb. 26-28—2020 Air Warfare Symposium. Rosen Shingle Creek Hotel. Orlando, Florida. See afa.org/events/calendar/2020-02-26/air-warfare-symposium

Feb. 29—GoFly Final Fly Off. Moffett Federal Airfield. Santa Clara County, California. See goflyprize.com

March 2-3—U.S. Naval Institute/AFCEA International WEST Conference. San Diego Convention Center. San Diego. See usni.org/events/west-2020

March 3-5—JEC World—The Leading International Composites Show. Paris-Nord Villepinte. Paris. See jec-world.events

March 4-5—Aviation Africa Summit & Exhibition. Ethiopian Skylight Hotel. Addis Ababa, Ethiopia. See aviationafrica.aero/home

Aviation Week Network Events

+1 (800) 722-6344 or Events.AviationWeek.com/

Feb. 24-26—MRO Middle East Summit & Expo. Dubai.

March 2-3—CAPA Middle East & Africa Aviation Summit. Dead Sea, Israel.

March 8-10—Routes Asia 2020. Chiang Mai, Thailand.

March 9-11—Commercial Aviation Industry Suppliers Conference. Beverly Hills, California.

March 9-11—Aerospace Raw Materials & Manufacturers Supply Chain Conference. Beverly Hills, California.

March 11-12—MRO Australasia. Brisbane, Australia.

March 12—Aviation Week Laureates Awards. Washington.

April 1-2—CAPA Airline Leader Summit: Making Money 2020. Dublin.

ADVERTISERS IN THIS ISSUE

VIEWPOINT

Why You Should Not Be Ashamed To Fly

By **George Novak**

Despite a recent record-breaking holiday travel season in the U.S., the concept of "flight-shaming" is gaining ground in Europe. Thanks to the environmental advocacy of activists such as Greta Thunberg, the public is being told to avoid airplanes and instead use mass ground transport. They are right that we need to do our share to reduce carbon emissions. It is just that choosing a train or bus ride in lieu of a flight is not always the most environmentally friendly option.

"SOMETIMES A FLIGHT CAN BE THE MORE ENVIRONMENTALLY FRIENDLY WAY TO TRAVEL."

AMTRAK (LEFT) AND JOEPRIESAVIATION.NET

Demonizing airlines, which provide safe and cost-efficient transport, makes little sense. From aircraft built mainly of lighter composites and ever more fuel-efficient engines to the use of sustainable aviation biofuels, the aviation industry is constantly seeking ways to improve performance. And airlines are working with agencies, such as the FAA, to design more direct and fuel-efficient flightpaths. This is simply good business, since reduced fuel consumption lowers costs as well as CO_2 emissions.

Still, it is worth asking the question: Are there viable alternatives to air travel to domestic points in the U.S.? I recently took a business trip from Washington to St. Louis by rail to put the tenets of "flight-shaming" to the test. The results were eye-opening.

If we accept a widely cited figure that railroads output 30% less carbon per passenger-mile, we must examine the routes they take to deliver passengers to their destinations in the U.S. A train journey frequently requires in excess of 30% more miles than a flight, quickly eroding the carbon-emissions-per-passenger-mile argument.

In this case, I took an overnight train through Chicago to get to St. Louis—a one-way trip of 1,094 mi. (1,760 km). The trip emitted 150 kg (330 lb.) of CO_2 and took 28 hr., including a 5-hr. layover in Chicago. A point-to-point return flight required only 720 mi., at a cost of 114 kg of CO_2 and took about 3 hr., including boarding and taxiing. So not only did the train ride take nine times longer and cost more, it produced 32% more in carbon emissions.

This is not a criticism of Amtrak. But if we are taking trains over airplanes to save the environment, we are failing our planet miserably.

Of course, environmentalists will argue that a high-speed rail network is friendlier to the environment. This ignores the hundreds of billions of dollars it would take to build a transcontinental high-speed rail network in the U.S., the massive carbon output required for such construction and the topographical issues and population displacement required to construct direct rail routes.

Simply put, mass public transportation is not a viable, effective alternative to air travel in much of the U.S., particularly because the existing airport network is already in place, and the U.S. government has been working with all stakeholders in the aviation community to make air travel safer, more efficient and cleaner.

Instead of being rewarded for providing safe, affordable and environmentally friendly air transportation, the aviation industry is under attack. Regulators are examining a mandate to remove seats to provide extra room for passengers. Such a rule threatens unintended consequences for the environment. If fewer passengers fly per aircraft, more flights will be required, leading to the production of more CO_2 emissions. That kind of regulation also could lead to the elimination of marginally profitable routes that serve less populated areas and force would-be passengers to drive long distances.

We should be working together to ensure the U.S. aviation industry can meet the ambitious goals for carbon reduction to which it has already committed. In an International Air Transport Association statement a decade ago, the aviation industry set: "three sequential goals for air transport: (1) a 1.5% average annual improvement in fuel efficiency from 2009 to 2020, (2) carbon-neutral growth from 2020 and (3) a 50% absolute reduction in carbon emissions by 2050." We don't take that commitment lightly.

In the end, my isolated experiment taught me a number of lessons. Passenger rail has a place for highly traveled and shorter routes such as in the busy Northeast Corridor connecting Washington and New York. However, air travel remains the safest, most fuel-efficient and most environmentally friendly option for much of the U.S. population. Our nation cannot afford to undermine the viability of its safest and most efficient transportation network.

I love the Earth, and I'm certainly not ashamed to fly. Nor should anyone be.

George Novak is the president of the National Air Carrier Association.

36TH SPACE SYMPOSIUM

SPACE FOUNDATION

The Broadmoor Hotel • Colorado Springs • Colorado • USA

March 30 – April 2, 2020

Where the World and Space Connect

Featuring Global Thought Leaders

Dr. Mohammad Nasser Al Ahbabi
Director General
United Arab Emirates Space Agency
(UAESA)

The Honorable Barbara M. Barrett
Secretary
United States Air Force

James Bridenstine
Administrator
NASA

Leanne Caret
Executive Vice President
The Boeing Company
President and Chief Executive Officer,
Defense, Space and Security

Prof. Dr. Pascale Ehrenfreund
Chair of the Executive Board,
German Aerospace Center (DLR)
President, International
Astronautical Federation (IAF)

Gen. John W. "Jay" Raymond, USAF
Chief of Space Operations
United States Space Force
Commander, United States Space Command

Dr. William Roper
Assistant Secretary
Air Force Acquisition,
Technology and Logistics

The Honorable Wilbur L. Ross, Jr.
Secretary of Commerce
Department of Commerce

BUILD YOUR UNIVERSE.

Where Ideas Launch • Connections Are Made • Business Gets Done

SpaceSymposium.org +1.800.691.4000 Share: #36Space #SpaceSymposium

Official Media Partner

AVIATION WEEK NETWORK

Technology that lets pilots focus on the fight.

Securing vertical lift superiority in the multidomain battlespace will require even greater mission capabilities than are available today. Featuring flexible and intelligent systems, the agile, lethal and survivable RAIDER X™ provides both pilots and warfighters on the ground the reach, protection, and lethality required in the most demanding and contested environments.

Learn more at lockheedmartin.com/raiderx

Lockheed Martin. Your Mission is Ours.®

SIKORSKY
A LOCKHEED MARTIN COMPANY