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2019 PHOTO ISSUE

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December 9-22, 2019 · Volume 181 · Number 24

FEATURES

DEPARTMENTS

42

Photographer Avichai Socher of Givat Shmuel, Israel, captured this Israeli Air Force C130j "Shimshon" combing the sky with flares as the Sun set.

ON THE COVER

The Red Arrows, the Royal Air Force Aerobatic Team, flies above Horseshoe Falls, the largest of three waterfalls comprising Niagara Falls on the U.S.-Canada border. The Sun casts a shadow from their contrails on the fast-moving waters below. See the winners and editor's picks from the 2019 Aviation Week Photo Contest beginning on page 42. This year more than 250 photographers from 27 countries vied for the title of "Best of the Best," submitting more than 800 photos. Photo by Sean Hower of Haiku, Hawaii.

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FEEDBACK

WORTH 1,000 WORDS

Thank you for the informative and well-researched article "The Pilot Challenge, Skills and Supply" *(Oct. 28-Nov. 10, p. 44)*. I was surprised and disappointed with the cover photo, however. The whole gist of the article seemed to be how the aviation industry can lure more women and minorities into the field. Surely you could have done better than this? Rather than going with the status quo, why not try to be part of the solution?

I have been flying commercially for 29 years and currently fly cargo internationally. I am happy to say that my employer has done an excellent job of hiring a diverse pilot group.

Jennifer Anderson, Anchorage, Alaska

SAFETY FIRST, SECOND AND THIRD

I spent 34 years in the U.S. Navy flight-test community, much of it involved with flight control system development tests. Several thoughts came to mind after reading "Operationally Challenged" *(Nov. 11-24, p. 24)*.

The first is that this is another example of commercial airline pilots who have become overly dependent on automation and lose control of the aircraft because they don't understand what a system is doing, and they can't fly the aircraft manually. While I agree the Boeing 737 MAX Maneuvering Characteristics Augmentation System control law was deficient, lack of documentation of it in the flight manual is not an excuse for failing to shut off electrical power to the trim system.

My second thought concerns the angle of attack (AOA) system. The aircraft I worked with had to undergo a post-maintenance or functional check flight (FCF) following an AOA sensor replacement. The pocket checklist for these aircraft contained a table of data the pilot could use on any flight to verify the system was working properly. It would be inconvenient to the airlines, but the certification authorities should consider requiring an FCF after an AOA sensor replacement for aircraft that use AOA data to compute flight or engine control actuator commands.

The third thought is that it is not in the general public's interest to have commercial aircraft flying overhead with anything less than two well-trained pilots in the cockpit. Advocates for reducing the flight deck crew from two to one or zero are driven by economic considerations, not safety.

Kevin L. Smith, California, Maryland

THE TRANSFORMATIVE POWER OF AVIATION

With regard to "Tough Choices" *(Oct. 14-27, p. 46)*, let's keep things in perspective. A widebody aircraft carrying 300 people from Australia to Europe using just over 100 tons of fuel equates to 150 mi. per gallon per person, which is approximately four times better than an average car. Smaller aircraft can be more efficient, though obviously very short hops are less so.

Other than medical advances, the aircraft industry has caused the best life improvement for billions of people. Millions of lives have been transformed by the emergence of tourism industries in exceptionally poor areas. Millions of farmers would not have a market for their produce if not for air cargo. And my own country, Ireland, held thousands of "American wakes," literally "funerals" for living people emigrating, because they would not be seen again.

This is not to say we cannot and should not improve. Climate change is very real and very worrying. And while the space industry has brought huge benefits (communications, aerial mapping, GPS, etc.), it is not fuel-efficient. Space travel just for fun needs to be rethought. Mankind is up to the problem; it has faced many issues in the past and come through.

Finbar Constant, Cork, Ireland

BACK TO SEATTLE

Good to read Tony Velocci again in "Up Front" *(Oct. 28-Nov. 10, p. 12)*. A seismic culture shift began in 2001, when Boeing moved 2,000 air miles away from its airplane-centric engineering roots in Seattle to finance-centric Chicago. Is it any wonder, Boeing lost its way?

The first thing Dennis Muilenburg's successor should do is to return Boeing to its roots and move back to Seattle.

Richard L. Hackmeister, Fort Lauderdale, Florida

ONLINE, in response to "Lockheed And Pentagon Joust Over Lucrative F-35 Data Rights," *Paladin* comments:

If LM developed the algorithms on their own nickel, there are IR&D records: technology and financial.

pkpmt@comcast.net replied:

True. And having worked for NASA contractors for over 30 years, I find the idea that LM developed that software on their own dime laughable. Those guys don't do anything on their own dime!

In response to "Opinion: How The 2020 Election Is Likely To Affect Defense," *fdmoore@ieee.org* writes:

Those of us who are invested in aerospace and defense companies care quite a bit about politics—it hits us in the net worth. Must look beyond the media BS to divine the likely impact of various hustlers running for office, and AWST can help us with that. Keep up the great work.

And *brbloom@mchsi.com* notes:

Overall, a pretty solid analysis of the political landscape. I would like to see a similar analysis of the impact of 2020 on the manned space program.

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

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WHO'S WHERE

Adina-Ioana Valean of Romania has been greenlighted as transport commissioner for the *European Commission* by the European Parliament. Among her responsibilities will be to work to fulfill European Commission President Ursula von der Leyen's plan to make the EU carbon-neutral by 2050.

Mike King has been hired as *FlightSafety International* president of services, overseeing aircrew training and contractor logistics worldwide. King, who worked at FlightSafety in 1990-2014, was chief operating officer at Simcom Aviation Training. He succeeds Hector Zarate.

Panasonic Avionics has hired **Ken Sain** as CEO. He succeeds Hideo Nakano, who will become a special advisor. Sain was vice president of digital solutions and analytics at Boeing Global Services and before that, CEO of Jeppesen, a Boeing subsidiary.

Cadence Aerospace—Tell Tool has appointed **Bernard P. Chowaniec** as vice president/general manager. **Edward Torres**, who was vice president and general manager for Cadence—Tell Tool, succeeds Chowaniec as vice president of operations at Cadence Aerospace.

Trenchard Aviation Group has hired **Martin Longden** as vice president of interiors. He previously held leadership roles for a maintenance, repair and overhaul company handling 60 airlines at more than 20 locations.

Tim Fagan has been appointed chief of industrial design for *Aerion Supersonic*, where he will lead the AS2 supersonic business jet interior design team. Fagan led industrial design of the Bombardier Global 7500 interior and the Bombardier Global 5000 and Global 6000 Premier Cabin

Western Aircraft, a Greenwich AeroGroup aircraft repair company, has promoted **Steve Myers** to jet service manager, **Steve Rozbora** to turboprop production manager and **Beau Hawkins** to avionics sales manager.

Astroscale, the nascent space-debris removal service aimed at securing long-term orbital sustainability, has hired **Gene Fujii** and **Mike Lindsay** as chief engineer and chief technology officer, respectively. Fujii was Orbcomm space segment vice president, and Lindsay was OneWeb director of spectrum architecture.

Centauri, an engineering, intelligence, cybersecurity and advanced technology company, has hired U.S. Air Force Col. (ret.) **Elena Oberg** as senior systems engineer and program manager. She was vice commander at the U.S. Air Force Research Laboratory at Wright-Patterson AFB, Ohio.

Salvatore Sciacchitano has been elected president of the *International Civil Aviation Organization* for a three-year term starting in January. He succeeds Olumuyiwa Benard Aliu of Nigeria, who held the position for two consecutive terms.

Thomas L. Fagan has been named *Space-Eyes* senior vice president of business development and government affairs. He had worked as an executive at BAE Systems, Lockheed Martin, ITT Defense, General Electric and was a Drexel University associate research professor.

Jobby George has been appointed general manager of *Air Partner*'s new office in Dubai. George has extensive experience in VIP and commercial aviation in the region and was commercial manager at Dubai-based Chapman Freeborn.

The DAES Group has hired **Jeffrey Long** as director of capital equipment Americas. Long was an airline pilot for Piedmont/American Airlines.

The General Aviation Manufacturers Association's (GAMA) senior-level policy committee for 2020 will include **David Paddock** of Jet Aviation as chairman, **Nicolas Chabbert** of Daher as vice chairman and **David Van Den Langenbergh** of Luxaviation, who will chair the European leaders steering committee, a new position. **John Knudsen**, Bye Aerospace general counsel, also has joined the GAMA board.

The International Aircraft Dealers Association has named **Paul Kirby** board chairman for 2020-21. Kirby, who is the QS Partners brokerage managing partner, succeeds Mente President and CEO Brian Proctor.

GE Capital Aviation Services has promoted **Greg Conlon** to president/CEO from executive vice president and manager of aircraft trading and business development. He succeeds Alec Burger, who will continue as president and CEO and will serve as board chairman.

HONORS AND ELECTIONS

Barbara Walters-Phillips has been chosen to receive the *2019 Katharine Wright Trophy* from the National Aeronautic Association. The trophy is awarded annually to an individual who "has contributed to the success of others or made a personal contribution" to advancing aviation and spaceflight over an extended period of time. Walters-Phillips is being recognized for career "contributions as a pilot, mentor, community advocate, and educator."

Robert Ireland has been given the inaugural S*AE International Contributor of the Year Award*. Ireland, Airlines for America managing director of engineering and maintenance, is being honored for his ongoing commitment and contributions to SAE and the entire mobility industry.

John O'Donnell, former Albany International Airport CEO, has received the *2019 Bill Shea Aviation Award* from the New York Aviation Management Association.

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.*

FIRST TAKE

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COMMERCIAL AVIATION

BOEING

Boeing rolled out the 737 MAX 10 at an employee-only event on Nov. 22. Scheduled to fly in 2020, the MAX 10 is 64 in. longer than the MAX 9, giving it a two-class capacity of 188-204 passengers.

United Airlines has ordered 50 Airbus A321XLRs to replace Boeing 757s, casting further doubt on Boeing's business case for launching development of the new midmarket airplane (page 32).

The steps required to deliver hundreds of stored aircraft have convinced the FAA it needs to take over issuing airworthiness and export certificates for Boeing 737 MAXs once cleared to return to service.

CRAIC will establish the CR929 engineering center in Moscow, following protracted negotiations between the Russian and Chinese partners in the widebody airliner program launched in 2016.

The EU failed to prove it removed illegal subsidies for the Airbus A380 and A350, the World Trade Organization has ruled, reaffirming its approval for the U.S. to apply up to $7.5 billion in punitive tariffs.

The European Union Aviation Safety Agency has cleared Airbus to raise the maximum passenger capacity of the A350-1000 to 480 from 440, made possible by the installation of dual-line slide Type A+ exits in all four positions on both sides of the fuselage.

The fatal crash of a FlyDubai Boeing 737-800 at Rostov-on-Don in March 2016 was caused by incorrect aircraft configuration and crew piloting, says the final report by Russia's Interstate Aviation Committee.

DEFENSE

Germany's MTU and France's Safran have reached agreement on development of an engine for the European Future Combat Air System fighter, paving the way for a demonstrator to fly in 2026.

France has launched the production phase of the Archange signals intelligence program, which will replace two Transall C-160 Gabriels with three modified Dassault Falcon 8Xs beginning in 2025.

New secure communication systems and data links to improve interoperability are at the heart of a $1 billion upgrade to NATO's fleet of Boeing E-3A Sentry airborne early warning aircraft.

Spain's Indra is to lead development of a European airborne electronic attack escort-jamming system to be funded through the European Union's Permanent Structured Cooperation initiative.

Spain has chosen Pilatus' PC-21 turboprop trainer to replace its air force's fleet of locally developed CASA C-101 Aviojets, tender documents show.

TURKISH AEROSPACE

Turkish Aerospace has rolled out the first of 109 locally assembled T-70 Black Hawk helicopters to be built under the Turkish Utility Helicopter Program. Deliveries are set to begin in 2021.

India will receive its first Russian S-400 Triumf long-range surface-to-air missiles in September 2021, Alexander Mikheev, head of the Rosoboronexport weapons trade agency, has told *RIA Novosti*.

VIEW FROM SEVILLE

A Vote of Confidence in Space

The 22 member states of the European Space Agency (ESA) have approved the most ambitious plan yet for the region's space sector—pledging a record €14.4 billion ($15.8 billion) over five years, securing current programs and paving the way for more.

One of the winners at the Nov. 27-28 ministerial meeting was the Copernicus Earth-observation program. With €1.9 billion in funding over three years instead of the proposed €1.4 billion, it will benefit from improved performance that allows CO_2 emissions to be more accurately monitored.

Cooperation with NASA and other agencies for exploration received strong support as the budget was boosted 30% to €1.95 billion over three years. ESA will contribute €300 million to the Lunar Gateway, starting with a communications system. Funding for the International Space Station is confirmed until 2030.

The meeting also launched the Space Rider reusable spaceplane program and studies of launchers beyond the Ariane 6 now in development. Space Rider is an unmanned spacecraft with an 800-kg (1,800-lb.) payload and the ability to fly six times for microgravity experiments and technology demonstrations.

A new pillar has been added to ESA's activities—safety and security. It received €541 million, less than the €900 million it hoped for, but Director General Jan Woerner expressed satisfaction at seeing issues such as space debris becoming part of the agency's agenda.

VERTICAL FLIGHT

Scheduled to fly in 2020, Russian Helicopters' VRT500 coaxial-rotor light single-turbine helicopter will be powered by Pratt & Whitney's PW207 turboshaft (page 30).

Boeing and startup Kitty Hawk have unveiled a joint venture, Wisk, that is developing the Cora two-seat electric vertical-takeoff-and-landing (eVTOL) autonomous air taxi.

Airbus Silicon Valley outpost A^3 has wrapped up testing on the Vahana autonomous eVTOL demonstrator, completing 138 flights totaling 13.4 hr.

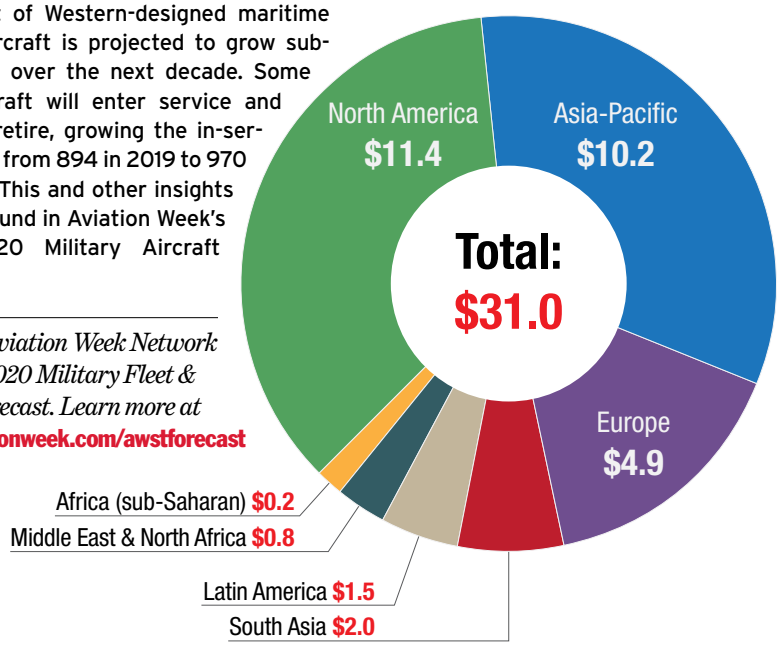
AIRBUS

Airbus has released the first image of its CityAirbus eVTOL demonstrator in tethered hover tests and says free-flight testing will begin shortly at Manching AB, Germany.

Maritime Aircraft MRO Market by Region, 2020 (U.S. $ Billions)

The fleet of Western-designed maritime patrol aircraft is projected to grow substantially over the next decade. Some 275 aircraft will enter service and 199 will retire, growing the in-service fleet from 894 in 2019 to 970 in 2029. This and other insights can be found in Aviation Week's new 2020 Military Aircraft Forecast.

Aviation Week Network 2020 Military Fleet & MRO Forecast. Learn more at **pgs.aviationweek.com/awstforecast**



OBITUARY

David Eshel, a longtime contributor to Aviation Week, died on Dec. 1 in Israel. He was 91. He was among the founders of the Israeli Defense Force's Armored Corps and Signal Corps. After his retirement from the military, he became a writer, commentator and defense analyst.

75 YEARS AGO IN AVIATION WEEK

On July 20, 1944, in the midst of World War II, the U.S. War Department announced that a Douglas C-54 Skymaster transport aircraft had made the first nonstop flight between London and Washington, covering 3,800 mi. (6,115 km) in 18 hr. McDonnell Aircraft Corp., a five-year-old military contractor that supplied the C-54's anti-drag ring cowls and wing leading-edge sections, placed an ad in our December 1944 edition to commemorate the feat. "Even in these days of globe-girding air operations, that's news," proclaimed the ad. "But after victory, such flights connecting the capitals and great cities of the world will become merely a matter of routine." The ad also hinted at McDonnell's ongoing development of the FH-1 Phantom jet fighter, which would make its first flight on Jan. 26, 1945, and go on to become the first U.S. jet to take off from and land on an aircraft carrier. "One day soon, when restrictions can be lifted, we hope to tell you about war planes of our own design and manufacture," the company said. McDonnell and Douglas merged into McDonnell Douglas in 1967.

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

UP FRONT

RICHARD ABOULAFIA

AIRBUS' DISCUSSIONS WITH GENERAL Electric on a possible new engine for the A350XWB, revealed by Aviation Week (*AW&ST* Nov. 25-Dec. 8, p. 14), threaten Rolls-Royce's most important platform. The value of forecasted Trent XWB deliveries is greater than Rolls' other commercial engine applications combined, so losing it would be catastrophic.

These discussions, coupled with Rolls' decision to not offer an engine for Boeing's proposed new midmarket airplane (NMA), also come after a decade of very difficult times for the company. Broadly speaking, there are three possible long-term outcomes, the last of which would be an engine-industry game changer.

The first scenario is simplest: Rolls-Royce improves its performance on its current products, particularly the Trent 1000, and is able to convince Airbus that its UltraFan is the best engine for any future A350XWB-neo. Rolls would continue to power 100% of all Airbus

ROLLS-ROYCE

twin-aisle jets. The status quo would be maintained, with Rolls-Royce holding on as the third-largest civil engine prime, just behind Pratt & Whitney. If the UltraFan is a big success, Rolls could even regain the second spot.

The second scenario would see Rolls-Royce losing the XWB application but remaining viable as a distant-third market player. It would simply trudge along, diminished, and increasingly dependent on UK defense spending and the high-end business jet market. It might be forced to defer or cancel UltraFan.

This scenario would not be immediately fatal. The 2030s will likely see a new round of single-aisle product launches at Airbus and Boeing, and while CFM and Pratt would have the advantage as incumbents, engine company fortunes can change quickly. As Pratt's experience in the 1990s and 2000s showed, it is possible for aero-engine companies to make a remarkable recovery, even after decades of misinvestment, execution problems and other setbacks.

The third scenario is the most intriguing. For at least three decades, there has been speculation about a merger between Pratt and Rolls. GE is the dominant single-aisle engine-maker and the second-largest twin-aisle player, but Pratt and Rolls are perfectly complimentary, with the former strong in single-aisles and the latter in twins.

The latest big complication with this possible tie-up is the United Technologies-Raytheon merger now underway. While United Technologies on its own might have been a conceivable buyer of Rolls one day, the much larger Raytheon Technologies would have a very hard time convincing regulators in the U.S. and Europe to approve the acquisition. The UK government would fear Rolls-Royce being under the complete control of a much larger U.S. behemoth, particularly if the acquisition were to take place with Rolls in a greatly weakened position—the loss of its biggest platform. Indeed, a Rolls-Royce sale to a large U.S. corporation could rival the political controversy over the sale of Westland to Agusta that beset the Thatcher government in the 1980s.

But an alternative view of the Raytheon-UTC merger presents an opportunity. What if the new company decides that Pratt offers few synergies with its other aerospace units? Jet engines are their own industry segment, with discrete supply chains, business models and

Three Futures

Possible pathways for Rolls-Royce

technologies. Spinning off Pratt, combining it with Rolls-Royce and listing the new entity on the market or placing it with private equity might offer a rational solution that would be acceptable to regulators and politicians.

But would Raytheon Technologies want to monetize Pratt? There are two possible areas of synergy between Pratt and the rest of the company. The first is the aerostructures division, in the event integrated propulsion units gain traction. But it is far from clear that primes really want integrated units from one provider, as evidenced by Boeing's decision to bring 777 and 737 MAX nacelle work back in-house.

The second possible area of synergy is hybrid propulsion systems, in the event the jetliner industry embraces these in the next few decades. This remains speculative, and it is not clear that a company that designs the systems and architectures cannot just work with an independent engine company.

It is hard to handicap these three outcomes for Rolls, but the merger scenario is most rational. If Rolls loses the XWB, merging may be the company's best hope for a recovery. And Rolls' difficult position was perhaps inevitable: The aero-engine business remains a triopoly, serving a duopoly that has a diminished interest in new product launches.

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

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GOING CONCERNS

MICHAEL BRUNO

'Two Thoroughbreds'

Commercial aviation suppliers **should focus on larger narrowbodies**

A LONG, LONG TIME AGO IN A marketplace far away—i.e., this past spring just before the Boeing 737 MAX was grounded and U.S. trade wars with China and Europe were solidified—Teal Group consultant Richard Aboulafia gave a round of presentations to some aerospace manufacturing conferences. One of them was titled "Two Thoroughbreds and a Herd of Donkeys."

Aboulafia's presentations addressed the whole aviation market. While a few of the important conditions on which he based his talks have changed since then, the most important factor has not: The 737 and Airbus A320 families of narrowbody jetliners continue to make up most of the growth in the aviation manufacturing sector. By comparison, business jets, regional jets and helicopters are expected to remain muted markets, while Western military aircraft as a whole may peak in coming years.

"It all comes down to really just two programs that are propelling things here," he said in March. "This is the most targeted and narrow upturn this industry has ever seen."

November's Dubai Airshow confirms the trend, and for suppliers, the ramifications are becoming clearer. Aerospace business growth continues to be driven by the two narrowbody leaders and especially their larger variants.

"The Dubai Airshow reinforced our view of a trend toward the middle for airliners," Bloomberg Intelligence analysts George Ferguson and Francois Duflot said on Nov. 22. "Large widebodies showed how out of favor they are, as Emirates canceled some of its 777 orders in favor of smaller, long-range aircraft. The future of the narrowbody seems to be larger and longer, as Airbus' new XLR continued to take orders."

Indeed, for an airshow that traditionally has served as an extravaganza for larger widebodies because of Middle Eastern airlines' strategies, several analysts took note of the new direction.

"Most notable are the first orders for the MAX since the grounding," Jefferies analyst Sheila Kahyaoglu and her team wrote on Nov. 20. "The Emirates order also points to balanced demand for smaller widebodies relative to larger aircraft."

Canaccord Genuity analyst Ken Herbert agrees that larger narrowbodies and smaller widebodies were the airshow's highlights. "We believe the Boeing 737 MAX order activity (30 incremental orders) is a positive," he says. "These are the first firm orders since the March 2019 grounding. However, Airbus booked over 150 A320 family orders and is gradually extending its lead in the narrowbody market."

The midsize-airliner's rise to dominance is gaining momentum. Airlines want larger narrowbodies or smaller widebodies that operate at narrowbody economics. To that effect, Boeing rolled out the 737 MAX 10 in an employees-only event in Renton, Washington, on Nov. 21, a key step in its effort to slow the Airbus A321neo's ascendance. At the same time, the embattled OEM continues to openly mull whether to pursue a new midmarket airplane (NMA), a potential 757-replacement.

After Dubai, analysts say larger widebody opportunities remain limited. "In widebody land, there was some skepticism as to whether Boeing can simply move the 787 rate back up to 14 a month in a couple of years given current demand trends, and so that could be something that chips away at industry profit and cash estimates if the rate has to come down again," Vertical Research Partners wrote on Nov. 22.

Inside the supply chain, opinions differ on how diversified a supplier should be. Some CEOs think a myriad of revenue streams is critical to business sustainability; others see the benefits of focused factories. But practically all executives will say the key is to be a supplier on the right programs, and not just a widget-maker for anybody who wants to come along and build an airplane.

According to Teal's Aboulafia, only large jetliners and military fighters have shown compound annual growth rates (CAGR) over the years (see table). While the 737 and A320 have their issues, the two programs remain the favorites without a doubt and are increasingly setting themselves apart from all the rest.

"If you are exposed to these products, you are a happy supplier," Aboulafia said in one of his spring presentations. "Everything outside the two thoroughbreds are just milling around in circles."

Aircraft Growth—and Not

World New Deliveries in 2018 (2019 $ billions)		CAGR 2003-08	CAGR 2008-14	CAGR 2014-17	Change 2017-18
Large Jetliners	$111.6	7.4%	9.9%	2.8%	4.3%
Business Aircraft	19.8	16.7	-1.9	-6.0	-1.4
Regionals	6.2	3.9	-3.1	-4.3	-7.8
Civil Rotorcraft	4.5	19.8	-2.0	-9.4	4.6
Military Rotorcraft	11.4	9.8	9.8	-9.3	-12.6
Military Transports	6.0	3.2	-0.7	2.6	-5.2
Fighters	18.6	1.6	0.8	1.0	3.9
All Civil	142.2	9.8	5.5	0.5	2.9
All Military	39.9	3.7	4.1	-2.6	-2.9
Total	$182	8.0%	5.1%	-0.2%	1.6%

Source: Teal Group

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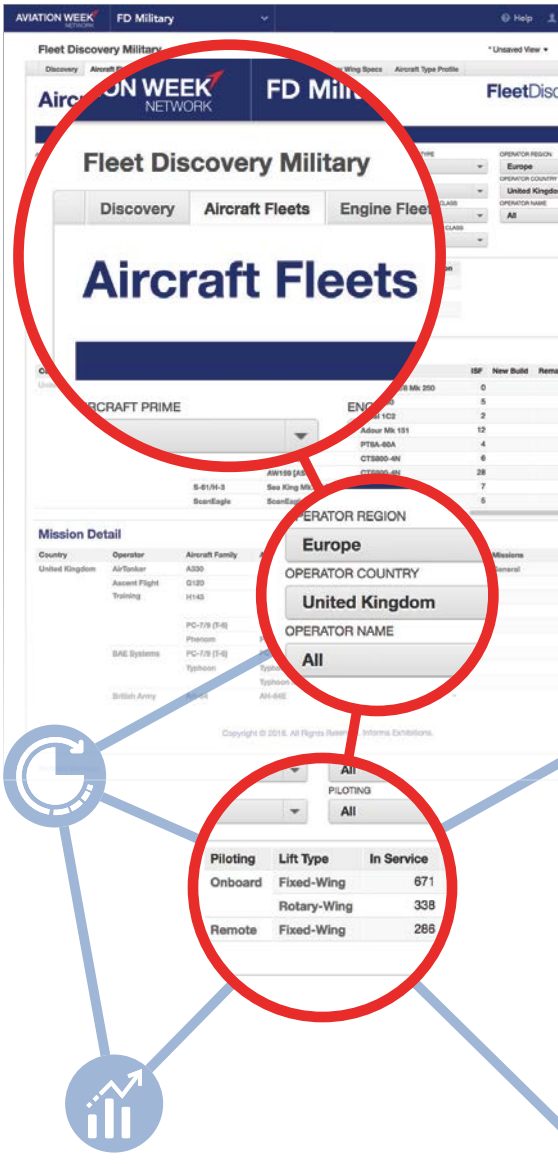

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AIRLINE INTEL
JENS FLOTTAU

EVER SEEN THIS ADDRESS: 717 S. Desplaines St., Chicago, Illinois, 60607? No surprise if not, because it isn't in an area the occasional Chicago visitor would see. It is on the eastern outskirts of downtown, an industrial-looking place between old and new warehouses and parking lots, the city's impressive skyline already at a distance. It is also where United Airlines is training for change.

The hangar, called Backstage by the airline, is a transformation tool and a legacy of CEO Oscar Munoz, who will become executive chairman in May and be succeeded as CEO by United President Scott Kirby. Thousands of employees have been channeled through the building to be shown what United wants to be about: good service, modern aircraft, comfortable cabins (at least on par with the industry's leading carriers) and more digital and smarter operations.

Needless to say, United had to transform itself. Its reputation for treating customers was horrible, its on-time performance lagged, and the fleet was old, as was the look of its cabins. It was losing out in the U.S. domestic market to rivals American Airlines and Delta Air Lines despite its hubs being in the best locations imaginable—Chicago, Denver, Houston, Newark (New Jersey), San Francisco and Washington. The airline did not take enough advantage of what connectivity it could offer through its biggest hubs. Even with major benefits from industry consolidation, United was less profitable than its peers.

Such turnarounds of large corporations are never easy and never happen quickly. A lot of unrefurbished cabins continue to fly that are not competitive internationally. But there are improvements, as many frequent-fliers will observe, to product standards and on-time performance, among other things. Munoz and Kirby have managed to change the story line to an extent.

Many wonder how United can make money with its fast-growing fleet of Bombardier CRJ550s, regional jets with space for 70 seats that are being used in 50-seat layouts including 10 in first class, 20 in economy plus and 20 in regular economy. The usage indicates the airline is betting on convincing premium customers with an upgraded product, an interesting concept for airlines accustomed to slimming down offerings so they can compete with low-fare carriers. Another topic of discussion is what United's large Airbus A321XLR order means for the industry (see page 32).

As far as delays and cancellations are concerned, American's reputation is now suffering from many disruptions.

So is all well again with United?

Over the last few years, management has put the house in better order by focusing inward. What is still missing is the next strategic step. That is where Delta is ahead. Its investments in markets important to it are scaring its competitors, even when the potential target is such a malfunctioning company as Alitalia. Delta managed to eclipse other carriers in Latin America through its proposed investment in LATAM Airlines. It already has a foothold in Europe and China.

Delta is thinking beyond alliances, making them almost obsolete and replacing them with something stronger. And it isn't the only carrier doing that: Qatar Airways has bought stakes in LATAM and Cathay Pacific and is the biggest shareholder in International Airlines Group (IAG). And now CEO Akbar Al Baker has raised the possibility of investing in Lufthansa.

JOEPRIESAVIATION.NET

The German carrier reacted strongly: "We did not privatize Lufthansa in Germany only to have it renationalized in Qatar." Its overblown reaction shows a measure of nervousness; after all, Qatar could simply choose to buy stock on the market, and no one could stop it. On the other hand, Al Baker dropped the idea of buying a stake in American after that carrier's management made it abundantly it clear it was not in favor.

But back to United: Given the level of profitability of the U.S. airline industry, Delta should not be the only one spending money on things other than aircraft. United owns a stake in Azul and has indirect control of Avianca Holdings, but collective bargaining agreements with pilots limit its flexibility to control other carriers, even if it could find a way to handle ownership and control regulations. These limitations did not really hurt in the past; executives were busy turning around an airline without much money to invest in the first place. But, again, things have changed—and they will have to continue to change if United wants to maintain its positive momentum.

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FLYING LIKE BIRDS

> AIRBUS LAUNCHES WAKE-RIDING DEMO PROJECT

> UP TO 10% LESS FUEL BURN IN A380 TESTS

> AIRLINES TO PARTICIPATE IN TRIALS

Airbus plans to start wake uplift trials in 2020.

Jens Flottau Dubai and **Graham Warwick** Washington

The air transport industry is under immense public pressure to reduce its environmental footprint and reverse a negative trend resulting from its rapid growth since the end of the global financial crisis 10 years ago. As one of many initiatives, Airbus is now trying to turn an old proposal into reality: enabling aircraft to ride the wake vortex of a preceding airplane to reduce fuel consumption.

The manufacturer's Fello'fly project, presented at the recent Dubai Airshow, is geared toward testing the technical feasibility of the concept while addressing as many operational issues as possible that may arise with airlines, air traffic management and regulators.

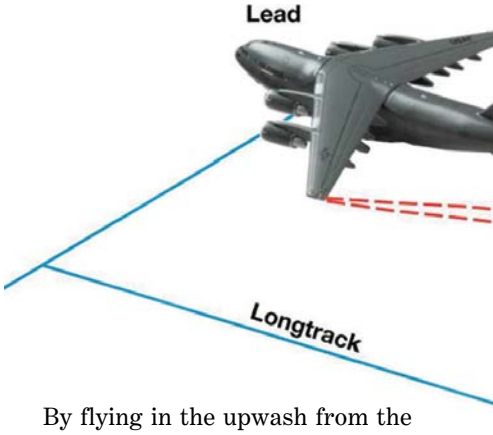
"Birds use the updraft of the bird flying ahead of them," says Sandra Bour Schaeffer, CEO of Airbus UpNext and head of the company's technology demonstrator programs. "There is lots of kinetic energy that is lost today, but we want to benefit from it in the future," she explains.

Taking advantage of the wake updraft, the following aircraft can save 5-10% of fuel by flying 1.5-2 nm behind the preceding one, according to Airbus calculations. "[The concept] has huge potential and is a very tangible solution," Bour Schaeffer says. "The air is quite smooth and therefore it is practical. There is no impact on passenger comfort." She also points out that the introduction of Airbus' "sharklets" on the A320neo required substantial structural changes to the aircraft and delivered a much smaller, 3-4%, reduction in fuel burn.

Airbus' plan to demonstrate the technical, operational and commercial viability of reducing commercial aircraft emissions through formation flying on long-haul flights builds on tests by NASA and the U.S. Air Force that show wake surfing improves fuel efficiency.

On formation flights by two Boeing C-17 airlifters between California and Hawaii in July 2013, the trailing aircraft averaged a 10% fuel saving. The potential for reducing drag by wake surfing was shown by NASA in 2001—using F/A-18 fighters flying manually and automatically in close formation, achieving a 14% fuel saving—and by NASA and the Air Force in 2010, using C-17s that were largely manually flown in extended formation, saving 7-8%.

Airbus itself tested the idea using two A380s. The flights delivered fuel-burn savings of 12%. With the announcement of the Fello'fly program, work on wake surfing is returning to Europe. The concept of reducing drag by flying in formation was first demonstrated in Germany in 1995 using a pair of Dornier Do 28s, during which the trailing aircraft achieved a 10% power reduction.



By flying in the upwash from the wingtip vortex shed by the lead aircraft, the trailing aircraft can retrim to a lower angle of attack. This helps by reducing induced drag and therefore the engine thrust and fuel flow required to maintain speed.

The attraction of the technique is that it can be employed by existing aircraft with minimal modification.

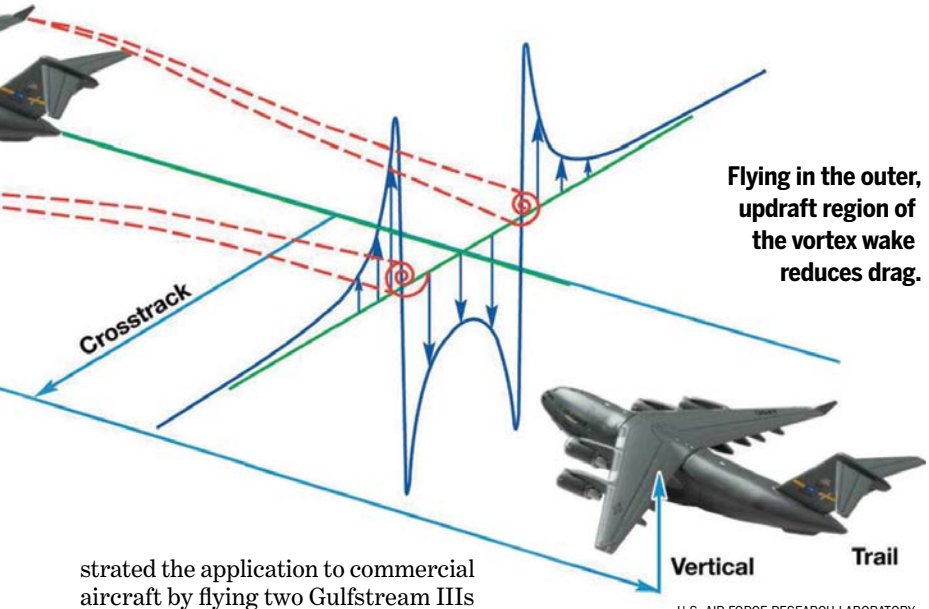
Airbus does not like to call the concept formation flying because it implies a proximity of the aircraft that may raise safety concerns and create uneasiness with passengers. However, the International Civil Aviation Organization (ICAO) refers to formations in a new working paper and reaffirms Airbus' idea. "While wake turbulence is commonly considered as a threat for commercial airplanes, this concept aims at taking benefit from the energy contained in trailing vortices, without compromising safety (which is paramount)," reads the working paper presented to the recent 40th ICAO Assembly, held

Sept. 24-Oct. 2. "Thus, positioning a trailing aircraft in a right way in the area where the vortex pushes air upward enables the trailing aircraft to save over 10% fuel."

The objective of the U.S. Air Force Research Laboratory's (AFRL) Surfing Aircraft Vortices for Energy ($AVE) flights in 2013 was to automate formation flying and show double-digit fuel-burn savings with only software modifications while not affecting the aircraft, engines or crew workload.

The mission computer was enhanced with the C-17's formation-flight system, which uses the traffic collision avoidance system data link to enable autonomous tracking of the lead aircraft. The wake was not sensed; rather the vortex location was predicted by aerodynamic analysis and wind measurements.

In December 2017, NASA demonstrated the application to commercial aircraft by flying two Gulfstream IIIs in formation. Automatic dependent surveillance-broadcast (ADS-B) "In" messages from the lead aircraft were fed into the trailing aircraft's autopilot. Again the vortex location was predicted.



AIRBUS

Flying in the outer, updraft region of the vortex wake reduces drag.

U.S. AIR FORCE RESEARCH LABORATORY

In the F/A-18 flights flown by NASA in 2001, the aircraft flew 150 ft. apart. For the $AVE trials, separation was relaxed to 3,000-8,000 ft. to reduce pilot workload. The Gulfstreams flew 4,000 ft. apart, and cabin noise as well as vibration in the trailing aircraft were measured to assess the impact of vortex turbulence on passenger ride quality.

In addition to testing the 1090 MHz ADS-B data link for cooperative-trajectory operations and wake surfing, the Gulfstream flights tested different types of wake display for the pilot and measured aileron and rudder displacements to assess the impact on the actuators.

There are, however, operational limitations to the idea. The concept's advantages play out best over long routes, so transatlantic or transpacific crossings could be the ideal environments. On short-haul services, among the many factors inhibiting success are the brevity of the cruise portion of flights and scheduling. An AFRL study in 2016 predicted fuel-burn reductions up to 7% for a C-17 on routes more than 4,000 nm Nonetheless, the study said the savings were reduced if it had to wait for the other aircraft to join the formation or hold so they could land simultaneously.

The study found there were formation-flight benefits for route lengths greater than 3,000 nm but also noted a significant reduction in the savings achieved if the trailing aircraft was required to carry fuel reserves that assumed no formation benefit.

Airbus plans to start technical feasibility flights in 2020 using two of its own Airbus A350s, building on earlier tests conducted by A380s. A year later, the manufacturer wants to start operational trials on transatlantic flight in cooperation with airlines. Bour Schaeffer says two carriers have signed up for cooperation deals, but she declined to reveal who they are.

Airbus is to provide concepts to operators about how to make the idea work but declines to reveal details. In principle, the flying-together concept can be expanded to include more than two aircraft, but Bour Schaeffer says the trials are being limited to two to reduce complexity.

The timeline suggested by Airbus is quite aggressive. Bour Schaeffer anticipates that the concept could be used for routine commercial oceanic flights by 2025. "We have lots of questions to answer, but we believe we can make it a reality," she says. Initially focused on Airbus, the platform is to be opened to include other manufacturers' aircraft. The approach Airbus is developing involves pilot assistance functions required to ensure the aircraft remains positioned in the updraft from the aircraft it is following—in other words, maintaining the same safe distance apart while at a steady altitude. The current flight control systems will need software modification, but no other changes are needed, she says, adding: "The flight control system will be able to find the right position [for the following aircraft]."

Technical concerns to be tackled include: reliably predicting wake location, ensuring that wear and tear on airframe and actuators from flying in the vortex does not reduce life and increase maintenance, and avoiding any impact on passenger ride quality.

Among the open items is certifying aircraft for shorter separation. The availability of ADS-B in oceanic airspace is an important enabler of the concept because it allows closer tracking of aircraft. Airlines will also find ways to make the idea work in daily operational conditions—potentially by adjusting schedules.

A "new end-to-end operational concept has to be developed to ensure seamless integration of automated formation flight operations in the air traffic management environment and airspace users' operations," ICAO says. "New separation schemes have to be introduced to update current standards in cruise, whatever the airspace environment."

While Airbus believes the idea can become an operational reality within the next five years, ICAO sees 10 years as a more realistic planning horizon and warns that even that is optimistic, given its own workload limitations. As a specialized agency of the United Nations, the organization suggests new ways of cooperation between states to accelerate the process.

Future Flight Management System To Cope With More Complex Airspace

> THALES' IN-DEVELOPMENT FMS TO HARNESS EFB CONNECTIVITY

> COMPUTING POWER TO HANDLE MORE THAN ONE FLIGHTPATH

Thierry Dubois Toulouse

Usually, a pilot's fingers use interfaces. But in one particular instance they are the interface—between the electronic flight bag (or EFB if the cockpit is so equipped) and the flight management system (FMS).

The EFB is a user-friendly device for pilots to prepare for their flights and also find information in flight such as an airport chart. The FMS can be likened to the brain of the aircraft, as it is connected to 30 or so systems and creates the planned flightpath. But it can be cumbersome to program.

The two systems have been kept separate because they meet different standards; the FMS needs to be extremely reliable and is thus expensive equipment. Yet their disconnection means pilots duplicate some work.

THALES

Thales is betting on the retrofit market for its future flight management system to gain maximum exposure in the pilot community.

Thales hopes for a three-pronged advance by connecting the EFB to the internet, upgrading the FMS' computing power to today's standards, and linking the two. The idea is to make pilots more comfortable with flightpath changes, increase safety with inflight information updates and ultimately improve a route's fuel efficiency.

If successful in the market, the PureFlyt FMS may be one of the tools that make increased airspace complexity feasible—to the benefit of capacity and, to a lesser extent, the environment.

Thales has yet to bring it to a certifiable level and find customers. One lesson seems to have been learned from a parallel development, the FlytX flight deck. Ready for entry into service from 2022 on regional aircraft, business jets, military transports and helicopters, it has struggled to find an application, partly due to a dearth of new aircraft programs. The first customer is Airbus Helicopters, for a military rotorcraft scheduled to enter into service in 2026.

The plan for PureFlyt starts with offering it via retrofit on commercial aircraft. Thales hopes enough operators and pilots will enjoy the system to require it on Airbus' next cleansheet design. Thales has supplied the FMS for three Airbus types—the A320, A330 and A340.

One of PureFlyt's main features is the use of "open-world" data such as weather updates from a source on the internet. The FMS therefore "sees" weather from much farther away than the onboard weather radar does.

To keep the avionics segregated from a potential threat in the open world, retrieving data is done at the EFB level. The PureFlyt software program also runs on the EFB (not necessarily Thales' Aviobook), where the crew works out an intended flightpath. Elements of the preparation—done before or during the flight—are sent to the FMS from the EFB, which is not a certified piece of equipment. The FMS then computes the trajectory with the required integrity.

Another feature is in trajectory management—PureFlyt can handle more than one flightpath. If air traffic control (ATC) asks the crew to alter its route temporarily, the FMS will maintain a plan to return to the initial route. Once ATC authorizes the crew to return to their intended trajectory, the pilots will be able to do so with one click.

Advanced trajectory management will also give the crew the ability to prepare an optimized flightpath and switch to the hoped-for trajectory as soon as ATC allows it. Rerouting to avoid a thunderstorm is automated.

Pilots will spend more time "eyes out," says Peter Hitchcock, Thales' vice president for commercial avionics.

The trajectory management function is expected to be all the more useful as aircraft become more closely spaced due to traffic growth and progress in air traffic management. Trajectories around airports are predicted to become more complex because of noise-mitigation rules. Thanks to all the possibilities for trajectory optimization, Thales calculates an average of 4% of fuel will be saved on each flight.

Benefiting from multicore computer technology, the new FMS will calculate a new route 5-10 times faster than today. "So the pilot does not have to wait for the aircraft to catch up to make a decision," says Hitchcock.

Thales' design engineers estimate most of the functions are at technology readiness level (TRL) 7-8—system/subsystem development—while a few are below TRL 5, at a research stage. Airline pilots arrive to try the ground demonstrator in Toulouse every week, according to company executives.

The first flight of a prototype is planned for early in 2020. Progress has been made since the in-development FMS was introduced in June, including in connectivity, cybersecurity and automated rerouting, according to Thales' engineers. Entry into service could take place from 2024.

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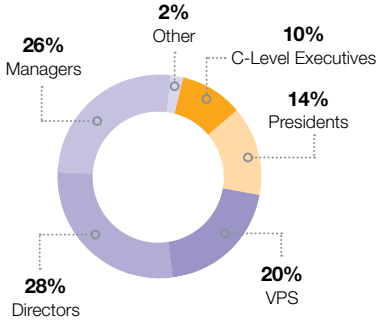

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Space Debris-Removal Demos Gain Momentum

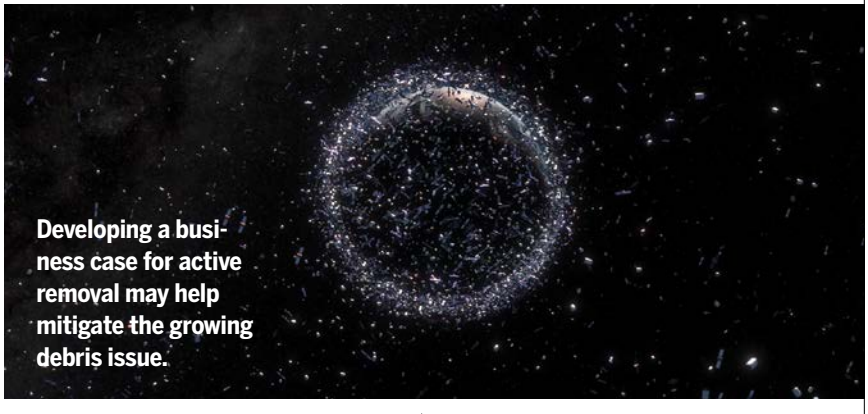
> SSTL AND ASTROSCALE LEADING DEBRIS-REMOVAL TECHNOLOGY

> ACTIVE DEBRIS REMOVAL LACKS A BUSINESS CASE

Thierry Dubois Bremen, Germany

Space debris is one of the human-made problems—along with the climate crisis and the oceans' plastic pollution, among other environmental issues—that keep growing despite persistent awareness. This may explain Jan Woerner's recent outburst. The director general of the European Space Agency (ESA) essentially said that every "good guy" in the space industry has to take action against debris. In other words, someone who does not act to deal with debris should be seen as a bad guy.

ESA



Developing a business case for active removal may help mitigate the growing debris issue.

After all, Woerner is one of the few people in the space community who represents more than one company or one country (ESA has 22 member states), so his exasperation reflects genuine concern for the collective.

Counting space debris is mind-boggling. As of January 2019, 3,050 nonoperational satellites were in orbit—61% of the total. Due to events such as explosions and collisions, 34,000 debris objects larger than 10 cm (4 in.) long are in orbit. There are also 900,000 objects between 1-10 cm, which can be harmful as well.

Woerner's statement, made on the eve of a key ESA meeting at the ministerial level, came as technology demonstrations for active debris removal (ADR) are gaining momentum. Meanwhile, some companies believe a business case can be found for satellite end-of-life servicing and ADR. However, these business cases at least partly rely on yet-to-be-issued regulations.

But Woerner argues, "we do not have the time" for rules to be written and enforced. "We should not wait for a regulation; the good guys [take action] by themselves," he says.

Woerner asserts debris-mitigation programs should include three steps. In addition to on-orbit spacecraft servicing and ADR, Woerner says the problem should be addressed at the beginning of the production cycle. A satellite should be designed to deorbit by itself, or its owner should hire a company specializing in deorbiting, he asserts. "Everybody should do that by ethics," he argues.

This view is echoed by Max Lange, Airbus Defense and Space's manager for advanced projects and products. "Who pays for something that is expensive and benefits everybody a little bit?" he asks rhetorically.

While not a binding regulation, the ISO standard for space debris has become stricter. This year, it has set the required reliability level at 90% for end-of-life satellite deorbiting. A spacecraft in low Earth orbit may no longer be disposed of above 2,000 km, meaning it has to deorbit.

But in the evolving era of mega-constellations, the 90% or even the 95% reliability some operators claim may not be enough. In a typical constellation of 10,000 satellites, 1% equates to 100 spacecraft. The pattern of trajectory-crossing in polar regions is dense, and defunct, nonmaneuverable satellites can create chaos.

Therefore ADR, which has progressively been considered as more relevant, is likely to become essential.

A spectacular demonstration was completed in January of 2019, when satellite manufacturer SSTL (an Airbus subsidiary) successfully conducted lidar and camera vision-based navigation to a target object and validated two devices to capture it—a net and a harpoon. At the end of the EU-funded RemoveDebris mission, a dragsail was deployed to deorbit the spacecraft.

In 2020, another demonstration is planned, this time for a semi-autonomous capture of a nonresponsive, tumbling satellite: Tokyo-based startup Astroscale will have its 16-kg (35-lb.) Target and 180-kg Chaser spacecraft performing a series of separation and capture maneuvers. The ELSA-d mission will use a capture-extension mechanism with a magnetic plate.

A key challenge is dealing with the tumbling rate, and Astroscale is looking for a de-spinning technology, says John Auburn, Astroscale's chief commercial officer.

Effective Space, a startup headquartered in the UK and with a research and development center in Israel, is designing an on-orbit service spacecraft first aimed at providing satellite life-extension. In a second phase, the Space Drone could perform ADR for large objects up to 10,000 kg in geostationary orbit.

But can ADR be profitable? ESA and Oneweb are funding a project to help Astroscale mature its technology. Astroscale founder Nobu Okada believes constellation operators will become its customers to keep their orbits clear of their defunct satellites, while governments should pay for the rest of ADR. Auburn predicts breakeven could be reached in 2-7 years, depending on the respective contributions of the institutional and commercial markets, the former being seen as more promising. He is planning on up to 200 commercial missions per year.

Governments should help "prime the pump," says David Henri, founder and CEO of propulsion specialist Exotrail. Institutional missions will prompt companies to develop new technologies, and first entrants will have an advantage, he says.

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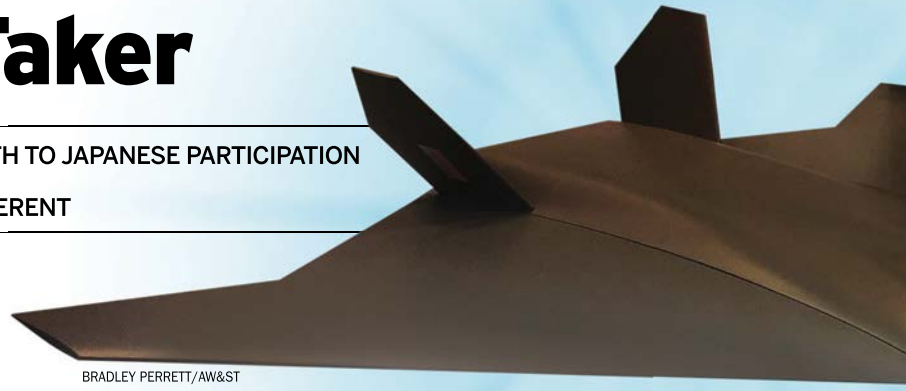
Tempest Taker



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> PROGRAM FLEXIBILITY OFFERS A PATH TO JAPANESE PARTICIPATION

> EVEN THE AIRFRAME COULD BE DIFFERENT

Bradley Perrett Tokyo

Japan says it wants international collaboration in developing its Future Fighter for the 2030s, but it wants to lead the project despite limited experience in fighter development. And it aims at a fighter much larger than any operated by a Western European country; the U.S. is not offering a possible joint project.

That seems to leave only the choice of indigenous development, perhaps with help from a foreign technical partner.

Nevertheless, participation in the UK's Tempest program may also be feasible. The Tempest project—which includes the Royal Air Force, BAE Systems, Rolls-Royce and MBDA—has a cooperation concept that leaves scope for Japan and other partners to use their own systems, weapons, propulsion and even airframes, says Air Cdre. Daniel Storr, head of combat aircraft acquisition at the UK Defense Ministry.

The model described by Storr gives Japan the flexibility to choose the size of its own fighter. Though evidently not an objective, this mix-and-match approach also creates an opportunity for Japan to continue to claim development leadership—but also to save money by sharing systems.

The policy goal of running its own fighter program, stated in 2018, has looked like a big obstacle to Japan's participation in the Tempest or the Future Combat Air System (FCAS) project initiated by France and Germany. But if the Future Fighter shared only some features with Tempest, Japan could reasonably say it was leading its own program.

BAE Systems promoted the Tempest program at the Defense and Security Equipment International (DSEI) Japan exhibition held in Tokyo Nov. 18-20. Prospective FCAS prime contractors, such as Airbus, did not show their concepts. Storr outlined the flexible model of cooperative development at an exhibition conference, but Japanese speakers at that event did not comment on the prospect of Japan joining Tempest.

Newly appointed Defense Minister Taro Kono seemed to play down the possibility of participation in a European program, telling *The Financial Times* Japan should explore all possibilities but needs to maintain interoperability with U.S. forces. Storr addressed that point, noting that working with the U.S. is a high priority for the UK, too.

Japan's alternative to international cooperation is developing a fighter by itself with the technical help of a foreign company. Lockheed Martin is supporting the Korea Aerospace Industries KF-X, and BAE is helping the Turkish Aerospace Industries TF-X in such an arrangement.

By working with Lockheed Martin, Boeing or Northrop Grumman, Tokyo would partially compensate the U.S. for its expenditures in defending Japan. But the U.S. would gain little from technical support fees, and Japan is already committed to buying 147 Lockheed Martin F-35 Lightnings as the aircraft to precede the Future Fighter.

The defense ministry has asked for development of the Future Fighter to be launched in the fiscal year beginning April 2020. It is not clear whether that means mobilizing resources to commence full-scale development or taking some lesser step to firm up the commitment to create the aircraft.

For the past year, the government's plan has been to launch no later than March 2024. However, Japanese companies, especially fighter builder Mitsubishi Heavy Industries (MHI), are pushing for a launch as soon as possible. They want to transfer knowledge to young engineers from the older generation that developed Japan's last fighter, the MHI F-2, which the Future Fighter will replace.

The UK does not want to commit to launching full-scale development of the Tempest before 2025, but its date for entry into service in 2035 meets Japan's objective, which is sometime in the 2030s. Meanwhile, the FCAS program is aiming at 2040.

Sweden and Italy are cooperating with the UK during the current early stage of Tempest research, while Spain has joined France and Germany for FCAS work.

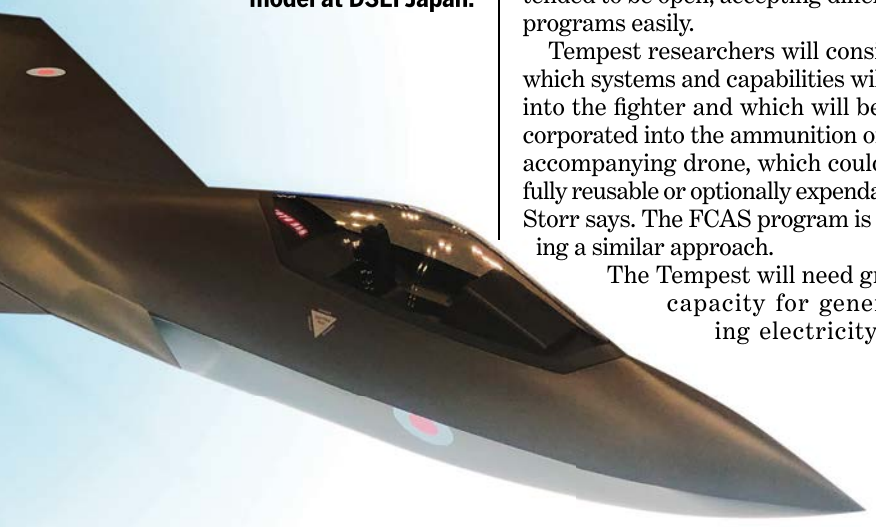
Like Storr, BAE has stressed the advantages of partners taking only as much of the Tempest as they want. "There is a range of different partnership models that can be considered," says Andy Latham, who is working on the program. "Japan has some great technology that any partner can benefit from. Their avionics industry is pretty effective."

The cooperation concept replaces the standard model, one in which partners spend years negotiating and compromising to define a design that all of them must accept. Instead, according to Storr, they can save time and money by agreeing to disagree—to the extent that each is willing to pay the extra cost of independent development and manufacturing of design elements.

The Japanese defense ministry's studies point to a need for a very big fighter with an empty weight well above 20 metric tons (44,000 lb.), larger than the Lockheed Martin F-22 Raptor. Superior endurance and internal weapon capacity are the key factors behind this choice.

No Western European country has operated a fighter more than about two-thirds as big, but Storr says a large configuration for the Tempest cannot be ruled out. The mockup exhibited at the 2018 Farnborough International Airshow was bigger than the F-22.

Still, the UK and other European partners might want a much smaller



BAE Systems exhibited this Tempest model at DSEI Japan.

fighter; concept designs that have not been shown are not as big as the mock-up. But the concept for cooperation would allow for Japan to devise its own airframe while, for example, using the same engine and some weapons, software and avionics as other partners.

The architecture of the software is intended to be open, accepting different programs easily.

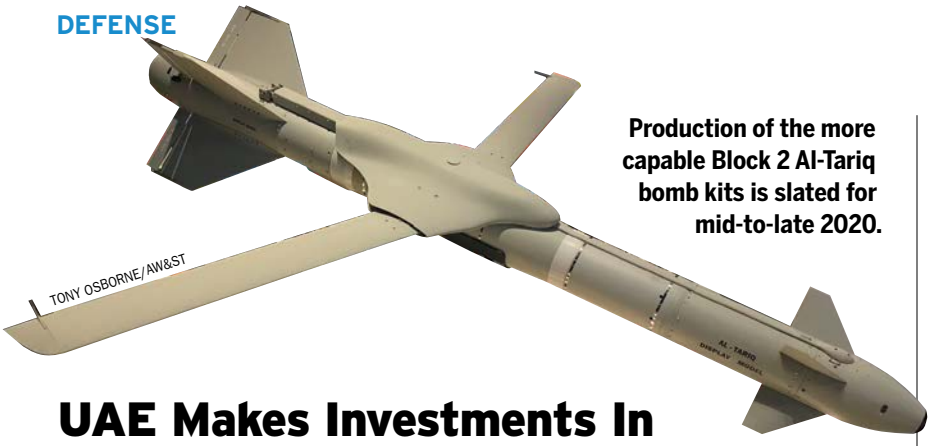
Tempest researchers will consider which systems and capabilities will go into the fighter and which will be incorporated into the ammunition or an accompanying drone, which could be fully reusable or optionally expendable, Storr says. The FCAS program is taking a similar approach.

The Tempest will need great capacity for generating electricity, he says, and the weapon bay should be regarded as a payload bay, perhaps for holding additional fuel that would extend endurance on surveillance missions.

The Japanese finance ministry is insisting upon private investment in the Future Fighter program, in part to ensure contractors are fully incentivized to avoid failure. Contractors will be able to make money in civil programs from technology developed for the fighter, says the ministry, which is highly influential but does not have a final say.

"Judging from past program examples, it is clear that the Future Fighter program would bring a risk of a budget overrun and schedule slippage, but would also benefit the private sector," the finance ministry said in an October presentation to the Council on Fiscal Policy, an advisory body. "The government and private sector should invest funds and resources to build a failure-proof framework."

Noting that MHI used technology from the F-2 program in its development and manufacturing of the outer wingboxes of the Boeing 787, the ministry says contractors can expect to gain similar opportunities for civil applications of technology from the Future Fighter program—so they should invest in it.



TONY OSBORNE/AW&ST

Production of the more capable Block 2 Al-Tariq bomb kits is slated for mid-to-late 2020.

UAE Makes Investments In Precision-Guided Munitions

> MBDA TO WORK WITH TAWAZUN TO DEVELOP SMARTGLIDER WEAPON

> EDGE DEVELOPING MORE CAPABLE AL-TARIQ BOMB KIT

Tony Osborne Dubai

The United Arab Emirates (UAE) is taking major steps to develop indigenous capabilities to develop air-dropped weapons.

Like their neighbors in Saudi Arabia, the Emiratis envision developing high-tech defense capabilities and exporting them. But the move also reflects the Gulf state's recent struggles in procuring advanced weapons from the U.S.

In July, Congress blocked plans to transfer guided rockets and missiles to Abu Dhabi and Riyadh over humanitarian concerns about the Saudi-led campaign in Yemen. Only President Donald Trump's controversial veto of the congressional resolutions allowed the transfers to take place.

Today, the UAE may be trying to extricate itself from the Yemeni conflict, but recognition of the need to secure the supply lines for munitions to support its hard-hitting air power capability is still a priority. What is emerging is a highly specialized capacity to produce bespoke but valued precision-guided air-to-ground weapons.

The UAE is no stranger to weapons development. In the 1980s, it worked with Britain's Marconi Dynamics to develop a bespoke weapon—the PGM500, a family of glide bombs with laser, TV and infrared-imaging seekers, known locally as the Hakim, which were developed to be carried on both the UAE's Dassault Mirage 2000 and F-16s.

The capabilities provided by the Hakim are now being developed at home within the newly established EDGE defense holding company established in the weeks prior to the Dubai Airshow.

Some 25 local defense companies were absorbed into EDGE; two of them, Al-Tariq and Halcon, form part of the group's Missiles and Weapons cluster.

Of these, Al-Tariq is perhaps the most familiar. Renamed from Barij Dynamics and before that Tawazun Dynamics, Al-Tariq is a joint venture between EDGE and South Africa's Denel Dynamics. The joint venture is responsible for producing Al-Tariq kits that transform dumb bombs into precision-guided munitions, some with wings enabling a glide range of up to 120 km (75 mi.). Since 2012, Al-Tariq has produced more than 6,000 guidance kits for both the Mk. 81 250-lb. and Mk. 82 500-lb. bombs, in a so-called Block 1 configuration, primarily equipping the United Arab Emirates Air Force Dassault Mirage 2000-9s. The company is now working with Lockheed Martin to introduce the weapon on the F-16 Block 60s also operated by the UAE Air Force.

Al-Tariq is also working on a Block 2 guidance kit introducing a modernized navigation system and a power pack to reduce the weapon's dependence on the carrier aircraft's electrical power system. Engineers are looking to extend the range of the weapon using a turbojet, essentially turning the weapon into a cheap cruise missile.

"This is the weapon of choice for the UAE Air Force," Theunis Botha, general manager of Al-Tariq, told Aviation Week.

Al-Tariq has attracted regional interest too. The company has been one of the drivers for extending the range and introducing the power pack that gives the weapon 8-hr. autonomy and allows the customer to be less reliant on the aircraft's OEM for integration.

Halcon is the lesser known of the two companies. Unlike Al-Tariq, it appears to be entirely homegrown, developing its own family of weapons and performing warhead design. It produces two families of weapons: the Thunder, which is a precision guidance kit for dumb bombs, and the Desert Sting, a new family of small, low-collateral munitions with warheads weighing 5-35 kg (11-77 lb.). Both are suitable for light attack platforms and unmanned aircraft systems.

"Halcon is a 100% UAE company, and we own 100% of the [intellectual property], manufacturing all of the parts," Halcon Design Engineer Khalifa Al Tamimi said at the Dubai Airshow. The company scored its first major contract worth $1 billion at the event, a deal with the UAE to deliver the Desert Sting weapon. Quantities and delivery dates were not revealed. Halcon's Thunder is integrated on the Mirage 2000, while the Desert Sting is being targeted for the new Calidus B-250 light attack platform, 24 of which have been ordered by the UAE military (*AW&ST* Nov. 25-Dec. 8, p. 21).

With Halcon and Al-Tariq brought under the EDGE holding company, officials say there will likely develop more cooperation between the two where there was once competition.

European missile house MBDA has also seen an opportunity to plant its own flag in the UAE, signing agreements with the Tawazun Economic Council to pursue the local development of the SmartGlider family of glide bombs. The SmartGlider was first unveiled at the 2017 Paris Air Show in response to a growing international need for aircraft that would not only be able to carry more weapons but also be capable of dealing with a wider range of target sets.

MBDA wants to be able to arm the UAE's Mirage 2000s with up to 12 SmartGlider weapons carried on specially developed launchers.

Together, MBDA and Tawazun will set up an engineering center to work on the SmartGlider weapon and also establish a local flight-testing capability. They hope the facilities and development work can get underway within two years.

Monitoring the Health of Motors and Munitions

> REAL-TIME MONITORING TRANSFORMS LIFE-CYCLE MANAGEMENT

> RAPID PROTOTYPING KEY TO SHOWCASING POTENTIAL TO CUSTOMERS

NORTHROP GRUMMAN

Graham Warwick Washington

Technology developed by Northrop Grumman to individually and continuously monitor the health of solid rocket motors promises to reduce the cost and extend the service life of munitions. And the company has partnered with 3D-printing specialist Stratasys to use rapid prototyping to demonstrate the technology to potential customers.

The integrated munition health management (IMHM) technology combines sensors on the rocket or weapon with internet-of-things (IoT) connectivity, digital-twin modeling and augmented-reality presentation of data to enable real-time monitoring rather than traditional periodic fleet sampling.

"Today we take a few motors out of service and test them, then statistically relate the results to the rest of the fleet. If they are not performing reliably, we may decommission the entire fleet," says Nathan Christensen, senior manager of engineering and scientific methods at Northrop Grumman Innovation Systems (NGIS).

But subsequent destructive testing often reveals that many decommissioned motors are still good. "Having a system that can monitor health individually will really change the way we manage the fleet and save a significant amount of money over the life cycle of the munition," he says.

Uncertainty in fleet life can span decades using current sampling tests. In an example presented to NATO in October, Northrop says a fleet of munitions could have to be retired after just 13 years if test failures exceed a threshold. But by tracking individual motors, those with a "severe history" could be retired at 22 years while "benign-history" motors could last 41.

"Munition health monitoring enables the near-real-time service life estimates for individual assets to be determined and [for them] to be culled if necessary to maintain fleet reliability," the presentation says.

"The key to predicting the health of a munition is to monitor the chemistry of the propellant," says Scott Hyde, a program manager in advanced programs with NGIS. "If the chemistry is pristine, it will perform as designed. If the chemistry has aged in a bad way, it will not perform," he says.

By attaching sensors to existing munitions or embedding them in next-generation designs, it is possible to measure continuously the environment each motor experiences: temperature and relative humidity as well as loads and displacements during handling and transport, including any bumps or drops.

The first step is to monitor as continuously as possible the environment the munition sees, then compare the data with sophisticated mechanistic models that predict the health of the motor. "The second step is to take some missiles out of the force, cut them up and test them to make sure the chemistry is close to or exactly what we model. If [it is] not, we improve the models," says Hyde.

Northrop has been developing the monitoring technology for two decades, "making sure we can do it safely," says Christensen. "But it is the maturity of IoT that has allowed the system to become what it is." IoT makes it possible to remotely and securely monitor weapons and rockets fielded around the world.

Stratasys 3D-printed this rocket motor model rapid prototype to demo real-time health monitoring.

IoT also makes it possible to monitor munitions in the factory, in storage, during transportation—and even the G-loading experienced during sorties of missiles mounted on aircraft. "As long as we can measure the environment each asset is seeing, we can predict its health," he says.

To educate potential customers on the benefits of IMHM, Northrop partnered with Stratasys to rapidly prototype a rocket motor display model that it can use to demonstrate real-time munition health monitoring to customers around the world.

Stratasys used two different polymer 3D-printing techniques to achieve three distinct material characteristics that were critical to correctly representing the rocket motor with its rigid casing, rubber-like propellant and the insulation layer between them.

Fused deposition modeling was used to produce the rigid rocket motor case using ABS thermoplastic, says Lucas Haugen, aerospace segment leader at Stratasys. High-resolution PolyJet printing, a variation on inkjet technology using jetted photopolymers, was used to produce the propellant and insulation layer—which have different hardnesses—as a single piece.

Using its rapid prototyping capabilities, Stratasys produced an initial version of the rocket motor model for Northrop. "They then wanted to change the design so that it better represented their technology, so we went back into our software and printed another iteration," Haugen says.

"Stratasys built a rapid prototype that simulates a motor, an inert one we can take on the road, with its hard casing and rubber-like propellant rel-

atively close to correct stiffness modulus," says Christensen.

Using the model, Northrop can demonstrate how the sensors detect aging, displacement loads and other effects and how their data are combined with a digital twin and augmented reality to display motor health in real time.

"During the demonstration, viewers watch a sensor alert pop up on a fleet asset and see the temperature going out of spec. It's a very interactive process that helps demonstrate the technology to customers," he says. "Although there is a lot of prognostic sophistication in the system, it displays data in a simple way that is easy to understand."

Northrop is already monitoring motors in different environments inside its production plant under a two-year U.S. Air Force program to validate the technology. But the system uses scalable commercial technology that is ready to deploy now, says Christensen. The company's goal is to incorporate the health-monitoring technology into its next-generation products.

NATO Turns Attention to Far East as Beijing's Influence Reaches Europe

> CHINA'S BALLISTIC AND HYPERSONIC CAPABILITIES WORRY NATO

> DISSENSION IS CAUSING RIPPLES IN ALLIANCE RANKS

Tony Osborne London

NATO is widening its gaze beyond Russia and toward China in recognition of Beijing's growing military might and power projection.

For seven decades, the alliance's attention has been focused on the Soviet Union and subsequently Russia, leaving the U.S. and its Asian allies to monitor the buildup of China's military capabilities. But now NATO is sitting up and taking notice, particularly as Beijing's power begins to gain influence around the alliance's soft underbelly.

China is now the world's second-largest spender on defense and has demonstrated its ability to deploy combat aircraft as far west as Turkey; Chinese warplanes exercised with their Turkish counterparts in 2011. And this past summer, Serbia announced it will buy Chinese armed unmanned aircraft systems as part of a tightening defense relationship between Belgrade and Beijing. Several NATO nations are embracing the People's Republic's Belt and Road investment initiatives and looking to adopt new-generation communication networks developed by Chinese technology companies.

"We recognize that China's growing influence and international policies present both opportunities and challenges that we need to address together as an alliance," NATO Secretary General Jens Stoltenberg told journalists following a meeting of NATO leaders in London Dec. 4. "This is not a one-dimensional issue. . . . The economic rise of China provides great economic opportunities," he said. "But at the same time, we see that China is investing heavily in new modern capabilities."

Stoltenberg noted the deployment of the DF-41 intercontinental ballistic missile, which provides Beijing the ability to hit cities in Europe and North America, as well as advances in hypersonic weaponry.

Beijing has also deployed hundreds of intermediate-range ballistic missiles, which "would have violated the [Intermediate-Range Nuclear Forces Treaty]," had China been a signatory, Stoltenberg said.

Acknowledging the China challenge is one step, Stoltenberg said; the next step is to try to bring China into future arms-control agreements. Beijing has signed the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), and Stoltenberg suggested the NPT could be an initial building block toward an arms-control dialog.

Concerns about China could also be linked to commitments made by NATO leaders to ensure the security of telecommunications infrastructure, including future 5G networks. Stoltenberg pointed out that member nations can rely "only on secure and resilient systems."

However, it is unclear where this leaves nations such as Germany and the UK, which said that Chinese company Huawei could play a role in such future networks.

British Prime Minister Boris Johnson appeared to harden his stance on the use of Huawei technology, saying at the meeting that while he does not want the UK to be hostile to overseas investment, "we cannot prejudice our vital national security interests nor can we prejudice our ability to cooperate with other Five Eyes security partners."

The London gathering of NATO leaders began on a shaky foundations and dissension in the ranks following comments by French President Emmanuel Macron that the alliance had become "brain dead" in response to the withdrawal of U.S. troops from Northern Syria. Turkish President Recep Tayyip Erdogan provided obstacles as well: Before the meeting, it emerged that Ankara had blocked updated defense plans for the Baltic States and Poland because Erdogan is frustrated by a lack of NATO support in recognizing as terrorists Kurdish groups in Syria and Iraq that allegedly support the PKK (Kurdish Workers Party).

Turkey's purchase of a Russian-made S-400 air and missile defense system continues to be a thorn in the side of NATO, particularly in light of apparent recent initial testing of the radars using the first battery set up near Ankara using F-16 fighters. Stoltenberg said he was concerned about the consequences of Turkey's decision to buy the system, noting that it "will never be integrated into NATO" and "will never be a part of the integrated air and missile defense system." He added that the Turkish S-400 will always be stand-alone.

Controversy also remains over the slow pace of some alliance members to increase their defense spending to 2% of gross domestic product (GDP) by 2024. Nine of the 29 alliance members have met or will meet the 2% target by year-end. NATO says defense cuts have finally stopped, with nations having invested $130 billion since 2016. This is expected to grow to $400 billion by the end of 2024.

U.S. Sanctions Threat Clouded by Uncertain Policy

> U.S. THREATENS SANCTIONS ON SU-35 DELIVERIES TO EGYPT

> TURKEY TESTS S-400 SYSTEM, DEFYING TRUMP WARNING

TURKISH MINISTRY OF NATIONAL DEFENSE

In July, Russia started delivering to Turkey the first of two S-400 batteries, including this support vehicle unloaded from an Antonov An-124.

Steve Trimble Washington

Egypt has emerged as another flashpoint in an increasingly fierce global competition with Moscow to hold on to once-reliable purchasers of U.S. weaponry.

The government in Cairo remained silent last month as U.S. and Russian diplomats traded threats and accusations over a reported—but never confirmed—deal by Egypt to import 20 Sukhoi Su-35 fighters from Russia. The Egyptian Air Force already received MiG-29M/M2 fighters ordered from Russia in 2015 without triggering complaints from Washington. But Egypt's possible Su-35 order, if consummated, will not be ignored by the State Department.

"It puts them at risk for sanctions, and it puts them at risk for loss of future acquisitions," Clarke Cooper, assistant secretary of state for political-military affairs, told reporters at the Dubai Airshow when asked about Egypt's interest in Russian fighters.

Cooper's remarks drew a swift response from Moscow's ministry of foreign affairs, which, in an ironic twist from Cold War-era diplomatic language, accused Washington of prioritizing the ideology of security partners over the principle of free trade. "Like our Egyptian friends, most of Russia's partners in the world prefer to make independent decisions, focusing on value for money," says ministry spokeswoman Maria Zakharova.

A combination of three factors—the recent export availability of the S-400 air defense system and the Su-35, overseas opposition to key aspects of American foreign policy, and a 2017 U.S. law that proposes blanket sanctions on Russian arms buyers—continues to roil the global arms trade. Huge arms deals all over the world swing in the balance as U.S. policymakers still work to clarify how the Counter America's Adversaries Through Sanctions Act (Caatsa) will be applied.

The U.S. has imposed Caatsa restrictions only once. At the end of 2018, the State Department applied Caatsa penalties on China for importing the S-400 and Su-35 several months earlier.

But the key test case remains in Ankara, the capital of Turkey and a 70-year-old bulwark of the NATO alliance. Turkish President Recep Tayyip Erdogan has showed no signs that he will bow to U.S. demands to return, destroy or somehow disable two S-400 batteries delivered from Russia since July. Moreover, Turkey activated the S-400s for the first time in defiance of escalating rhetoric from the U.S., including a personal intervention by President Donald Trump with Erdogan two weeks earlier.

But the U.S. president's commitment to applying the sanctions mandated by Caatsa against Turkey has remained an open question. Trump has never opposed the Defense Department's decision to banish Turkey from the F-35 program over the S-400 deliveries, but he has publicly sought to achieve some sort of compromise with Erdogan to avoid imposing restrictions. A White House meeting between Trump and Erdogan in early November was intended to clear up any lingering doubt about the U.S. position, Cooper says.

"President Trump did say to President Erdogan: 'Not only are you still not part of the F-35 program, but to get to reconciliation we have to address the S-400. So either destroy it, send it back or somehow compartmentalize it,'" Cooper says. "It was certainly something the rest of the world was watching, including in Cairo."

Instead of automatic sanctions, the White House has preferred to consider each case individually. So countries that have an established supply chain for Kalashnikov rifle ammunition, Cooper says, need not worry about triggering the otherwise mandatory penalties under Caatsa. Cooper's choice of anecdote at the Dubai Airshow may not be an accident, as neighboring Saudi Arabia is in talks with Russia to establish a local Kalashnikov rifle plant.

Although Russia protests the fairness of the Caatsa sanctions, the industry does not yet acknowledge feeling any harm. Rosonboronexport posted a record year with $13.7 billion in arms sales in 2018, and it plans to match that total by the end of 2019. But the U.S. pressure seems to be causing some countries to think twice. Indonesia, for example, announced a deal in 2018 for Su-35s but has yet to set a timetable for delivery.

"Nothing is holding up [deliveries to Indonesia]," Rosoboronexport CEO Alexander Mikheev told reporters at the Dubai Airshow. "The contracts are signed. All the formalities have been fulfilled. So we are expecting the contract to start."

Check 6 *Aviation Week editors discuss the evolving aviation landscape from the Dubai Airshow:* **AviationWeek.com/podcast**

The Coaxial Coming in From the Cold

- THE VRT500 WILL USE PRATT & WHITNEY'S PW207V ENGINE
- FIRST FLIGHT IS PLANNED FOR 2020; CERTIFICATION ENVISAGED IN 2022

Tony Osborne Dubai

Russian Helicopters believes the VRT500 will find a niche in the urban air mobility mission, thanks to its coaxial configuration.

Russian Helicopters is hoping that its newest product will find a niche as a pathfinder for urban air mobility.

The 1.65-metric-ton, single-engine VRT500 was born from a challenge set by Russian Helicopters' parent Rostec to define a product that could be a "source of growth in the civil market," says Alexander Okhonko, the general manager of the newly established design bureau within the Russian Helicopters holding VR-Technologies (VRT). And with the market for offshore helicopters in the doldrums, the company set its sights on the trend for urban transport.

Although billions of dollars have been invested in electric-vertical-take-off-and-landing urban and regional air mobility programs, Russian Helicopters believes its little coaxial could begin delivering urban air mobility (UAM) services in a couple of years—and well before all-electric services can get underway.

VRT has used its links with the story design bureau to bring its coaxial technology onto the aircraft, a move it believes could be the "secret sauce" to securing a foothold in UAM operations.

Using a coaxial means the company can produce a platform with a small fuselage: There is no need for a lengthy tail boom and complex tail rotor assembly, resulting in more room at the rear of the aircraft.

Eliminating the tail rotor removes a safety hazard for ground operations and reduces the noise levels, but it also introduces new flying characteristics that may be unfamiliar to many rotary-wing pilots.

The helicopter's UAM potential has already attracted Emirati interest. At the Dubai Airshow, Abu Dhabi holding company Tawazun announced it will purchase a 50% stake in VR-Technologies, with the aim of generating some €400 million ($440 million) for the development program. The deal will be finalized in the first quarter of 2020.

The rotorcraft also has secured its first customers: In August, Malaysian company Ludev Aviation announced it will take five VRT500s, and Swedish company Rotorcraft Nordic AB announced at the air show that it is buying 10.

Unlike previous helicopters from the Russian Helicopters stable, the VRT500 has been developed with a "different mindset," with a focus on the commercial rather than military market, Okhonko says. "We have focused on lower vibration, low noise signature, passenger comfort and style," he adds.

That mindset also extends to the extensive use of Western suppliers. Pratt & Whitney is providing its PW207V turbine—the same engine that powers the Ansat twin-engine light helicopter. Thales is supplying the avionics, and Liebherr is providing the environmental control system.

Also contributing to the helicopter is Italy-based automotive design house Italdesign. And perhaps most crucially of all, it will be built in Italy, which will drive the need for certification with the European Union Aviation Safety Agency (EASA). Among Russian rotorcraft, only Kamov's Ka-32 has an EASA certificate, which is for firefighting and aerial work.

Manufacturing in Italy represents a radical departure for the OEM, which has traditionally built its helicopters domestically. Okhonko says it has already established a production facility with a "daughter company" near Rome but did not provide further details.

"We have opted for mature technologies and well-recognized suppliers," says Okhonko. He also notes that VR's engineers selected a metallic airframe and composite skin rather than going all-composite, a compromise that Okhonko says will help shorten the certification process.

Recognizing that some cities do not allow the operation of single-engine helicopters, VR-Technologies is exploring the addition of a hybrid propulsion system with a battery pack that would be able to provide 3-5 min. of power in the event of an engine failure, giving the pilot additional time to find a safe spot to land. "Everybody is working on a purely electrical solution, but this is difficult to design and bring to market," says Okhonko. "Using a hybrid would give us additional redundancy and a power boost on takeoff." Similar work is underway by Airbus.

"With that technology, we could find a solution to be safer, cheaper to operate and more environmentally friendly," says Okhonko. The hybrid propulsion system could be available in 2023.

Developments in the VRT500 have come on thick and fast since a model of the helicopter was first unveiled at the HeliRussia show in 2018. Current plans call for a first flight in 2020 and type certification in 2022.

Okhonko would not provide a price for the aircraft, but it is set to compete with the likes of Bell's 505 JetRanger X, Robinson's R66 and Enstrom turbine models, which are $1-2 million. Okhonko believes the helicopter will have greater appeal because of its larger cabin space, making it attractive for a wider range of missions than competitors might be able to provide. Assessments by the company suggest a market for 1,000 VRT500s by 2035.

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TIPPING POINT

United Airlines plans to serve additional destinations in Europe with its incoming fleet of 50 Airbus A321XLRs.

AIRBUS

- LARGE 737 MAX CUSTOMER UNITED AIRLINES CHOOSES AIRBUS A321XLR
- LONG-RANGE A321NEO VARIANT TO REPLACE BOEING 757 FLEET
- MOVE RAISES SERIOUS QUESTIONS ABOUT VIABILITY OF CURRENT NMA CONCEPT

Jens Flottau Frankfurt and **Sean Broderick** Washington

There has been growing uncertainty for some time around Boeing's proposed new midmarket airplane (NMA), for now conceived as a small widebody targeting the niche between the 737 MAX and 787. At the same time, the continuing MAX grounding has raised questions about that program's longer-term viability, and the 777X is another reason for concern rather than a relief.

United Airlines' Dec. 3 decision to order 50 Airbus A321XLRs as a replacement for a large part of its Boeing 757 fleet, the same market Boeing is targeting with the NMA—and to a lesser extent with the MAX—could be the tipping point for the program, the last bit of evidence for the OEM's leadership that it needs to revise the concept. In addition, because the MAX crisis is so much worse than expected and the A321XLR is selling so well, finding a MAX replacement sooner is becoming an increasingly urgent issue.

The United order is a nightmare for Boeing in two ways: It shows that another large MAX customer believes both that the aircraft is not suitable for its long-range missions and that it is not worth waiting for the NMA 2-3 years beyond the Airbus delivery dates.

"Whatever life was left in the NMA might have just been extinguished," says Richard Aboulafia, vice president for analysis at the Teal Group. He believes Boeing "needs a different middle-market strategy." And "different" to him means very different: "It's clear that this is a single-aisle segment."

The Airbus A321XLR, with a range of 4,700 nm, has built an impressive order momentum since its launch at the 2019 Paris Air Show. Even Airbus CEO Guillaume Faury said, at the recent Dubai Airshow, "We underestimated the success of the A321neo."

United was not even an Airbus A320neo-family customer before the XLR order. The other two big U.S. legacy carriers, American Airlines and Delta Air Lines, already have large A321neo orders in place—for 120 and 100 aircraft, respectively. It is easy to conceive they also may be tempted to convert some of those to the XLR.

"Boeing vastly underestimated the A321neo," says one senior industry executive. "The A321neo has such strong momentum, the optimal timing [for a

Dash 8-400 gains more orders p. 36

competitive response] may have been missed."

Customers warned Boeing about the threat years ago, he says. "But Boeing always thought the large 737 airline customer base would naturally gravitate airlines to the MAX.

"In hindsight, a new aircraft smaller than the NMA is the way to go with engine choice," the executive continues. "There are many believers [in the concept] in Seattle and among airlines. . . . [However, Boeing's board] is in no rush to jump into a new program that could cost north of $15 billion. The 777X debacle and lack of customers weigh heavily on any new capital allocation commitment."

No quick decisions are expected, though, with the NMA still "a project of interest," as Boeing CEO Dennis Muilenburg put it recently. "They are not in a hurry to do anything new or drastic until the MAX is revalidated and back in airline service for at least 4-5 months," an industry source says.

While quiet explorations gauging interest in a new aircraft covering both the NMA and MAX space are believed to be ongoing, Boeing is "in a tough spot," as one source describes it. "If they even talk too much about a new plane, it could be a brutal blow to the 737," the source explains. "And without the 737 revenue for the next 5-7 years, Boeing would face a financial nightmare."

Another challenge facing a revised, smaller version of the NMA that could (partly) replace the MAX is the engine: "A new 30,000-36,000-lb.-thrust engine that is as reliable as the latest CFM-56 could take 6-7 years to fully develop and validate," the industry executive says. Given recent experience with introducing new engines, there is little appetite among engine OEMs to launch another program anytime soon.

United operates 174 A320ceo-family aircraft but no A320neos. The longtime 737 operator has all three MAX versions on order and had 14 in service—all MAX 9s—when the global MAX fleet was grounded in March following two fatal accidents in five months. The MAX fleet remains grounded while Boeing finalizes changes demanded by regulators.

"The new Airbus A321XLR aircraft is an ideal one-for-one replacement for the older, less efficient aircraft currently operating between some of the most vital cities in our intercontinental network," says Andrew Nocella, United's executive vice president and chief commercial officer. "In addition to strengthening our ability to fly more efficiently, the A321XLR's range capabilities open potential new destinations to further develop our route network and provide customers with more options to travel the globe."

The A321XLRs will replace two-thirds of United's remaining 757 fleet and are logical successors to its 757-200s. The Aviation Week Intelligence Network Fleet Discovery database shows the carrier has 53 757-200s, all configured with lie-flat business-class seats and used on both transatlantic and premium U.S. transcontinental routes. United also has 21 two-class 757-300s with standard domestic, reclining first-class seats, used mostly as U.S. domestic hub feeders.

The latest order also will see the airline leverage its East Coast hubs at Newark Liberty International in New Jersey and Washington Dulles International airports to "explore serving additional destinations in Europe" using the A321XLRS, the airline says.

The United order pushes Airbus' A321neo firm-order backlog past 3,200 and further tightens its grip on the 4,000-nm-plus narrowbody market. Airbus advertises the A321LR's range at 4,000 nm with 206 passengers, while the A321XLR's range is touted as 4,700 nm. Boeing was working with lessor Air Lease Corp. (ALC) on a 4,000-nm-range 737 MAX 9 before the grounding, but talks stopped. ALC was one of several customers to place commitments that led Airbus to launch the A321XLR at the recent Paris Air Show.

United also rescheduled deliveries of its 45 Airbus A350-900s as part of its order, pushing them out to commence in 2027. The carrier in 2017 converted a 2013 order for 35 A350-1000s to 45 of the smaller, longer-range Airbus widebodies and pegged them to replace 777-200ERs starting in 2022.

United has 55 777-200ERs—33 Pratt & Whitney-powered models that average 20.5 years of age, and 22 GE-powered versions that are about two years younger, on average, than their Pratt-powered fleet mates. It also has 19 Pratt-powered 777-200s that average about 23 years of age. The airline's new-generation widebody fleet includes 46 787s—12 -8s, 25 -9s and nine -10s—as well as another 13 -9s and five -10s on order, the Aviation Week Fleet Discovery database shows.

Condor Expects Clarity About New Owner in January

> THOMAS COOK FAILURE PUTS FINANCIAL PRESSURE ON CONDOR

> CARRIER HAS RECEIVED SUPPORT FROM GERMAN GOVERNMENT WHILE NEW OWNER IS SOUGHT

Jens Flottau Frankfurt

In the German air transport market, Lufthansa Group is far and away the dominant player, a position further strengthened as a result of the 2017 bankruptcy of its biggest rival, Air Berlin. Following the collapse of leisure group Thomas Cook, another competitor, Condor, is seeking rescue. While tour operators and consumer groups lobby for Condor's survival, the company faces a complex set of circumstances.

Condor was part of the Thomas Cook Group, which ceased trading Sept. 23 after a rescue plan led by banks and Chinese investor Fosun failed. The airline entered a scheme called a "protective umbrella" Sept. 26, which temporarily shields it from creditors' claims. The process is a special case in Germany's insolvency legislation introduced in 2012, specifically designed for companies that are highly likely to be successfully restructured.

Condor also has been granted a €380 million ($422 million) six-month rescue loan guaranteed by the German federal government and the state of Hesse; it must be paid back by the end of March. The closure of its parent, Thomas Cook, means it had scant financial reserves for the winter, as cash was pooled for all companies at the group level. With the Thomas Cook bankruptcy, Condor also lost its biggest customer, responsible for buying around 15% of its seats. But CEO Ralf Teckentrup says the airline managed to almost entirely make up for the shortfall within one month as other tour operators chipped in.

Condor expects to gain clarity about its future ownership in January. Teckentrup says nonbinding offers for the carrier should come "in early to mid-December," adding, "We expect a solution in January or maybe a few days later." Teckentrup stresses that he is convinced the company will not have to be dismantled and "will emerge stronger" from its current challenges.

The airline posted improved results for the 2018-19 financial year ended Sept. 30. Revenues were up 6% at €1.67 billion, and its operating profit before special items reached €57 million, 32% higher than a year earlier. Condor carried 9.4 million passengers, 7% more than in the previous year.

Condor administrator Lucas Floether hopes the airline can exit the umbrella scheme in March or April. That would require finding a new owner in January to allow time for regulatory and creditor approvals. While Condor has been consistently profitable over many years, the workout process may yet prove to be complex. "It would be best to sell Condor as a whole. But a breakup is an option that we cannot argue away," Teckentrup says.

CONDOR

Condor operates 16 Boeing 767-300ERs, one of them painted in a retro livery.

European rivals such as EasyJet or Wizz Air would be interested only in Condor's short-haul operation, if anything. Lufthansa, by contrast, could use a well-run long-haul leisure portfolio like Condor's. There have been discussions among Germany's many tour operators to jointly invest in Condor, but even for a group of them, the airline would be a massive undertaking that may have to include the support of financial investors.

Other important market changes loom. Tourism giant TUI Group announced it will enter the German long-haul market next year, building a fleet of Boeing 787s and flying them mainly to destinations where the group owns hotels or needs transport for its cruise ship customers. That business has traditionally been Condor's strength.

Lufthansa is also redefining its own strategy for the segment, having realized that its affiliate Eurowings has failed in the long-haul market. The subsidiary is now retrenching to focus on short-haul operations. Its parent plans to build a new long-haul franchise under a different brand, modeled on the highly profitable Swiss leisure carrier Edelweiss, which operates out of Swiss International Air Lines' Zurich hub in close cooperation with its parent.

Meanwhile, Condor is looking at ways to lower its unit costs, and Teckentrup believes a 3-4% reduction is achievable. "We are going through every contract; we need to slim down administration. And we are talking to the unions" about new collective bargaining agreements, Teckentrup says.

One important factor in the restructuring is Condor's aging Boeing 767-300ER long-haul fleet. Many observers argue that the aircraft need to be replaced in the coming years, which will require massive investment on top of the acquisition price of the airline, which may scare off most potential buyers. However, Teckentrup disagrees: "The fleet is interesting for any investor," he says. Most of the 16 767s are leased; only two are owned. Teckentrup argues the aircraft can be phased out as leases expire and replaced over time, providing profit upside. On the other hand, the airline does not have firm order commitments. Condor studied 767 replacement options in 2018 and is believed to have short-listed the Airbus A330 and A330neo.

Condor currently has a fleet of 58 aircraft, according to the Aviation Week Network's Fleet Discovery database. Sixteen of these are owned. In addition to the 767s, Condor operates 15 Boeing 757-300s, 26 A320-family aircraft and one A330 leased from Air Tanker.

Tough Road for New Norwegian Boss

> JACOB SCHRAM STARTS AS NORWEGIAN CEO JAN. 1

> NORWEGIAN SHORES UP ITS FINANCES, STREAMLINES ITS NETWORK

Helen Massy-Beresford Paris

Europe's biggest low-cost, long-haul carrier has a new captain. But as a newcomer to the aviation industry, Jacob Schram will be relying on his experience with complicated management challenges in other sectors to help Norwegian Air Shuttle navigate through its ongoing financial turbulence.

Schram may not have jet fuel running through his veins—like many of the industry's top bosses and his predecessor, Bjorn Kjos, a former pilot—but the 57-year-old has 30 years of experience in large international companies. And the Norwegian citizen has also been working over the past year on projects related to the topic of "Future Mobility 2030."

That experience will be useful to an executive entering the industry as calls for a reduction in the environmental impact of aviation intensify and operators look for innovative ways to cut their carbon footprint. This is particularly important in Norway, where the government has pledged that all domestic flights will be zero emission by 2040.

NORWEGIAN

Jacob Schram

Schram is also the author of a management book titled, *The Essence of Business*, which details his role as CEO in the transformation of Statoil Fuel and Retail. His industrial experience, albeit from a different sector, will certainly help him take on the challenge of improving profitability for Norwegian while there are still doubts about the viability of the broader low-cost, long-haul business model's long-term future.

"I believe the low-cost, long-haul business model is sustainable, just not the way Norwegian has implemented it to date," says Diogenis Papiomytis, global program director for commercial aviation at global business consulting firm Frost and Sullivan.

The fact that Geir Karlsen, who has been acting CEO since Kjos' departure, is staying on as chief financial officer and deputy CEO is reassuring.

JOEPREISAVIATION.NET

The ongoing Boeing 737 MAX grounding has affected Norwegian, which has 18 in its fleet.

"Karlsen has done a lot of work over a 6-9 month period, particularly on the balance sheet," says Davy Research analyst Ross Harvey. "The fact that he will remain within the executive team will reassure the market that the pragmatism and newfound discipline he has brought to the company's operations will remain."

Karlsen is behind the recent drive to shore up the carrier's finances, helping it acknowledge that its rapid expansion of both fleet and network has been overambitious. The airline has started to take steps toward its stated strategy of focusing on profitability and not growth.

Norwegian says it raised new capital through a placement and convertible bond issue completed Nov. 5, leaving it "fully funded through 2020 and beyond."

The fundraising was just the latest in a series of steps, with a rights issue, announced in January, underlining just how serious the carrier's financial situation has been.

Norwegian has taken other measures in recent months, including stepping up cost cuts, restructuring aircraft orders to cut capital expenditure, establishing a joint venture to reduce capital commitments, selling noncore assets and aircraft, and forming a feeder-traffic-boosting partnership with JetBlue.

The efforts seem to be starting to bear fruit. The airline revealed a 28% rise in third-quarter net profit to 1.7 billion krone ($185 million) Oct. 24, against an 83% drop in net profit for the first nine months.

"Norwegian was in a difficult situation earlier this year from an operational and financial perspective," Harvey says. "Slowing growth, releasing equity from noncore assets and eliminating capex on the [A320neos] by setting up a [joint venture] were feasible, but we didn't know if the company could execute them all,"

The airline has also been revamping its route network, cutting some long-haul transatlantic services to focus on its more profitable routes and adding some seasonal flights.

Analyst Papiomytis says: "Norwegian's collaboration strategy with JetBlue and EasyJet is a step forward. And the new CEO could bring capacity growth down to a more manageable pace."

However, even if Norwegian is back on track, there is still a ways to go. And external factors are not helping either.

The carrier has been affected by the extended grounding of the Boeing 737 MAX on its transatlantic network—it counts 18 of the type in its the fleet—as well as Boeing 787 issues. And like other European airlines, it is contending with intense competition, pricing pressure and high costs as well as scrutiny on the environmental impact of aviation. All this makes for a tough operating environment for airlines in Europe, where several have collapsed in recent months.

"The airline industry is characterized by strong competition and unforeseen events, but it is also an industry that is important to people everywhere," said Schram. "Now my main focus will be to bring the company back to profitability and fortify the company's position as a strong international player within the aviation industry."

New Deals Suggest Dash 8-400's Run Could Go On

> DE HAVILLAND LINED UP 37 DASH 8-400 COMMITMENTS IN DUBAI

> FINALIZING ORDERS WILL HELP THE COMPANY JUSTIFY RELOCATION OF PRODUCTION

Sean Broderick Dubai

Recently reborn De Havilland Aircraft of Canada Ltd. left the Dubai Airshow with commitments that translate into better than a year's worth of Dash 8-400 production. More important, the Dubai success represents votes of confidence from a variety of customers in the company's ability to thrive as a commercial aircraft manufacturer.

The Toronto-based company has a lot of work ahead if it plans to keep building new aircraft beyond June 2023, when the lease deal on its production facility expires. But given where it was six months ago, it has already come a long way.

Formed when Longview Aviation Capital bought the Dash 8 program—including support for out-of-production models, the current-production -400 and the De Havilland Canada name, which dates to 1928—from Bombardier, the new company began life as De Havilland of Canada on June 1. It inherited many former Bombardier employees, including Young, a 30-year company veteran and former head of the commercial turboprop program. It also inherited a backlog of about 60 aircraft—enough to keep the production line busy until November 2020.

While selling more aircraft was a top priority, an even more crucial step was getting support in place for the 1,100 Dash 8 family aircraft, including 500 of the in-service out-of-production -100s, -200s and -300s. De Havilland cut a transitional service agreement (TSA) with Bombardier that included establishing spare-parts hubs in Chicago and Frankfurt and smaller depots in Singapore, Sydney and Tokyo. Three other TSAs cover on-site logistics support—basics such as transportation at the co-located sites—information technology and administrative support. The agreements will bridge the gap while De Havilland stands up its own functions in each area. And they may look different than legacy Bombardier's setup.

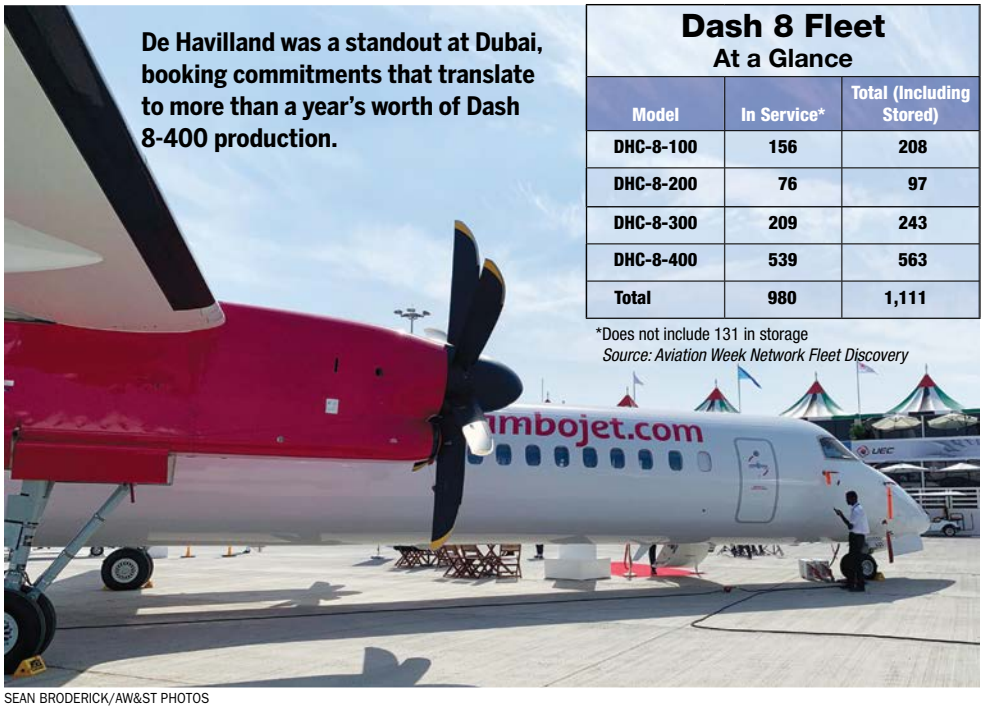
"We are now working on our planning, to say, 'What would the De Havilland distribution network look like?'" Young says.

With the in-service fleet's needs addressed, De Havilland can shift more attention to its long-term strategy. Like any sensible aircraft manufacturer, it is working to match orders with delivery slots. But De Havilland faces the unique challenge of needing to find a new home for its production facility if it wants to keep building aircraft well into the next decade.

Its deal with Bombardier includes subleasing office and shop-floor space to support Dash 8-400 production. But the land, prime real estate within the Downsview section of Toronto's city limits, has been flagged for redevelopment. De Havilland's deal runs through mid-2023. Young says a short extension is possible, but if Dash 8-400s are going to be built in, say, 2030, the work will be done elsewhere.

"We already started to look at locations where we could possibly go," Young says. The company's administrative offices, including its commercial group and engineering organization, are likely to stay "roughly where we are today," he says. Ideally, the production facility will be within commuting distance of Downsview as well, to minimize staff turnover.

"Final assembly line, preflight, paint—that would have to be moved somewhere," Young says. "We haven't defined where the somewhere is, but we know locations where we could go in



De Havilland was a standout at Dubai, booking commitments that translate to more than a year's worth of Dash 8-400 production.

SEAN BRODERICK/AW&ST PHOTOS

Dash 8 Fleet
At a Glance

Model	In Service*	Total (Including Stored)
DHC-8-100	156	208
DHC-8-200	76	97
DHC-8-300	209	243
DHC-8-400	539	563
Total	980	1,111

*Does not include 131 in storage

Source: Aviation Week Network Fleet Discovery

De Havilland was arguably Dubai's biggest commercial aviation sector surprise, unveiling orders and letters of intent (LOI) for 37 aircraft from three operators and two lessors. Several customers spoke openly of eyeing follow-on orders as their fleet plans firm up or their lessees step up. The Dubai haul helped fill delivery slots beyond the end of next year and to give the company confidence that its plan to stay in the regional aircraft production business is more than a pipe dream.

"We are looking forward to building aircraft for many years to come," says Chief Operating Officer Todd Young.

Ontario. Of course, we could go outside of Ontario," he adds, noting that the aircraft manufacturer has attracted plenty of interest, and some incentive packages, from suitors.

Young says the company is targeting mid-2020 as a loose deadline for finalizing its production plans. "At the end of the day, it's going to be what makes the most sense for the program," he says.

In the meantime, Young and his team are working to give the company reason to explore a relocation. De Havilland came into Dubai with some delivery slots left in its fiscal 2020 production plan, which runs through next October. Locking up all 37 commitments—three of which are firm orders—provides enough backlog to fill all of fiscal 2021 and several months in 2022. Current plans call for building 26-28 aircraft annually—a figure that could increase if demand justifies the change.

While De Havilland is leaning on Bombardier during its early days as a stand-alone company, Young is confident the new setup will be the best of both worlds. De Havilland inherited Bombardier's turboprop expertise but not the corporate-level burdens that held the program back. Bombardier's priorities were almost always elsewhere, and understandably so: The CRJ regional jet program helped establish it as airliner manufacturer, and the C Series demanded significant attention and funds during its 12-year development and entry-to-service phases.

Operating as a business unit under Longview, De Havilland's focus is sharper—and its customers are buying in.

De Havilland will need more sales and a new location for its assembly line to keep Dash 8-400 production going.

"We have full confidence in their ability to continue to grow and support the fleet and are very pleased to be part of that growth story," says Brett Hurst, group managing director of ACIA Aero Capital, which signed an LOI for three Dash 8-400s in Dubai and plans to add more. "I think it will be better because it's very focused. It's not also the CRJs" or other models, he adds. "They're so passionate about about the whole program as a group. I believe they will make it work."

NTSB Recommends Redesign of Boeing 737NG Fan Cowls

> A FAN BLADE CRACK LED TO THE SOUTHWEST ACCIDENT

> EARLIER INSPECTION METHODS WERE INADEQUATE

Bill Carey Washington

Airlines would have to retrofit thousands of in-service Boeing 737NGs with redesigned engine cowls if the FAA enforces an NTSB recommendation stemming from an engine failure on Southwest Airlines Flight 1380 in April 2018.

The safety board on Nov. 19 announced its probable cause finding into the accident, tracing its origin to a "low-cycle" fatigue crack in one of the fan blades in the left CFM56-7B engine of the Southwest 737-700. The separation of the fan blade at its root—called a fan-blade-out (FBO) event—sent blade fragments into the engine fan case and compromised the outer fan cowl structure. Fragments of the fan cowl, including a latch-keeper component, struck the left side of the fuselage near the cabin window at Row 14, dislodging the window and causing the rapid depressurization of the cabin.

NTSB

Separation of the fan blade at its root on Southwest Airlines Flight 1380 sent blade fragments into the engine fan case and compromised the outer fan cowl structure.

The passenger in seat 14A was killed in the chain of events that occurred on the flight on April 17, 2018. It was the first fatality on a U.S. passenger airline since the crash of Colgan Air Flight 3407 in February 2009. There were 144 total passengers and five crew on the scheduled Southwest flight from New York LaGuardia Airport to Dallas Love Field. Southwest Capt. Tammie Jo Shults and First Officer Darren Ellisor performed an emergency landing at Philadelphia International Airport after the engine failed at 32,600 ft.

Nineteen months after the accident, the NTSB determined the crack in the No. 13 fan blade—one of 24 titanium alloy blades comprising the fan—probably could not have been detected when it started, given the inspection methods used when the blades were last overhauled and lubricated.

Metallurgical examinations of the fractured fan blade found the crack had likely begun before the fan-blade set's last overhaul in October 2012. At that time, the overhaul process included fluorescent penetrant inspection (FPI) to find cracks; however, "the crack was not detected for unknown reasons," the board says.

After an FBO event involving a Southwest 737-700 in August 2016 that forced the pilots to land at Pensacola International Airport, engine manufacturer CFM International developed an eddy current inspection (ECI) procedure that is performed during an engine overhaul in addition to the FPI process. An ECI can detect cracks at or near the surface of a blade; an FPI can detect only surface cracks.

CFM also developed an on-wing ultrasonic inspection technique that is performed when fan blade "dovetail," or root ends, are lubricated, improving on visual inspections.

While the fan blade crack escaped detection in the Southwest 1380 accident, the "post-FBO" damage to the engine could not have been predicted by structural analyses and certification tests performed when the CFM56-7B engine and 737-700 aircraft were certificated in December 1996 and December 1997, respectively, the NTSB found.

New technologies and analytical methods developed since then will better predict how an FBO event affects the engine and airframe, the board advises.

The separated fan blade in the Southwest 1380 accident struck the fan case at the 6 o'clock position, at the bottom of the engine. During CFM56-7B engine FBO containment certification tests, CFM had selected a fan blade release position of 12 o'clock.

Post-accident analyses by Boeing "found that the fan cowl structure is more sensitive and more susceptible to failure when a separated fan blade impacts the fan case near the six o'clock position," the NTSB states in an abstract of its accident report.

Among top-line recommendations, the board calls on Boeing to redesign the fan cowl structure on all 737NG-series airliners and to install it on new-production aircraft.

The NTSB recommends that operators retrofit the redesigned fan cowl structure on in-service airliners.

Boeing is working on a design enhancement "that would fully address the safety recommendations from the NTSB," it says, in a statement released after the board's probable-cause hearing. "Once approved by the FAA, that design change will be implemented in the existing NG fleet," the Boeing statement says.

Responsibility for installing redesigned fan cowls would fall mainly on operators. Boeing counts 117 airlines that fly 737NG-series airliners and 6,800 in-service aircraft. The manufacturer reports just 47 unfilled 737NG orders, including for the P-8 Poseidon naval variant.

Having recently complete FAA-mandated inspections of high-cycle 737NGs for cracked fuselage parts, Southwest would have to retrofit hundreds of 737NGs with redesigned fan cowls if the agency enforces the NTSB recommendations.

Southwest operates 509 Boeing 737-700s and 207 737-800s, according to the Aviation Week Network's Fleet Data Services. The airline is storing 34 grounded 737 MAXs at Southern California Logistics Airport, which would not be affected.

DECEMBER 2019

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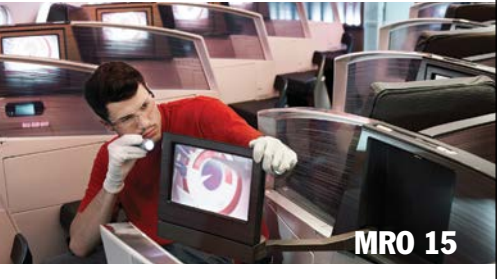


COVER: SARCOS

MAINTENANCE CHECK

Stepping Up Sustainability Efforts

The end of this year will usher in a new decade. Should we expect to see any major changes as 2020 starts?

For one, the aviation industry will need to focus more on sustainability. Look at the impact on and attention to sustainability that 16-year-old Greta Thunberg of Sweden has generated. People in 150 countries protested in late September to urge governments to do more to halt global warming. Although there are "many issues in play, Sweden's international air traffic is well down in 2019," about -2.3% so far, most likely influenced by flight-shaming, a trend Thunberg has been promoting, says Peter Harbison, chairman emeritus of CAPA–Centre for Aviation.

The European Parliament declared a "climate and environmental emergency" in late November, ahead of the UN climate change conference being held Dec. 2-13 in Madrid.

The increased focus on sustainability is not going away.

Speaking at the CAPA-Aviation Week Airline Operations Leaders' Summit, Harbison pointed out that aviation accounts for 2% of global greenhouse gas emissions, according to the International Air Transport Association and the Air Transport Action Group.

While aircraft and engines' efficiency has greatly improved, passenger traffic is growing faster—and "carbon dioxide emitted from commercial flights rose by 32% from 2013 to 2018," 70% higher than the International Civil Aviation Organization projections had assumed, says Harbison.

This means the aviation industry needs to do more to reduce emissions now—and communicate the steps it is taking to do so in a cohesive way.

If the industry isn't proactive, there is a good chance that governments or regulatory bodies will impose mandates. For instance, Harbison points out that the UK's Committee on Climate Change is considering charging passengers based on the number of miles they fly, or banning frequent-flier programs, which incentivize people to fly more.

In this month's Viewpoint, Paul Stein, Rolls-Royce's chief technology officer, points out several actions that aviation companies can take now (see MRO 29)—from carbon-offsetting schemes to improving the availability of sustainable aviation fuels.

Sustainability is going to be a big issue for the aviation industry in 2020. It's time to "think big and act small," a popular business mantra that is very applicable to this issue.

What is your company doing? Is it trumpeting its initiatives?

Sustainability is not just going to be the issue of 2020—it will be an important issue for years to come. While aviation companies are developing electric propulsion, creating biofuels and recycling aircraft, collectively we need to do more to decrease emissions and make a smaller footprint.

The aviation industry is more than just an economic driver—it helps connect people worldwide. But it is a target of flygskam, or flight-shaming, so the time is now to take steps to decrease emissions—which probably will make the industry more efficient as well.

—Lee Ann Shay

"Carbon dioxide emitted from commercial flights rose 32% from 2013 to 2018."

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

Highlights

Widebody MRO Averaged $1,452 Per Flight Hour

Unit MRO costs remain an intense focus of airline managers, who often seek to benchmark their own expenditures against industry averages. The latest global data indicates that the world's airlines spent an average of $1,452 per flight hour on maintaining widebodies in 2018. This worked out to $5.7 million per aircraft for the year. These figures were provided by the International Air Transport Association's Maintenance Cost Technical Group, which surveyed 37 airlines operating 1,666 widebodies averaging 8.8 years in age.

Equivalent estimates for narrowbodies were $824 per flight hour and $2.5 million for the year, based on reports from 50 carriers operating 2,649 jets averaging 8.9 years of age. For regional jets, MRO costs averaged slightly less, $817 per flight hour and $2.1 million per aircraft year. Regional jets averaged 7.5 years old and were reported by 13 airlines. Thirteen airlines reported an average of $993 MRO spent per flight hour on turboprops averaging 7.8 years of age.

Sanad Combines Engine MRO, Finance Arms

Mubadala Investment Co. is consolidating three of its businesses, including Sanad Aerotech and Sanad Capital, into a new entity that the parent company believes will allow the units to leverage their synergies to drive growth.

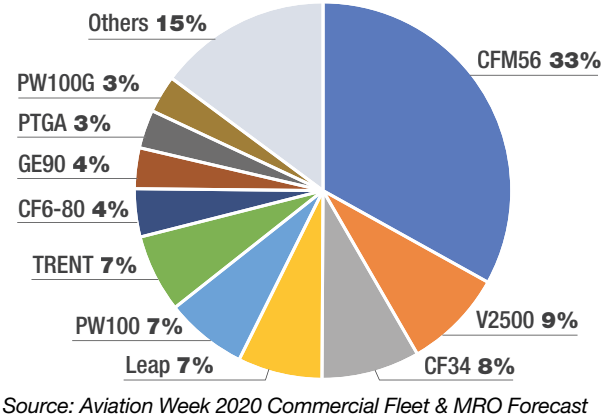
The new entity, named Sanad, combines engine MRO specialist Sanad Aerotech, gas turbine services provider Sanad Powertech, and engine and spares leasing specialist Sanad Capital into a single entity.

"Sanad will spearhead Mubadala's strategic investments in key technologies and capabilities to enhance and strengthen its global positioning," says Badr Al-Olama, head of Mubadala Aerospace. "As a trusted partner providing holistic services in aviation and industrial MRO, engine financing, and leasing, Sanad will play a key role in promoting Abu Dhabi as a global aerospace hub."

The new entity's creation continues a process that has been happening at the business unit level. Sanad Aerotech, formerly the aerospace segment of Turbine Services and Solutions, has been implementing advanced technologies aimed at lowering costs and reducing turn times.

Engine In-Service Fleets by Family, 2020

The number of global commercial aircraft engines in service is expected to exceed 69,860 by the end of 2020. CFM56 will dominate the engine fleet, holding one-third of the engine market in 2020, followed by the V2500 and CF34 with 9% and 8%, respectively.



Source: Aviation Week 2020 Commercial Fleet & MRO Forecast

For more information about Aviation Week Intelligence Network data, go to **awin.aviationweek.com**

Contracts

AJW Group extended a power-by-the-hour contract with **Air Astana** of Kazakhstan for its Boeing aircraft: four 757s and three 767s.

Ateliers Bigata of France was selected by **Spairliners** to provide Embraer E-Jet component repairs starting in 2020.

CAS Components of Alabama won a five-year component overhaul agreement with an unidentified major cargo airline to support high-flow pneumatics, air-cycle machines and mechanical accessories for 757Fs, 767Fs, MD-11Fs, and A300Fs.

CFM International finalized a 12-year, $1 billion Leap MRO deal with **Colorful Guizhou Airlines** for 35 Airbus A320neos. It also booked a $4 billion **Qatar Airways** order to supply Leap 1As for 50 A321neos in a deal that includes MRO support.

EFW in Germany redelivered its third converted A330-200F (610) with Trent 700s to **Egyptair Cargo.**

GE Aviation won a 12-year TrueChoice services agreement with **China Southern Airlines** for its avionics systems on 787s.

HAECO ITM won an **Air Hong Kong** contract to provide inventory (component) technical management support for two A330-300Fs.

Lotams of Poland extended its E-Jet heavy maintenance contract with **KLM Cityhopper** for 17 aircraft over the next five years.

Pratt & Whitney secured long-term EngineWise maintenance support agreements with **Vietnam Airlines** for 20 GTF-powered A321neos, **China Southern Airlines** for 24 GTF-powered A320neos and **China Eastern Airlines** for its V2500s.

Contract Source: SpeedNews

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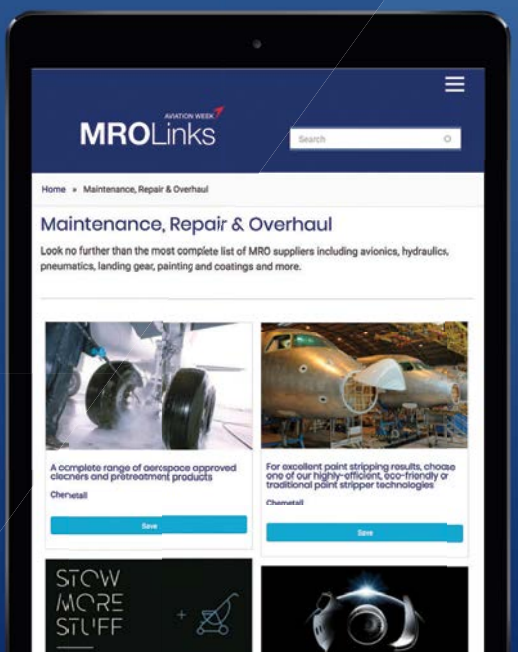

AVIATION WEEK NETWORK

Timed Out

LAZYLLAMA/ADOBE STOCK

The aviation education community seeks to bypass regulators after waiting more than a decade for regulatory reform.

Industry has long advocated for an update to regulations that govern aviation maintenance training schools (AMTS). Title 14 Code of Federal Regulations (CFR) part 147 was originally established under the Civil Aeronautics Administration, circa 1958, and recodified into 14 CFR in 1962. Since that time, neither the regulation nor the subject areas it mandates schools to teach have significantly changed.

Given the technological advances the aviation industry has made since then, 1950s teaching standards for would-be maintenance personnel are grossly inadequate. While schools have and do provide training above and beyond what is required for a mechanic airframe and/or powerplant (A&P) program, the part 147, 1,900-hr. seat-time mandate limits how much "extra" content a school can incorporate and remain marketable.

FAA-certificated schools that offer the A&P as part of a degree program have the added challenge of competing with other occupational pathway programs. Common educational standards set the minimum number of credits required for an associate's degree at 60 semester hours—or 1,800 clock hours—making it difficult for an AMTS to justify adding more coursework to an already credit-heavy AMT degree.

Regulatory relief has been slow in coming. A 2015 notice of proposed rulemaking (NPRM) came eight years after an Aviation Rulemaking Advisory Committee submitted a formal recommendation to revise the rule. It took another four years for the FAA to publish a supplemental proposal, an extra step to make adjustments to the NPRM in response to industry feedback. FAA officials have said they are still two years away from issuing the final rule, targeting publication in 2022.

Adding insult to the glacial pace, industry has serious concerns with the FAA's proposed revisions to the rule. Comments submitted by the Aviation Technician Education Council (ATEC)—and supported by a coalition of trade groups including the Aeronautical Repair Station Association, Airlines for America and the Regional Airline Association—beseech the agency to adopt a performance-based approach that defers to U.S. Education Department oversight for all matters concerning quality of education. ATEC says the FAA's proposed rule is too restrictive, overly prescriptive and would stifle an already inadequate pipeline of workforce personnel.

Given the anticipated timeline and the high-stakes need for the new rule to withstand another 50 years of innovative technological advances, industry has asked Congress to step in.

The Promoting Aviation Regulations for Technical Training (PARTT) 147 Act—a bipartisan and bicameral bill championed by Sens. Jim Inhofe (R-Okla.) and Tommy Duckworth (D-Ill.) and Reps. Don Young (R-Alaska) and Cheri Bustos (D-Ill.)—would direct the FAA to replace the current part 147 with a new, community-draft rule.

Language in the PARTT 147 Act is largely derived from regulatory text offered by ATEC in its comments to the original and supplemental FAA proposals. If it goes into effect, the law would give the FAA oversight responsibility for a program's facilities, equipment and instructor qualifications. Accredited institutions could rely on the quality systems approved under Education Department regulations, without having to go through duplicative FAA approvals that exist under today's regulations and in the agency's proposed revisions.

The draft language would also implement a community request for the FAA to change the way it approaches dual enrollment programs and allow AMTS to provide A&P content away from their primary locations (at a high school, for instance). Many aviation technical schools are prevented from expanding their programs through off-site offerings under the current regulatory structure, a problem the community says is easily remedied through utilization of additional fixed locations, something not currently available to part 147 certificate holders.

The direct rule language relies heavily on imminent FAA airman certification standards (ACS) as a check on quality. The new testing standard—being developed by an industry-FAA working group and slated for publication in the summer of 2020—will set forth the knowledge and skills required to safely and adequately perform work on aircraft and components and to act as the basis for the FAA written, oral, and practical mechanic tests.

Under the proposed framework, schools would use the testing standard as the basis for their curriculum, which would ensure training and FAA testing are correlated and that A&P programs continue to evolve as the FAA continually revises the testing standards in line with industry needs. The agency would use FAA mechanic testing results to assess a school's mechanic program and set a 70% target passage rate for all AMTS students taking the FAA mechanic test.

The PARTT 147 Act has been referred to the Senate Committee on Commerce, Science, and Transportation and the House Committee on Transportation and Infrastructure. Those bodies will ultimately decide whether the legislation goes to the House and Senate floors for a vote.

—Crystal Maguire

Big Brother Is Watching

FAA.GOV

The FAA's big data project is undergoing congressional scrutiny again, following years of delays.

The U.S. Department of Transportation Office of Inspector General (OIG) is looking into the FAA's handling of its safety data analysis system. In response to a congressional mandate, the inspector general will evaluate and report back any new information related to the FAA's efforts to improve the Aviation Safety Information Analysis and Sharing (ASIAS) system since the program was initiated in 2007.

The ASIAS is a jointly led industry and government partnership that compiles data from a variety of sources. The program provides tools and resources to analyze and disseminate aggregated and de-identified data to proactively detect risks before accidents or serious incidents occur. Source data is compiled from a myriad of databases including the Aviation Safety Action Program (ASAP), FAA Service Difficulty Reports and the FAA Accident/Incident Data System.

The FAA Reauthorization Act of 2018 specifically directed the OIG to evaluate the agency's efforts to "improve the ASIAS system's predictive capabilities and solutions developed to more widely disseminate results of ASIAS data analyses." As part of the study, the OIG will also evaluate the FAA's response to recommendations it made in a 2013 audit report, to include establishing a mechanism for providing safety inspector access to aggregate, de-identified data trends and developing guidance on how inspectors can use the data to enhance oversight, including integration with the Flight Standards Safety Assurance System (SAS).

The previous audit found that ASIAS lacked advanced analytical capabilities and that aggregate results were not readily available to aviation safety inspectors. The FAA concurred with all four OIG-issued recommendations set forth in the 2013 audit report. Those recommendations have since been marked as "closed" in the OIG Recommendation Dashboard. Nevertheless, the renewed look will focus on progress made since then to improve the system and provide better data access.

According to a recent FAA release, 47 air carriers, 88 corporate operators, 12 educational institutions, five manufacturers and two MROs contribute to the ASIAS program. The agency has recently started targeting the business and general aviation communities in an effort to broaden the scope of its data and will soon expand its reach to the helicopter industry.

The OIG mandate is one of more than 400 directives Congress passed down to other branches of the government in the 2018 FAA Reauthorization Bill.

—Crystal Maguire

ARSA UPDATE

New Risks on the Hill

PRESIDENT DONALD TRUMP SIGNED a multiyear FAA reauthorization bill into law last October. Ordinarily, aviation policy would be on the back burner on Capitol Hill for the next few years. But these are not ordinary times. If, as expected, Congress moves new FAA-related legislation, it is a good bet that the MRO sector will be a target.

The Boeing 737 MAX accidents have thrust the FAA's aircraft certification process and terms like Organization Delegation Authority (ODA) and the Maneuvering Characteristics Augmentation System (MCAS) into the public consciousness. In addition to multiple investigations by safety regulators, the House Transportation and Infrastructure (T&I) Committee is also conducting its own, which Chairman Peter DeFazio (D-Ore.) has called "the most extensive and important investigation this Committee has undertaken during my time on the Committee."

At recent House and Senate hearings, Boeing CEO Dennis Muilenburg described the steps his company has taken to address problems with the 737 MAX and its own processes, including establishing a board of directors safety committee and creating an internal product and services safety organization to review and elevate safety concerns. The company has also restructured to require all engineers to report up to Boeing's chief engineer.

"We know we made mistakes and got some things wrong," Muilenburg told lawmakers. "We own that, and we are fixing them. We have developed improvements to the 737 MAX to ensure that accidents like these never happen again."

But that clearly will not be enough for some members of Congress. "[The] 737 MAX accidents show that we need reforms in how commercial aircraft are certified and how manufacturers, like Boeing, are watched and overseen by the regulator," DeFazio said during the Oct. 30 hearing.

House Aviation Subcommittee Chairman Rick Larsen (D-Wash.) echoed those sentiments: "I see one undeniable conclusion: The process by which the [FAA] evaluates and certifies aircraft is itself in need of repair."

T&I Ranking Member Sam Graves (R-Mo.) cautioned against rushing to judgment, saying that other potential causes of the 737 MAX accidents need to be explored, including pilot actions, airline operations, maintenance and training programs. "[A]ny issues should be addressed, but only after we have the benefit of various investigative work yet to be completed," Graves said. "Jumping to conclusions before that work is complete risks doing more harm than good."

Such restraint may not win out. DeFazio's antipathy toward contract maintenance—and foreign FAA-certificated repair stations in particular—is well known and has taken legislative shape in the form of the Safe Aircraft Maintenance Standards Act (H.R. 5119). If passed into law, H.R.5119 would cause major disruptions for maintainers outside the country, U.S. air carriers operating globally and American manufacturers seeking to provide product support in growing foreign markets. U.S. repair stations and their employees would be made vulnerable to similarly hostile policies from other civil aviation authorities, which would jeopardize the certificates those companies hold and make it impossible to serve international customers.

DeFazio's fire has been fueled by unions representing airline mechanics, which have stepped up media outreach and anti-repair-station lobbying and faulted the executive branch for failing to increase scrutiny of foreign repair stations and finish the rulemaking on drug and alchohol testing. Before the Oregon Congressman had gotten to work, California's John Garamendi had introduced a union-backed bill to shame airlines that use contract maintenance (foreign and domestic).

Our industry's critics ignore the outstanding safety record and refuse to acknowledge that certification standards are the same for U.S. and foreign maintenance facilities. Foreign repair stations are also essential to American air carriers operating internationally as well as manufacturers and MROs seeking to serve a growing global customer base.

What's more, banning new foreign certificates and making it harder for U.S. air carriers to send maintenance overseas would almost certainly lead to retaliation against U.S. industry. More than one-third of U.S. repair stations hold at least one foreign certificate. Those companies—and their employees—would suffer the consequences of a maintenance trade war.

ARSA is stepping up efforts to make sure lawmakers understand the facts and do not impose new mandates and restrictions that do more harm than good. But we cannot do it alone. The whole industry must step up to ensure Congress knows the important role repair stations play in making aviation the safest form of transportation.

When lawmakers' agendas are not based on the facts, and safety is not the overarching goal, the result is policymaking at its worst.

Get more information, including access to a "myths and facts" document, at arsa.org/legislative and keep tabs on H.R. 5119 at arsa.org/hr5119.

Christian A. Klein is the managing member of Obadal, Filler, MacLeod & Klein and executive vice president of the Aeronautical Repair Station Association.

Boeing Global Services' New CEO


BOEING

Inside MRO's *Lee Ann Shay conducted this exclusive interview with Ted Colbert, who transitioned to CEO of Boeing Global Services in October, from Boeing chief information officer and senior vice president of information technology and data analytics.*

Given your IT and data analytics background, how much of an influence will this have in your new role?

My degree is in industrial engineering. It's a fun field because it brings together everything—business, technology and industrial optimization—so I've always had that balance of business and technology, and I've always led and worked with a business mind first in everything that I've done. Even though behind the scenes I love technology and can geek out on really technical things, I'm a businessperson first, a people leader and technologist.

When this opportunity came, I'd been leading a pretty substantial IT organization, one of the largest in the world. We made a lot of progress in catalyzing the transformation of the company across every part of our value stream. There's a natural extension to leading a big transformation in a big company. Essentially, over the years we have taught our IT leaders to run IT as a business, [to] focus energy and investments on the work that delivers the highest value to our business and to our customers. All I've done is take one step closer to being able to deliver value to our customers.

I'll take all of the skills that I've built over the years around leading people, leading large organizations and optimizing investment of resources and staying focused on the customer. So it feels like a natural extension. This business in particular will have a strong underpinning in technology. We all talk about the Fourth Industrial Revolution and the opportunities that brings to the industrial world. That's not just about how a company runs but also about how it delivers products and services to its markets. Stan [Deal] and Leanne [Caret], my peers, are partners, and I've known them for many years. I've been working with Dennis [Muilenburg] since I joined the company.

Given your industrial engineering background and work with cross-functional teams, that sounds like a natural background for this job.

It's super important because our offerings—engineering and modifications, supply chain, digital, parts business—do not exist in isolation. It all has interdependencies with other parts of the business and partners outside the company and with our customers, from a demand, quality and safety perspective. To continue to grow a business and find adjacencies, it requires a ton of collaboration. You don't make decisions in isolation.

Within the company, you optimize the supply chain and optimize your ability to sell parts and get them to the right place at the right time by using the rest of the value stream—capturing data and insights so you get to an environment where there are no surprises and being able to use the intelligence and feedback loop about demand and quality, and feeding that back into the engineering organization for future design work.

A lot of people don't realize that information technology professionals often know a lot more about your business than you do because they are always trying to figure out how to get things to work. We tend to keep a very systemic mindset and focus on cause and effect. Especially in my previous job, I tended to focus on the context of the value stream—design, engineering, manufacturing, supply chain and services. So many decisions we make have an effect on that whole value stream.

The focus is on optimizing the system instead of suboptimizing pieces of the system. Collaboration is a muscle that we use a lot. It's a way toward getting to our glidepath of $50 billion, which is a fun but big, audacious goal that I walked into.

Last year, Boeing Global Services had 17% year-over-year (YOY) growth. Are you on track for 2019?

Yes, we are on track for this year. In the third quarter, we had 14% YOY revenue growth, to $4.7 billion. We had orders of $6 billion and a backlog of about $21 billion: The focus is creating more lifecycle value for customers. We estimate the services market at $3.1 trillion over 10 years. If you break down the business in pieces, you find market opportunities and fill up the area under the curve to get to $50 billion. We're on the path to get there, but we haven't figured out everything yet.

We purchased KLX [Aerospace Solutions] one year ago, and we've gotten lots of good benefit from that. We call it Boeing Distribution Services (BDSI) now. There are a lot of synergies there that will helps us grow—that's been a big organic play. We just acquired [mobile and web-based aviation application provider] Foreflight, which will help us grow and help us shore up solutions in that realm. We also need to drive operational excellence with everything we do—from safety to quality and

productivity. Getting to $50 billion will be about thoughtful organic plays and driving optimization for ourselves and our customers.

When do you think you'll get to the $50 billion?

The goal is 2025. From a leadership perspective, you have to shoot high. When we set up this business, we believed it was important to pull together the services business from our commercial, defense and government worlds into one business so we could take advantage of the life-cycle value of our products to better serve our customers. By pulling it all together, we can leverage a ton of economies of scale and talent that is focused on the customer. I think the thesis for this is absolutely right. You have to set a big goal. That's the only way you'll drive the efficiencies needed to really serve customers well.

Are you planning any other supply chain changes other than finishing the SAP implementation?

Implementing SAP provides the core end-to-end process capability for the business. We will continue, as with any enterprise resource planning (ERP) and supply chain environment, to drive optimization. That is super important. Acquiring KLX and turning it into BDSI allowed us to learn a lot more about how it was operating distribution services. Then that allowed us to better optimize the whole.

There's a lot of synergy between what our team is doing with Aviall and with BDSI. Right now, we're taking advantage of all of those synergies that were in the thesis to bring KLX in-house in the first place. We've got a lot of investment in used serviceable materials, and we're looking at how additive manufacturing can serve us from a parts perspective. That world is all about continuous improvement. That's an area of our digital world that I've been involved with for a long time.

Speaking of ecommerce, is Boeing looking into blockchain?

This is another area of synergy between my old job and new job. We think blockchain is very interesting and could have a future. I wouldn't say we've gotten to the point where we're going to implement anything yet—it's a technology-to-watch area that could be important in the future, for sure.

In conversations I have had with Stan Deal, he mentioned that the new mid-market airplane (NMA) would be a key piece of leveraging developments across the whole life cycle—from development to manufacturing to services.

Let's put NMA to the side and look at the concepts you're talking about. Model-based engineering and model-based enterprise is foundational for how we as a company move forward. When you start with model bases for everything—from requirements or part definition—and you pull that thread through engineering and design and into manufacturing, it allows you to have digital twins. That basis of data and definition flows right into services. Independent of any program, that work has to continue. We have to drive toward a model-based future and a digital future because the ability to pull that thread through to the services world and provide a feedback loop from the field and our customers will be more and more important as we design for safety and quality. We're still making a lot of investments in a model-based future, and that won't change.

The industry still has concern about data ownership and how it's used. Can this be solved?

From a human perspective, I think there's still a lot of fear about what the data will be used for. If you extend our experiences from a personal perspective, with all of the cyberincidents and intrusion into our personal data getting lifted from places we trusted, that sets a context for that fear.

Then we shift to our business world, and we realize that data is an asset. It's a big asset that is difficult to assign a particular value. We will break through this over time because most of the future capabilities that our industry will deliver—and the safety and quality that will be required—will require us to pull together disparate data. That data will have to come off of the airplane, the helicopter, the fighter jet, the engine, the other elements of the ecosystem and environment so that we can better predict the things going on around us.

We're developing solutions in vertical capabilities to demonstrate outcomes and to demonstrate whether we can trust algorithms or not. Over time, we'll realize the value of the data is the outcome and not just the data. There will be value in the data, but we'll focus more of our attention on the outcomes associated with using the data. We'll figure out the business case around sharing data.

There are ways to obfuscate specific data points and use the data to deliver specific outcomes to solve problems. Big problems will pull us through this over time. But right now it is hard—and our commercial world has not caught up with how to assign value to it and what it will look like over time. Because once you have access to data and you solve a problem, you move onto the next problem. Then the value of that data or solution diminishes very quickly. There's a business model that we haven't quite figured out yet. Over time we will figure it out, and I think partnerships will be important.

Data is an asset, and we know leveraging data over time frankly is its own vertical or an extension of all of our verticals. So you have to be very thoughtful about how you use it, how you assign value to it. And then there is a ton of work that you have to do to stick with the foundations of integrity, availability and confidentiality of data.

Does that relate to cyber?

In my last role, part of my job was responsibility for cybersecurity of the enterprise. There is also a role in ensuring, with as much vigilance as possible, the protection of all of our capabilities. Having that assurance that the data is what it says it is and is in the hands of who it should be will continue to be important. It will be table stakes for everything that we do and potentially a differentiator over time.

What most excites you about your new role, and what is most daunting?

We're in a $3.1 trillion market—it's a huge market, so there are tons of opportunities. I get excited about

solving problems for customers. I know this sounds cheesy, but in the first century of our company, we helped shrink the world. In the second centry, we'll help shrink the Universe, and our services business will be right there helping. The ability to grow our business from the high teens in revenue to a $50 billion objective—how do you not get excited about that?

For the second part, this world that we're in has grown up in its parts and pieces. As a businessperson and a technologist, it's daunting to think about how to really integrate a bunch of capabilities that are strong-performing and have lots of value for customers. In your mind, you see orders of magnitude of more opportunity if you can really integrate them. That's big, and hard—doing that without disrupting customers and not hindering quality or safety. You've got to solve that one day at a time.

That's how I've approached many big problems in my career. I know there are synergy opportunities, but it's hard to drive that without real integration. And frankly, that involves people. Do our people have the skills they need for the future, and do we have the culture that we need for the future?

Digitalization has to be part of this. And what role do additive manufacturing, robotics and virtual/augmented reality and artificial intelligence play?

I try not to be a digital zealot—but the fundamentals of business are still there: You still need to manage throughput, work in progress and cycle time. You still have to design products that fit together and that mechanics can use safely. The "and" of technology is always super important to me. It's always additive and not subtractive.

We've done some experimentation around augmented reality (AR) and virtual reality (VR) in the training world and in the factories assisting our technicians and mechanics. Those technologies will continue to mature. VR goggles look really cool—but then when you dig in, you see you have to get a lot of data to that thing, and someone would have to wear it for how many hours? So there are a lot of problems that need to be solved. It's not trivial, and this isn't a video game.

If you have a model basis for all that we do, then over time the ability to leverage additive manufacturing becomes even more powerful, because additive requires you to get parts definition to a machine and create.

For artificial intelligence and analytics, Greg Hyslop, our chief technology officer, is a great partner, and our research and technology team and our IT team are looking at applications across the value stream. We are learning about the application of artificial intelligence. In our world, because safety is so important, the microscope on algorithms is intense. And how do we bring our regulators along, too? There is a lot of work to be done in that area.

But I do think within the enterprise and within the supply chain, we will absolutely use more automation and artificial intelligence in our warehouses to be more efficient, to be able to predict demand signals and use that information to become more efficient and right-size our inventories for customers. We're just starting to scratch the surface.

There are a lot of 737 MAX aircraft parked. From the services perspective, what's happening?

It's the most important priority for our company. We continue to work with the regulators on the plan to get planes back in motion with customers as revenue-generating assets. Our team is right there with the broader team and being part of the training piece as we implement new software and all of the logistics required to get the planes back in the air.

Beyond our team working to get the aircraft back in the air, we are also engaged with customers affected by the accidents. We've established a $100 million fund for the families [of those killed in the Lion Air Flight 610 and Ethiopian Airlines Flight 302 crashes]. It's been emotionally gut-wrenching for all of us.

We believe in our products and services, and our goal is to work with regulators and learn from everything—learn, learn, learn from everything and become a better company. It's an unfortunate pathway to progress, but we will make the company and industry better.

Digits and Devices

Digital tools that could transform MRO processes

Henry Canaday Washington

The digital age is steadily revolutionizing aircraft maintenance in many ways. Digitized data enables the powerful analytics that are transforming maintenance strategies. But digital technology is also enabling many tools and devices that can perform very specific maintenance tasks faster, more precisely and at lower cost.

Sarcos Robotics' Guardian XO exoskeleton can help workers lift heavy or awkward objects.

As digital technology transforms both the strategy and tactics of MRO, a number of trending technologies are affecting efficiency, accuracy and safety on the workshop floor.

SCANNING AND INSPECTION

To save time and increase accuracy in maintenance tasks such as inspections or reverse-engineering of parts, many MROs are turning to hand-held scanning devices.

One of these is Spectrum Metrology's 4D InSpec XL surface-defect gauge, which measures in three dimensions micro-defects such as scratches, nicks, pits, protrusions, radius of curvature of grooves, spheres and shafts and even rivet geometry. Using a camera for stability, 4D InSpec is portable, allowing measurements on shop floors without dismantling large parts.

For aircraft MRO, the device is most commonly used for measuring pits, nicks, wear, scratches and corrosion on parts being inspected, and then edge blends of welds, rivets and grinds done during maintenance, says marketing manager Ed Schrock. "We provide a three-dimensional measurement of the area of interest, which can be analyzed by hand or through automated analysis with a 'pass' or 'fail' result."

Spectrum Metrology says InSpec's increased accuracy enables an MRO to accept more parts, rather than reject them. "Our customers report a 20-40% increase in yield," Schrock says. Portability means instant results, saving time compared with sending parts to laboratories. According to the company, these advantages have led General Electric and other major engine OEMs, the U.S. Air Force and five of the top 10 global airlines to adopt InSpec.

Another inspection system is 8Tree's DentCheck, which also analyzes surface deformations, checking for dents, bumps or waviness. It was built to aviation specifications and is currently used by many airlines and MROs. Lufthansa Technik (LHT) selected DentCheck for damage-mapping at all of its base maintenance facilities. Cathal O'Loughlin, head of tooling for LHT base maintenance, likes both the easy use and performance of DentCheck.

8Tree CEO Arun Chhabra says case studies at Delta TechOps, Allegiant Air, EasyJet and TAP-M&E demonstrate that DentCheck reduces inspection and reporting times by up to 90%, shortening turnaround times. Allegiant estimates that DentCheck inspection for possible damage during induction of four aircraft reduced the time required by traditional manual methods by 87%.

Another scanning device with slightly different capabilities is Shining 3D's FreeScan X7, a hand-held laser 3D scanner developed in China. The X7 is light, weighing just over 2 lb., and highly portable. It blends optics and inertia for scanning.

The device can be used for several maintenance tasks, according to Shining 3D account manager Kevin Crittenden. Using inspection software, X7 can determine whether the shape of any part deviates from the shape of a computer-assisted design model.

In addition, X7 can reverse-engineer a part. It first scans the area to be modified. Then reverse-engineering software can create a computer-assisted design (CAD) model to simulate design challenges like fit, finish and function before physical modification begins. "A lot of parts needing repair do not have CAD models—all they have is the old, broken part," Crittenden explains. So engineers can scan

SARCOS ROBOTICS

the part, then fix the geometry by taking dents out to produce a CAD model.

Finally, X7 can assist computer-aided machining, rapid prototyping or additive manufacturing. Data collected by FreeScan can be imported into software to produce a computer numerical-control machine's cutter path or guide a 3D printer to make a replacement component. Magnetic MRO used the X7 for a refurbishment project for TUI.

AUGMENTED REALITY AND WEARABLES

Also saving time—as well as physical effort by workers—are a variety of wearable devices that are making their way into MRO environments.

RealWear's HMT-1 is a helmet-mounted android PC, camera and display that has been ruggedized for tough assignments and—through voice control—allows hands-free operation by mechanics or other workers. RealWear CEO Andy Lowery says the HMT-1 can help aircraft mechanics in two ways.

First, it enables remote collaboration between less experienced technicians on-site and more experienced experts at a distant location. Instead of making a phone call to collaborate on repairs, the technician and expert can share the same view of the maintenance problem. A BMW study of a similar device found no difference between the effectiveness of this type of remote collaboration and assistance provided by a physically present expert. Lowery says a 75% reduction in troubleshooting time can be achieved. RealWear has had discussions with Emirates about putting an HMT-1 on board its aircraft to assist with inflight troubleshooting.

A second potential application would be ensuring safety compliance in line maintenance. Mechanics could use the HMT-1 to ensure they see and comply with required checklists.

RealWear says the HMT-1 is more suited to outdoor use than the lighter—but more fragile—Google Glass and has a longer battery life. Lowery also argues that Microsoft's Hololens is more designed for data display than reality. "We focus on reality first and then supplement it," he stresses.

Moving from the head to the hands, Proglove says its smart data glove is reinventing scanning for a smarter workforce. Saying it is one of the lightest, smallest and toughest barcode scanners in the world, Proglove connects workers at Lufthansa Technik Logistics with actionable information via the Internet of Things.

With a scanner on a glove, mechanics can scan hands-free. Saving 4 sec. a scan and reducing errors by up to a third, Proglove says its smart data glove can return its investment in a month. LHT estimates that Proglove has so far saved nearly 4 million hr. of work and prevented nearly 15 million scanning errors.

LHT uses the wearable at check-in and packing stations for shipping aircraft parts. The devices give workers visual, acoustic and touch feedback on each step in their jobs. But Proglove's wearable barcode scanners can be used anywhere there is a need to scan barcodes, explains spokesman Axel Schmidt. Proglove could also be used to document which parts are built into specific aircraft for configuration control. "The benefit of our products is that you wear them," Schmidt stresses. "You do not have to reach for a conventional scanner gun."

LHT also uses the feedback option on Proglove to identify aircraft-on-ground (AOG), high-priority items. "That way, workers know right away which shipments need to go express," Schmidt says. If a parcel is for an AOG,

the worker receives an AOG alert combining light, sound and vibration.

For the very heavy-lift work in maintenance, mechanics may someday don an exoskeleton—such as Sarcos Robotics' Guardian XO. The XO is a powered, untethered, industrial exoskeleton suit that improves human strength and endurance without restricting the worker's freedom of movement.

Sarcos says the XO can enable workers to safely, comfortably and easily lift up to 200 lb. repeatedly and without exertion, strain or injury during an 8-hr. workday. "The Guardian XO is able to perform physical activity that would otherwise be impossible for a single human to perform, in environments where lifting of heavy materials or awkward objects is required yet cannot be fully automated or aided by standard, mechanized lift systems," explains Sarcos Executive Vice President Kristi Martindale.

Maintenance tasks ideally suited for the XO include lifting and manipulating heavy parts or materials such as tires, assembling or maneuvering large pieces of equipment, overhead work and large-tool handling. The weight of the suit, as well as its payload, is transferred through the suit's structure to the ground, thus offloading all the weight the worker would otherwise bear as well as the weight of the suit itself.

Sarcos says major benefits include increasing maintenance productivity and mechanic well-being, equalizing the workforce by enabling more worker diversity in heavy-duty jobs and possibly extending career longevity. The last two are especially important, given the shortage of aviation mechanics.

And exoskeletons may be coming faster than you think. Martindale says the XO will be released to a select set of customers in early 2020 and begin shipping commercially in the second half of 2020.

PREDICTION AND TRACKING

Predictive maintenance is all the rage now, but in order for it to achieve maximum benefit, the whole supply chain must be able to anticipate parts needs as well.

Beep Analytics offers a tool for OEMs, distributors and other parts suppliers to forecast demand for parts accurately. CEO Jens Peder Pedersen says Beep's demand forecasts are based on a supplier's existing sales and product data combined with aircraft fleet and MRO data that are available commercially. The company is also building its own data sets for certifications and parts manufacturer approvals (PMA). Beep reconstructs detailed aircraft bills of material tailored to the product portfolio of each of its OEM or distributor customers. It also tracks aircraft movements, flight hours and cycles, and correlates this information with design data.

8TREE

Airlines such as EasyJet and Allegiant are using DentCheck to reduce inspection and reporting times.

Beep typically needs supplier historical sales data going back five years, but it can make demand predictions in other ways if necessary. Pedersen expects Beep's algorithms to be very accurate, within ±10% of the true figures. The company is now working with a number of OEMs and distributors in various stages of testing and implementing its system.

Predictive maintenance for aircraft parts requires building virtual doubles of aircraft components. But this digital twinning approach can also be used at a higher level of activity. Ubisense has been building digital twins of factories and workshops for 20 years.

"We focus on real-time locations and what is happening in the hangar during maintenance work," explains sales director Hugh Revie. "We can virtually represent tasks, tools, materials and people, and present on the screen an accurate 3D model of what is happening in the hangar during a work order."

Revie says this twinning model has enabled managers to increase productivity 20-30% in nonaerospace sectors, and he believes similar gains should be possible in aviation maintenance.

Ubisense offers hardware to track objects in hangars and can pinpoint objects in real time down to centimeters. Its SmartSpace software exploits location and identification data from multiple sources including Wi-Fi, Bluetooth, GPS, barcodes and RFID to track physical locations and determine which tasks have been completed and which remain to be done.

Revie believes an MRO digital twin created by SmartSpace for aircraft maintenance has enormous potential. Making the most of this would start by monitoring the physical world with the right sensing technologies, then transforming this data and building a model that reflects MRO processes. The final step is continually optimizing each process.

Also focused on tracking objects is Singapore-based Xerafy, which specializes in high-performance passive metal RFID tags for better performance in industrial environments such as aerospace. "We manufacture some of the world's smallest and most durable RFID tags, which make them uniquely suited to applications in aerospace," explains product director Michel Gillmann. He says Xerafy's metal tags are especially resistant to shocks, fluids, harsh chemicals and extreme temperatures.

The company is seeing interest in tool control and preventing foreign object damage at point of use. "MRO warehouse management is another hot topic," Gillman says. "Think of tool cribs that come fitted with detectors for tool control in real time or hand tools that embed RFID tags to support tracking and control."

Gillman believes the primary benefit of Xerafy's RFID tags would be preventing foreign object damage to tools on shop floors by automating tool control and detection of missing tools.

Tricks of the Trade

Examining the cabin refurbishment market for aircraft transitioning between leasing customers

SR TECHNICS

Alex Derber London

Several new aircraft and a range of new cabin options have hit the market over the last decade. For eye-catching technical innovation, Boeing led the way with the 787's oversized, electronically dimmable windows. More recently Airbus has had sales success but ensuing production problems with its Airbus Cabin Flex build.

At the same time, the market has experienced a surge in the popularity of midlife aircraft, which in turn has prompted demand for cabin retrofits to either refresh interiors for an aircraft's existing operator or to adjust it to the needs of a new one as the aircraft moves between leasing customers or airline owners.

GECAS estimates that it transitions about 100 aircraft each year between airlines, although the actual number can vary appreciably. The rough average equates to about 8% of its portfolio, which if scaled to the wider leasing industry, means about 1,000 leased aircraft moving between operators—and needing new cabins—each year.

Obviously, the unpredictability of factors such as airline bankruptcies and mergers make this a hazy approximation, but it is in the ballpark of other estimates. For example, consultancy IBA has calculated there were about 900 lease returns in a 12-month period from 2014 to 2015.

This adds up to a significant volume of work for MRO providers capable of performing cabin retrofits.

SR Technics, for example, reports that two-thirds of its interiors business on the engineering side is from aircraft transitioning between lessees. Meanwhile, Brian Dowling, head of transactions and transitions for lessor CDB Aviation, says the market for narrowbody cabin retrofits is "vast," with most MRO shops and Part 21 design houses capable of undertaking Airbus A320 and Boeing 737 interior jobs.

"Where the market changes is in the widebody arena, where the number of suppliers and vendors with demonstrable capability in widebody reconfigurations is a much smaller pool to work from," he adds.

Who pays for reconfiguration work when aircraft transition between leases depends on negotiations between lessor, ex-lessee and new lessee. In some circumstances, the former lessee might contribute to the cost of the new cabin in exchange for forgoing return conditions that may not be needed for the next lease configuration. A typical example might be meeting wear-and-tear criteria for the existing cabin—a pointless exercise if the new operator wants to install its own cabin. This also circumvents a fairly common disagreement in lease transitions over the definition of "normal wear and tear"—a standard return condition but one that can mean different things to an airline about to receive an aircraft and an exiting lessee eager to see it out the door.

More often it is the new lessee or the lessor that pays; in the latter case, the cost of the new cabin usually would be factored into the lease rate. That said, Lucas Mollan, chief technical officer for CDB Aviation, notes a growing trend for new lessees to undertake—or oversee—widebody cabin reconfigurations themselves.

Cabin integrator SR Technics offers design, engineering and MRO services.

"Several reasons may be behind such developments, such as recent experience by [the] next lessee with similar reconfiguration programs, and hence their ability and knowledge to undertake such a program to make savings on cost and lead times based on previous experience and relationship with vendors and Part 21 design organizations," he says.

David Campbell, executive vice president and chief technical officer of GECAS, agrees, highlighting cases in which large fleet-retrofit programs give airlines volume-based pricing power. "Lessor and lessee may then come to an arrangement where the lessor contributes toward the purchase of interior parts with the lessee managing the equipment purchase," he says.

REGIONAL VARIATIONS

When choosing an MRO provider for cabin work, a customer will often seek one capable of performing a concurrent heavy maintenance check. In some cases, this will mean choosing a provider on the same continent, although most players in the cabin-replacement market regard the competition for design, certification and material provision as global.

"For cabin-reconfiguration work, one has fundamentally to deal with three distinct groups: the design houses that carry out the engineer-

ing; the parts suppliers such as seats and galley vendors that manufacture the parts; and the MRO facilities that do the typical hands-on touch labor," observes Dowling.

He sees few regional preferences for types of cabin configuration, noting more of a distinct delineation between low-cost carriers and full-service operators. Campbell agrees, adding that "large carriers tend to value rigid cabin commonality while smaller carriers tend to be more flexible with cabin configurations."

Randolph Odi, SR Technics' vice president of aircraft engineering and head of design organization, agrees and describes a "higher acceptance of [in-flight entertainment (IFE)] systems" in the narrowbody fleets of American and Asia-Pacific operators than elsewhere, which he attributes to longer flights in those regions, as well as intense competition that drives operators to improve passenger services. "By contrast, most narrowbodies in Europe will have limited or no IFE at all," he says.

Another important regional difference concerns the Chinese narrowbody fleet. Low-cost carrier (LCC) penetration is relatively low in the country, and single-aisle operators tend to prefer dual-class configurations and young aircraft. This means that many narrowbodies will leave the country after their first lease, often requiring conversion to the single-class configuration favored in other parts of the world.

PATRICK DELAPIERRE/AFHLM E&M PHOTOS

Many carriers are expanding their business-class sections at the the expense of first class.

WIDEBODY TRENDS

"The notable trend in widebody configuration is from a typical three-class configuration, in an eight-abreast layout, toward a much higher-density nine-abreast layout, in either all-economy or some form of premium economy at the front," says Lucas Mollan, chief technical officer of CDB Aviation.

Mollan also notes that customers are increasingly asking for in-seat power throughout the cabin for passengers' personal devices, and that some are moving away from video-on-demand IFE in every seat as a result. This trend could reduce some of the complexity of cabin retrofits, although new demands for connectivity and higher densities will mitigate any gains to some extent.

At SR Technics, Odi also has observed greater appetite for Wi-Fi connectivity and in-seat power, for which the complexity of installation can be exacerbated by other factors. "Long material lead times for certain parts means that operators want to use the inventory available on one platform on another platform, leading to complex certification challenges," he says.

Another difficulty, says Mollan, is that higher densities require seats with a minimum pitch of 28 or 29 in. "The number of such certified seat models to low-pitch levels is extremely limited, hence the ability to source some on the second-hand market in any great numbers is a challenge."

Campbell says that some seat suppliers have responded by releasing more off-the-shelf products, although long lead times for cabin parts and work remain an issue. "The complexity of the certification process, new requirements such as HIC [head injury criteria] and pressure within the supply chain make it challenging to reduce lead times and costs for cabins overall," he says.

However, he also observes that IFE

costs have fallen due to more competition and simpler system architecture.

NARROWBODY TRENDS

Narrowbody cabin reconfigurations are simpler and cheaper than those for widebodies for many reasons. Aside from the obvious fact that single-aisle aircraft are smaller, their different mission type means equipment such as lie-flat seats and IFE is rarely required. Furthermore, narrowbody customers are frequently low-cost carriers, for whom maximum simplicity across fleets is desirable. On top of that, a plethora of MRO providers with narrowbody capabilities means airlines have more choice when it comes to doing the work.

Higher-density preferences from LCCs have put pressure on seat suppliers.

Nonetheless, there is a growing trend for full connectivity across narrowbody and widebody aircraft, which adds to complexity, while the shift toward larger-gauge aircraft such as the Airbus A321 and longer mission ranges are causing many carriers to rethink their cabins. JetBlue, for example, operates "all-core" and lower-density "Mint" configurations of its A321s on domestic routes and has mooted plans for a "reimagined transatlantic version" of Mint featuring more lie-flat seats as well as a long-haul version of its core economy layout.

"For longer-range narrowbody aircraft, interior configurations are increasingly complex," observes Campbell. Running against that trend is the fact that "personal electronic devices are likely to replace embedded IFE on shorter-range aircraft," although he says the "jury is out on whether this will extend to long-range aircraft."

SR Technics' product sales director for aircraft engineering services, Oladi Olukolu, points out that while narrowbody cabin work is somewhat less complicated than for widebodies, "this creates a false illusion because there are still material lead times that are often overlooked." His colleague, Odi, highlights the passenger-service units that sit above each seat as an example, while also noting that changes to cabin management systems can require reprogramming services from original equipment manufacturers that match the changed configuration. "Such services typically have a long lead time and must be carefully planned from the start," says Odi.

To minimize cabin turnaround times, cabin integrators also need to carefully manage the mix of buyer- and supplier-furnished equipment (BFE). Odi points out that since the airline orders the former, integrators like SR Technics have no contractual relationship with the BFE supplier but in many cases will still be expected to ensure that all the necessary equipment is in place on-time for installation.

"The transparency of the actual on-dock dates across different suppliers has been a challenge for the entire industry," says Olukolu.

One way to ease certain supply chain pressures might be additive manufacturing, which can allow MRO providers to manufacture parts on-site. Indeed, 3D printing within the aftermarket has been applied more to interiors than any other part of the aircraft. Even so, the technology is still too young to have much application beyond prototyping.

"A big advantage would be to improve the availability of the right parts at the MRO location where the cabin work will be carried out," says Odi. "The conclusion, however, is that integrators need to learn how to design and execute projects that take 3D printing into account from the start.

EMERGING CABIN TRENDS

If one were to judge modern air travel solely by the marketing of the biggest carriers, one might conclude that it had never been more luxurious, with passengers able to relax in private cabins, stretch out in double beds and nibble on gourmet offerings from the galley.

The reality is very different; while ultra-luxurious offerings are a prime marketing tool, airlines increasingly favor premium-economy and business-class seating over first class. OAG data shows that in the past decade the number of first-class seats on offer between London and Los Angeles has fallen by 41%, with similar drops recorded on the London-Hong Kong and Singapore-Sydney routes, as well as many other city pairs.

Emirates is one of the few major airlines to have added first-class capacity in the last 10 years, but even the world's biggest proponent of luxury flying is having to adjust. In November, it was revealed that Emirates would reconfigure two A380s to feature more business-class and premium-economy seating.

Lie-flat seats in business class are now regarded as essential for long-haul flights, while innovation is also coming to the economy cabin as airlines seek to offer increasingly personalized services. "The increasing sophisitication of travelers in all classes is increasing the demand for a unique treatment. Integrators who can use their creativity to enable operators to take advantage of this demand and find ways to generate more value will be successful in the future. Such success can only be achieved through a paradigm shift in cabin design," says Odi.

Clearing the Air

Projects are in the works to improve cabin air quality

DHL

Pall Aerospace Corp. developed the first cockpit fresh air filtration system for commercial aircraft application under an STC for DHL's Boeing 757-200 freighters, approved by EASA in 2012.

Paul Seidenman and David J. Spanovich San Francisco

When American Airlines Flight 729 took off from London's Heathrow Airport on a routine flight to Philadelphia on Oct. 21, a strong odor engulfed the cabin of the Airbus A330-300, prompting the flight crew to divert to Dublin, where it landed safely. News media reported that passengers complained of burning eyes and itchy skin. Of the 287 customers and 12 crew onboard, two crew members and one customer were taken to the hospital for evaluation, and all were released the same day.

The source of the fumes was a cleaning solution that spilled in the galley.

While fume events are rare, they are a reminder that cabin air has potential health risks. This is because the air supply on nearly all turbine-driven aircraft is a combination of fresh and recirculated air. The fresh air pumped into the cabin is engine bleed air. Currently, the only exception is the Boeing 787, which uses a separate, bleed-free system. Once in the cabin, that air is filtered to screen out pathogens and odors as it is recirculated.

"It is the bleed air that will be contaminated with engine oils, mainly from the compressor bearings compartment, as the oil seals leak—and all engine seals leak," says Tristan Loraine, cofounder of the London-based Global Cabin Air Quality Executive.

"In recent years, there has been growing concern about the health risks of smoke and fume events from the bleed air, sometimes generated by the failure of an engine oil seal," he notes.

Loraine also reports that another inhalation hazard from bleed air is hydraulic fluid, which, he points out, is about 70% organophosphate. Although he adds that HEPA (high-efficiency particulate arrestance) filters have proven very effective at removing bacteria and viruses from recirculated air, Loraine points out that no regulations—only guidelines—exist as to when they should be replaced. "Some airlines are installing dual HEPA/activated carbon filters to remove [volatile organic compounds (VOC)] from the recirculated air," he says.

In fact, suppliers of aircraft environmental control systems (ECS) see opportunities in the field of cleaning cabin air and are developing technologies to pursue them.

At the Aircraft Cabin Air International Conference in London last September, Pall Aerospace Corp. announced that its aerospace team completed the first full-system ground test of its Purecabin Total Air Filtration System. Pall Aerospace aims for certification of Purecabin on the Airbus A320 family by mid-2020 as a full fresh air cabin and cockpit filtration system, according to Steve Simpson, senior marketing director. He adds that by mid-2020, Pall Aerospace expects to certify a sensor that will detect the presence of engine oil, hydraulic and deicing fluid in the air supply. The sensor will work in conjunction with, or independent of, the filtration system. Purecabin, Simpson

says, will bring filtered bleed air to the passenger cabin for the first time.

It employs a "high-performance synthetic carbon" which, Simpson explains, has been extensively tested by an independent laboratory against a wide range of chemicals.

"We have demonstrated that this synthetic carbon will mitigate the presence of chemicals that may be found in the cabin air supply, including tricresyl phosphate, or TCP," he notes. "The Mist and Vapor Eliminators (MaVE) fresh air filters will also remove odors that originate from outside the aircraft or those that are due to system malfunction."

He says the system has been designed with a minimum-weight, low-maintenance approach. "Weight and maintenance were an important consideration for Purecabin, since it has to be integrated into an existing aircraft system," he explains.

Simpson confirms that a number of new technologies are under consideration for future filtration. "However, we have to be careful that by solving one problem, we do not create another," he says. "For example, catalysis can be effective, although in some cases it may produce contaminants of more concern than those currently entering the system."

Pall Aerospace already has a successful track record with bleed air filtration. The company created a fresh air filter for cockpit retrofit on the Boeing 757-200 freighter—specifically powered by the Rolls-Royce RB211-535—certified by an STC for DHL Aviation. Installed in an existing air duct, the cockpit filter has had full production approval since 2012, under European Union Aviation Safety Agency (EASA) declaration of design performance (DDP) approval. To date, the DHL 757-200 freighters are the system's only application, although other airlines, which Simpson is not at liberty to disclose, are considering it.

Stacy Morrissey, managing director of fleet engineering for American Airlines, reports that the carrier has been working with filter manufacturers for the past several years on fresh air filtration systems by providing aircraft, facilities and support for full-scale ground tests. However, she cautions that while the technology is promising, retrofits are not expected to be easy or inexpensive.

"As with many projects, there are technical issues that must be overcome. For this project, for example, we need to make sure that airflow to the cabin and the ability of the system to control temperature is not appreciably affected with the filters installed," says Morrissey.

In the meantime, a new approach to cabin air purification by Savannah-based Aviation Clean Air (ACA) could make it unnecessary to use the more expensive filters in aircraft cabins and cockpits, according to Mallie Seckinger, managing member. ACA was established in 2012 to develop and market its eponymous Aviation Clean Air component, which is available for retrofit under an STC from Southern Aviation Parts and Service (SAPS), ACA's certification engineering partner and majority shareholder.

As Seckinger explains, Aviation Clean Air's ACA component is "100% green technology" since it is completely electronic, uses no chemicals and produces no odors or harmful byproducts. "The technology replicates and accelerates nature's natural cleansing, odor-elimination and pathogen disinfection process through an electronic ionization process," he says.

Activation commences when the aircraft's ECS is switched on, and air begins flowing into the cabin and cockpit through the air ducts. Seckinger stresses that the system is not a filter and has no filter-system structural characteristics. "The component is quickly installed seamlessly in the air ducts, has no moving parts to wear out and requires no scheduled maintenance," he remarks. The system weighs 2 lb., including mounting hardware. The number of components needed per aircraft depends upon the layout of the existing duct system. "As examples, a Gulfstream G550 requires two, while a Boeing 737 requires four," he says.

The ACA component, Seckinger points out, was designed to achieve continuously improved air quality, along with surface purification, simultaneously. "Within just a few seconds, it proactively and effectively controls both existing as well as newly created odors, such as VOCs, including those associated with, but not limited to, fuel emissions and the fueling process," he says. "It also eliminates cooking, cleaning and stale air odors, wherever the conditioned ECS air reaches."

Seckinger says that the ACA component also kills existing as well as newly created pathogens brought into the aircraft and spread by aircraft servicing personnel, passengers or crew members through touching, coughing

AVIATION CLEAN AIR

A mockup of the Aviation Clean Air system as it would look installed within a 7.5-in. environmental control system duct on a Boeing 737.

or sneezing—throughout the cockpit and cabin—significantly reducing the likelihood of flight-acquired diseases.

Initially installed on a Falcon 2000 in 2014 under an FAA Form 337 Return to Service following an alteration or modification, the ACA component is certified on in-production and in-service Gulfstream jets—specifically the G450, GV, G550, G650 and G650ER, either under an STC or Form 337. Also certified on the Leonardo AW169 helicopter, it is now on the verge of a commercial air carrier application for the first time.

"The ACA component has been included with some airliner VIP configurations, specifically on the Boeing 737-800, 737 BBJ, 737 MAX 8, Airbus A320 and A330-200," Seckinger explains. "We see the airline market as a growth opportunity, and, in fact, we are in talks with two airlines about a fleet retrofit."

While he could not disclose those airlines' names, he did comment that the focus is on the A320 and 737. Seckinger reports that ACA can either sell the components individually to meet the airline requirements per their drawings for installation, or the vendor can manufacture any required hardware for the installation.

Lance Bartosz, chief engineer for aircraft cabin air quality at Collins Aerospace, confirms that the company provides what is still the only 100% fresh air ECS on large commercial aircraft—currently the Boeing 787. As he explains, the traditional pressurized bleed air provided by the engine is replaced by electric-motor-driven compressors that take in outside ambient air and provide pressurized air for the cabin. "This completely decouples the engine bleed air from the cabin air and precisely tailors air flow to aircraft requirements throughout all modes of operation, increasing cabin comfort while reducing fuel consumption," says Bartosz.

With the arrival of more-electric aircraft, Bartosz explains that there is now a tradeoff between traditional pneumatic or a more electric function. "Bleed air usage is considered a fuel penalty since it takes away some energy generated by the engine for a purpose other than propulsion. Depending on the aircraft and ECS configuration, for example, it could be more efficient to generate pressurized air using an electric compressor."

Collins Aerospace, he says, continues to work with its filtration partners to develop ways to optimize the ECS and improve passenger comfort with air quality, humidity, temperature and fresh air flow rate.

"In some cases, we may consider the addition of new equipment to improve the cabin environment. But adding new components such as additional filters to an existing aircraft can adversely affect the cabin conditions if the system is not properly engineered. While we try to minimize the additional weight and maintenance associated with adding components, inevitably it is unlikely to result in a zero net impact," he says.

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Doing MRO Smarter

ST Engineering's aerospace division is using new technologies to increase MRO efficiency

James Pozzi Singapore

As an MRO provider with engineering expertise, ST Engineering's aerospace arm has never been shy of exploring technology to improve its operations. As part of its Smart MRO initiative to increase efficiency across its operations, the Singapore-based company identified four key pillars to achieving better results, including digitization, data analytics, additive manufacturing and automation.

Overseeing this strategy is Lee Hui Fung, ST Engineering's aerospace sector's vice president of smart MRO, who says the digitization pillar laid the foundations of its efforts across its facilities in Singapore and overseas. "Digitization was a very important first step," she told *Inside MRO* during a visit to its facility in late September. "The data generated through paperless shop floor systems allows us to move into data analytics and optimization."

In the digitization pillar that has underpinned its efforts, ST Engineering has launched several projects. Some are active and being put into practice, while others remain in the developmental stage or are readied for trials. The implementation of its internally developed ENVIS software system is one project that is active, leading to a full digitization of operations at its engine MRO workshop in Singapore. Since going live, ST Engineering Aerospace says ENVIS has reduced physical paperwork more than 80% and labor costs by 10%.

Like other MROs, ST Engineering is building its own algorithms to analyze the flood of new data being generating by next-generation aircraft for maintenance work undertaken at its shops. "This started off looking at internal systems in areas such as inventory optimization and manpower planning before moving on to predictive and preventive maintenance across aircraft, engines and components," Lee says.

ST Engineering Aerospace is using additive manufacturing for cabin design and authorization work along with printing of components. The company has several additive manufacturing-related projects in the trial phase. This includes collaborating with third-party airline customers to try out a virtual warehouse for cabin components, focusing on parts frequently replaced or with long procurement lead times. Air New Zealand (ANZ), which has collaborated with ST Engineering on several technology-driven projects, is among its customers in additive manufacturing, with the parties working together for several years to produce parts for the airline on request.

This work has included combining additive manufacturing with blockchain to create a digital supply chain. Earlier this year, in a project involving ST Engineering, ANZ, component maker Moog, and Microsoft, the airline simulated a defect in a polymer bumper in the interior of a Boeing 777 aircraft. Then ST Engineering Aerospace digitally transferred an aircraft part file for Moog to 3D-print on the ground while the aircraft was in flight. By the time the flight reached its Los Angeles location, the part was ready for use.

However, ST Engineering isn't stopping at 3D-printing parts just to replace existing components. It is also working on the certification of additively manufactured components with aviation regulators to enable operators to get needed parts 3D-printed.

Already having European Union Aviation Safety Agency certification for several aircraft interior parts, ST Engineering is working toward similar certifications with other regulators, including the FAA, to expand its parts inventory list based on demand. This will begin with noncritical parts, before "going up the food chain" toward more critical components. Ultimately, ST Engineering's plan for the additive manufacturing pillar is a move toward a supply chain 4.0 setup, with a virtual warehouse enabling the development of 3D-printed cabin parts designed and certified by the company.

Automated tools involving robotics have also been steadily introduced for repairs. These have included introduction of a grinding robot to restore an engine fan case, where it helped remove its abradable expoxy layer. A robotic arm has also been used to automate the task of manually polishing an aircraft's airfoil surface, reducing the time taken to polish one set of airfoils from around 2,800 min. to just 1,000 min.

On the hardware side, it is also moving toward drones for inspection work, developing its DroScan automated general visual inspection tool, which uses data to carry out visual inspection of an aircraft's exterior, to eliminate safety concerns for technicians inspecting at height while reducing labor hours. The data analytics tools will help identify defects spotted by the drone's camera. ST Engineering hopes to gain approval from the Civil Aviation Authority of Singapore for DroScan's commercial rollout to airframe customers by year-end.

ST ENGINEERING AEROSPACE

The company's smart initiatives include drone trials in Singapore.

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Caerdav Sets New Course

Potential investment from the UAE's MOBH has enabled new training and paint facilities earmarked for 2020

James Pozzi London

This year's re-branding of Cardiff Aviation to Caerdav, the MRO and pilot training business owned by Iron Maiden frontman Bruce Dickinson, signalled a rebirth for a company that had experienced a tempestuous few years.

Having set up the company seven years ago at St. Athan, South Wales, on the site of a former Royal Air Force maintenance base, Cardiff Aviation acquired a steady stream of airline and leasing customers for base maintenance and modifications work. However, the past few years have been challenging. In 2017, there were unwelcome headlines about unpaid rent and overdue wages. Dickinson, who was plugging many of the company's financial holes, also expressed the need for fresh investment to help turn around the loss-making business.

At Aviation Week's MRO Europe in October, Dickinson was back in the UK having played to 60,000 fans at Iron Maiden's concert at the Estadio Nacional in Chile's capital Santiago just two nights before. Despite having flown more than 11,000 mi. overnight, he evidenced no sign of weariness when elaborating on the challenges the business has faced in recent years.

"We found at lot of things we weren't particularly enamoured with in terms of how the business was being run," he said. Dickinson took 100% shareholder control of the business in early 2019, leading to a clean-sheet approach toward turning around a company that he says should have started to reverse its fortunes two years ago. "We set about effectively starting again. There was still goodwill from some existing customers such as TUI, but we wanted to bring back previous operators, one or two of whom, to be frank, had bad experiences with the former Cardiff Aviation," he noted.

In addition to changes to its name and branding, the company shook up its management. These changes included the addition of Joachim Jones as CEO in February, whose previous employment included heading up the aviation arm of GulfCap from 2012 to 2016.

The appointment of Jones led to a link being formed with Dubai-based conglomerate MOBH Group, an investor primarily in real estate, making an initial foray into the aerospace sector. Just days before Dickinson sat down with *Inside MRO*, Caerdav signed a memorandum of understanding with MOBH for a multimillion-pound investment for a new maintenance facility along with pilot and cabin crew training facilities at the recently opened Bro Tathan business park. Caerdav expects the investment to be finalized by the end of this year before the facilities open in 2020.

Jones says the addition of paint services for aircraft up to the size of a Boeing 767 will be an important capability expansion. "The paint facility is needed to attract more leasing companies and even existing customers to bring in more lease hand-backs and returns for us to repaint on-site and help to make us a one-stop solution," the Caerdav CEO says.

The new training and paint investments follow the addition of other capabilities during a busy 2019. First, Caerdav received FAA Part 145 repair station approval in May, allowing the company's MRO business to carry out airframe and powerplant repairs on U.S.-registered aircraft. In the summer, Caerdav also ventured into line maintenance by servicing ASL Airlines France's Boeing 737-800 aircraft fleet at a Cardiff Airport line station as another way of diversifying the business away from core base maintenance.

Caerdav's new investment will include the construction of an aircraft paint facility.

CAERDAV

With Dickinson hopeful that Caerdav will become profitable again in the first quarter of 2020, the company is also prioritizing job creation. It plans to launch a new apprenticeship program in 2020, with a projected first annual intake of 20. It also hopes to increase its staff, now numbering around 100.

"We want to become a jobs engine," says Jones, adding that its financial plan projects 700-800 employees being based at St. Athan within five years. Dickinson adds that staff numbers at the new paint hangar will not be large, but he believes the facility can be a "force multiplier" for the business overall due to the potential scale of extra work it can bring in to Caerdav as a one-stop shop.

Evolving Doors

Innovative materials and actuation systems are making doors lower-maintenance

Paul Seidenman and David J. Spanovich San Francisco

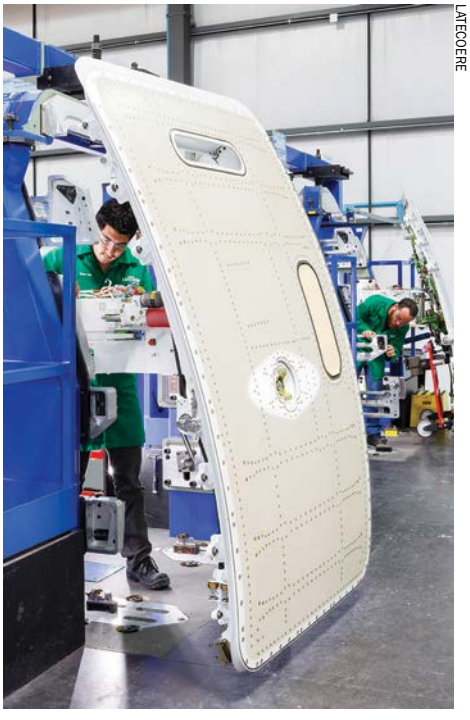
Passenger cabin and cargo compartment doors and their components have historically been high-maintenance items, given their vulnerability to corrosion and high collision risk. Fortunately, OEMs and their suppliers are working to make their products more damage-tolerant and less maintenance-intensive through innovation in materials and parts.

Lower aft and forward cargo doors on passenger and freighter aircraft tend to be most at risk for damage from ground service vehicles and unit loading devices during the baggage and cargo loading and unloading process, says Kin-Hung Chong, executive vice president of Evergreen Aviation Technologies (EGAT) in Taiwan. The company specializes in both narrowbody and widebody MRO.

Passenger-cabin and lower-deck doors, Chong explains, are inspected anywhere between 18 and 36 months for worn-out parts and seals. At EGAT, door repairs are focused on external-surface and internal-cover damage, as well as mechanisms, including rods, wiring and actuators. To date, those repairs have been exclusively on metal doors. However, Chong acknowledges the trend toward lighter-weight composite doors but cautions that composite repairs will be significantly more intensive—and costly. "It is likely that damaged composite doors will be replaced and not repaired at the MRO," he says.

Nonetheless, composites appear to be one of the more promising and proven innovations in door design and are already proving themselves with the eight passenger doors on the Boeing 787. Those doors were designed, developed and manufactured by Latecoere in France.

Stephane Bouzat, head of innovation, research and technology programs, advanced engineering and intellectual property at Latecoere's Aerostructures and Interconnection Systems Division, points out that the 787 doors were the first commercial composite doors in aviation history. He says Latecoere is the world's largest independent supplier of aircraft doors, including for passenger cabins, baggage and cargo compartments, and main deck doors for freighters.



LATECOERE

The Boeing 787 debuted the world's first commercial airliner application of an all-composite passenger door, developed and manufactured by Latecoere.

"With these doors, a huge step has been achieved using composites in the structure design," Bouzat notes. "The challenge now is to make a cheaper and lighter composite design with new composite materials and processes."

The 787 doors have proven to be very robust, he adds. "From what Boeing has told us, they have experienced very few in-service issues," Bouzat says.

But composite structures—including doors—may soon face serious competition in aerospace applications as new thermoplastic technology, now under development by Triumph Aerospace Structures, continues to evolve. In fact, according to Dave Dennison, vice president of engineering, the company holds one patent on its proprietary technology, with several patents pending.

Dennison points out that due to the increased toughness of the material, compared to traditional epoxy-based thermoset composites, all doors suitable for composites would also be good applications for thermoplastics, with the exterior panels being the biggest improvement. "The material significantly reduces road rash and handling damage, as well as reducing repair costs," he explains. "Also, the nature of the repairs will be inherently easier than traditional composite repairs, due to the ability to melt patches to the laminate."

Dennison argues that welded thermoplastics would also yield both cost and weight-saving advantages. He thinks a 10-20% weight savings could be achieved with thermoplastics over traditional composites when employing assembly techniques such as welding, which do not rely on fasteners.

Along with weight savings, Dennison cites corrosion resistance as a significant improvement—especially over metallic structures. "As compared to thermoset composites, thermoplastics will not absorb moisture or aircraft fluids, thereby improving their life-cycle costs." Other advantages of thermoplastics versus thermoset composites are greater shelf stability, no required refrigeration unlimited shelf life, no densification, and optional autoclave use.

But he adds that since the technology is still maturing, a thermoplastic door application has yet to be formally proposed for a specific airframe. Different aerostructures are being targeted. Among them is a thermoplastic elevator structure, announced on Nov. 4, as a joint development and airworthiness demonstration agreement between Triumph Aerospace Structures and Embraer. Using induction welding, the elevator will be fabricated of a unidirectional reinforced thermoplastic material, which will be an industry first.

The company is also contemplating the use of thermoplastics on structures as large as wings, fuselage sections and empennages. "Doors would fit well within this size," says Dennison.

Parent company Triumph Group announced in October that Triumph

Aerospace Structures will provide engineering and manufacturing services for Jaunt Air Mobility's Jaunt eVTOL all-electric aircraft. The airframe will utilize thermoplastics technology—including for the door.

At Saab Aerostructures, new developments in aircraft-door technology include electro-mechanical actuation systems as replacements for conventional hydraulic actuation—at a similar weight and cost. "Electro-mechanical actuation systems will avoid the maintenance tasks related to hydraulic actuators," explains Magnus Falk, vice president and head of business development, marketing and sales. "Saab is also developing new technology for the latching and locking systems as well as the actuation systems—especially for cargo doors."

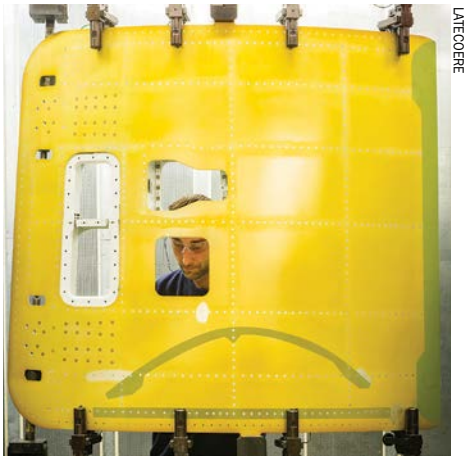
Along with that, new surface treatments compliant with European Union REACH (Regulation, Evaluation, Authorization and Restriction of Chemicals) rules are being applied, along with innovative joining methods that minimize the number of mechanical fasteners needed.

"The new technologies are targeted mainly at lower structural weight, to achieve a lower fuel burn, making them good for the environment [and] the airline, and [to] lower cost of production," says Falk.

Asked if there have been door maintenance or service issues that recent technology improvements by the OEM have addressed, Falk says such issues have been minimal. That claim, he notes, is based mainly on the OEM's experience with the Saab regional airliner fleet and the fact that damage has been generated primarily from cargo handling and misuse of equipment and tools by maintenance personnel.

"Also, hydraulic systems for opening and closing the doors will require a certain amount of maintenance—as all hydraulic systems will," he adds. "However, the [Saab] aircraft are typically operated 24/7 with extremely little downtime due to problems with doors."

Oliver Green, director of business development for Curtiss-Wright's Actuation Group, reports that the group supplies rotary actuators, which function as the opening and closing mechanism for the door. To date, he explains, rotary actuators are mainly used on cargo compartment doors, although they are used extensively on the Airbus A380



LATECOERE

Regulatory changes by Brazil's aviation authority required Latecoere to make design changes for the passenger doors it supplies for the Embraer E2 regional jet family.

passenger doors due to their size.

The technology for rotary actuators developed by Curtiss-Wright has concentrated mainly on limiting noise and vibrations generated when a lower deck cargo door is opened or closed. This involves a proprietary gear design—similar to the gears that operate flight control surfaces—working in combination with the actuator to reduce noise and vibration, says Green. "By reducing vibration as the door is opened and closed, so is wear," he says. The actuators are designed and qualified for the life of the aircraft. "They never come off the aircraft," he notes.

CURTISS-WRIGHT ACTUATION GROUP

Curtiss-Wright Actuation Group supplies the rotary actuator for the main deck cargo door on the Boeing 777 freighter. Rotary actuators are designed and qualified for the life of the aircraft and are an alternative to ball screw actuation systems.

Some aircraft doors are operated by a ball screw system that is more maintenance-intensive due to lubrication issues. "Ball screw systems tend to be more exposed to the environment and are prone to pick up contaminants," he points out. "But actuators are sealed."

Curtiss-Wright also supplies the proximity sensors that are used to check if the aircraft's doors are closed and locked correctly. Normally, 5-8 sensors are installed on a passenger aircraft's door. "If the locking is not done correctly, a warning light will appear in the cockpit," he explains. "Using a proprietary process, Curtiss-Wright is providing less costly proximity sensors, which have reduced door procurement costs," says Green.

Curtiss-Wright supplies the latching mechanism for the 787 cargo doors, the rotary actuators for the 777's and 767's small cargo doors, as well as rotary actuators for the 777 freighter's main and lower deck cargo doors. More recently, the company's flight lock-actuator was selected for the passenger door on the new Mitsubishi Space Jet regional airliner. "The flight lock-actuator will prevent the door from being opened in flight by preventing the opening mechanism from deploying," says Green.

For the Embraer E2 jet, Latecoere's Bouzat reports that due to a regulatory change made by ANAC—Brazil's aviation authority—additional door mechanism and design features were mandated to improve passenger safety. "The regulation changed between the E1 program and the E2, which required us to add functions to improve safety," he explains. The mandated additions included incorporating securing features on the locks and modifying the emergency opening system to regulate the door speed with the escape slide during an emergency opening.

"Also, due to feedback from operators of the E1 family, we simplified the operating mechanism system to improve handle load—the force a flight attendant must exert to open and close the entry door—in order to ease operation of the door," explains Bouzat.

Cabin Comforts

Lindsay Bjerregaard Chicago

1. Refurbishing the 'In-Between' Space

Company: **C&L Aviation Group**
Specifications: C&L Aviation Group provides interior refurbishment services to both regional and corporate airline customers, which it says puts it in a unique position to refurbish the "in-between" space of regional aircraft that are "elevated to a higher standard" (as in business aircraft) in-house. The company's interior services range from cabin elements such as sidewalls, headliners, carpet and stowage bins to complete reconfigurations. C&L is working with regional carrier JSX to redesign Embraer ERJ 135 interiors with 30-passenger configurations, including upgraded leather seating, LED lighting, electrical outlets and contemporary wood-design trim.
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2. Corporate Aircraft Interiors

Company: **Capital Aviation**
Specifications: Operating for 26 years out of Wiley Post Airport in Oklahoma, Capital Aviation specializes in paint and interior refurbishment for corporate aircraft. Capital Aviation's interior capabilities include soft goods, cabinetry fabrication and modification, floor plan and lighting changes and entertainment-system upgrades. The company offers a cabin insulation product that will not burn or produce toxic smoke when subjected to high-temperature flames, which it says is unique to the industry. Capital Aviation mainly serves customers from North America, but it has also completed major projects for customers worldwide.
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3. Interior Modification and Engineering Services

Company: **SR Technics**
Specifications: Swiss MRO SR Technics provides cabin modification and engineering services to Airbus and Boeing fleet customers, including removal of old cabin equipment and the design, manufacturing and installation of new interiors. Its interior capabilities include inflight entertainment (IFE) replacements, galley modifications and seating layout changes. The company recently completed a complex cabin refurbishment on four Airbus A330-200s for Virgin Atlantic Airways, which it says was delivered on schedule and in record time during the busy holiday season last year. The project included a customized trolley stowage unit as well as a cabin reconfiguration that introduced business-class and premium-economy seating with IFE.
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4. Interiors for All Aircraft Types

Company: **Rose Aircraft Services**
Specifications: As a full-service MRO and refurbishing center, Rose Aircraft Services provides complete interior refurbishing on general, corporate, commercial and military aircraft. Its refurbishment services include upholstery, cabinetry manufacturing, floor-plan modifications and upgrades, IFE and design services, and it was recently contracted to provide interior upgrades for the U.S. Air Force on C-21 aircraft. The company says it operates on a larger scale than most other facilities, with dedicated departments focused on various interiors segments, which enables it to simultaneously upgrade as many as 20 corporate aircraft at a time.
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5. Seating Expertise

Company: **ACC Aviation**
Specifications: ACC Aviation provides aircraft seat refurbishment to customers including lessors transitioning their aircraft and carriers operating older aircraft in need of refurbishment. Its interior-projects scope includes modernization of existing seats to VIP upgrades; ACC Aviation also provides wider support for the cabin, such as dividers

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and galleys, via its partnered network of suppliers. ACC Aviation says it holds the world's largest platform of aftermarket seat availability and provides specialist procurement services for interior parts. It recently worked on an Airbus A330 cabin retrofit for seasonal Hajj service—fitting the new cabin and first-class seating with an economic option suitable for heavy rotation, which allowed the carrier to move to a full-economy layout during the busy Hajj period.
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6. Minimizing Downtime

Company: Flying Colours Corp.
Specifications: Flying Colours Corp. specializes in refurbishment of midsize- to large-cabin business jets for executive, private and corporate owners as well as special-mission modification of interiors. Since the company also offers maintenance, avionics upgrades, exterior paintwork and repair, Flying Colours says it can help customers minimize downtime. This year, it announced expansion at all of its facilities, including new ones in St. Louis, Peterborough (Ontario) and Singapore. The latter recently completed the refurbishment of a Bombardier Global XRS for a China-based customer. Flying Colours is about to begin a Challenger 850 project that will include a complete maintenance overhaul and interior overhaul to fully remodel the cabin.
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PAUL STEIN
Chief technology officer for Rolls-Royce since 2017, Stein has held senior scientific and technology positions since 2010.

The Third Generation of Aviation

Aviation technology must address climate change

As global concerns about climate change rightly increase, the environmental impact of aviation—particularly CO_2 emissions—is coming under greater scrutiny. In response to this, the industry is working together to reduce net CO_2 through ever-improved aircraft and engine designs, widening the availability of sustainable aviation fuels (SAF), and new technology such as electrification, which is signaling an exciting new future for aviation—the third generation of aviation.

Human activity is increasing levels of greenhouse gas (GHG) in the atmosphere, which in turn has been shown to have caused an increase of global average temperature of around 1C (1.8F) in the last century. In 2018, fossil fuel CO_2 emissions exceeded 37 billion tons, of which aviation accounted for approximately 2-3%. At the same time, population and prosperity are growing, leading to higher demand for energy, trade and travel. By 2030, the global population will be 8.6 billion, with a predicted 6 billion annual fliers. There is a clear need for aviation to play its part in the transition to a net-zero carbon global economy.

Aviation has made great strides in reducing CO_2, nitrogen oxide and noise over the past 20 years and has already set ambitious goals, yet we must now accelerate this progress, particularly for reducing net CO_2. At the 2019 Paris Air Show, the chief technology officers of seven leading aerospace companies, including Rolls-Royce, committed to the existing highly ambitious environmental targets and agreed to explore how they could be achieved or exceeded with efforts focusing on these three pillars:

- Maintaining the relentless pursuit of technology to continue to improve airframe/engine efficiency by at least 1% per year on average, which has been achieved for the past 20 years;
- Working with global fuels companies for a pathway to increase the availability of drop-in (blendable) hydrocarbon SAFs not derived from fossil sources;
- Developing independent approaches to the third generation of aviation in which electrification will play an increasing role in aircraft propulsion; also, to exploring other radical alternatives such as the use of hydrogen as a fuel.

In addition to aircraft/engines, SAFs and third-generation technology, airspace management also has a part to play in reducing aircraft holding patterns and offering new flight paths that minimize climb and turn maneuvers.

There is a clear need for aviation to play its part in the transition to a net-zero carbon global economy.

On engine design, Rolls-Royce is proud of its Trent XWB engine, which powers the Airbus A350. The Trent XWB is 15% more fuel efficient than the Trent 700 (which powers the A330) and is the world's most fuel-efficient gas turbine in service. Beyond the Trent XWB, we are now developing UltraFan, a new Ultra-High-Bypass Ratio design engine with a newly designed core, which has the potential to increase fuel efficiency (and reduce CO_2) by a further 10%.

A first step toward tackling fuel-produced CO_2 is through carbon offsetting, and so the industry has implemented a global market-based system called Corsia (Carbon-Offsetting and Reduction Scheme for International Aviation), which targets stabilizing net CO_2 emissions from international civil aviation at 2020 levels. Corsia is expected to mitigate around 2.5 billion tons of CO_2 between 2021 and 2035, an annual average of 164 million tons. It will also generate $40 billion for projects focused on climate action.

However, the better strategy in the medium to long term is the development of SAFs with the right characteristics of compatibility, sustainability and scale. Existing and new fuel companies have developed a number of processes to produce SAFs—some from bio stocks such as fast-growing crops or organic waste and some from fully synthetic "power to liquid" (PTL) processes. We expect to see a significant ramp-up of SAF availability when the right economic and regulatory conditions are in place.

Rolls-Royce is developing electrical propulsion technology to cover a range of aircraft such as eVTOL (electric vertical-takeoff-and-landing) types to replace helicopters and larger designs such as the E-Fan X demonstrator (jointly with Airbus), which will show the applicability of hybrid-electric propulsion to regional routes. Larger aircraft, from the A220 up to the largest long-haul aircraft are likely to benefit from electrification in much longer time frames, possibly not before 2035.

Hydrogen is also being proposed as a fuel for short-range flights, but analysis of cost, safety and practicality is still ongoing.

We will see aircraft and engine designs evolve to reduce their environmental impact and to serve our customers in many new ways. Aviation is now set to redefine transportation, and Rolls-Royce is proud to work closely with our industry partners in meeting this challenge.

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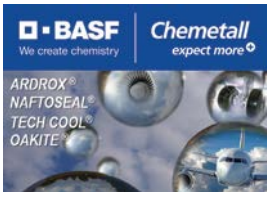

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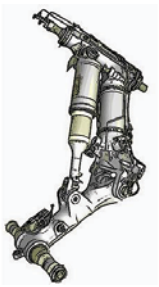

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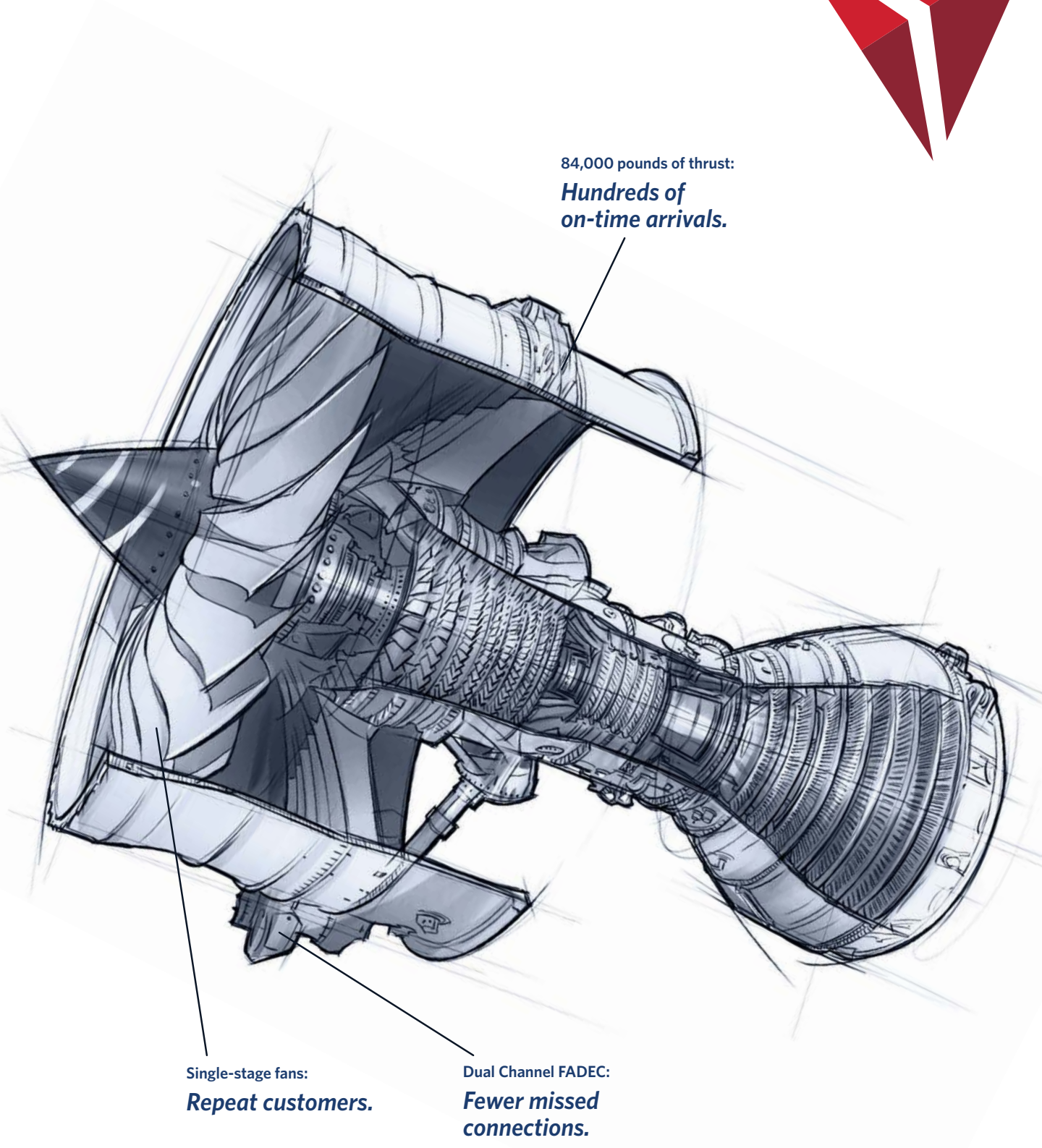

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> ELECTRIC ACTUATION RATHER THAN PROPULSION IS EARLY FOCUS

> GOVERNMENT SEES OPPORTUNITIES IN MOTORS, BATTERIES AND SUPERCONDUCTION

Bradley Perrett Tokyo

When jet propulsion appeared, decades of piston-engine knowledge no longer gave established companies great advantages over newcomers. Realizing this, the U.S. government put World War II jet work in the hands of General Electric (GE), which had some applicable technology but had never built an aircraft engine. Soon it was building plenty.

Similar thinking underpins a push to enlarge Japan's small presence in the subsector making onboard systems for civil aircraft, where the government sees new electric technology pulling down barriers to entry. The Ministry of Economy, Trade and Industry is promoting technological cooperation between local industry and Boeing in that field and also manufacturing composites at high rates.

Noting projects in which Boeing has taken an early interest, the ministry is helping to fund two proposals in aeronautical electrics—with actuation rather than propulsion as the obvious near-term opportunity. Boeing and Japanese companies are exploring possibilities under an agreement between the U.S. manufacturer and the ministry signed in January. The ministry is also working with Airbus to find ways in which Japan's technologies can be used to deepen its involvement in making aircraft.

Japanese industry has for decades had a strong presence in making aircraft structures and engine parts. But it has been largely unable to challenge foreign makers of onboard systems, companies that have entrenched positions and enjoy the low costs of high volumes.

Now, prospective changes in aircraft technology are presenting Japan with the potential to reach into areas of the industry where everyone is going back to square one—or close to it, says Hiroyuki Hatada, director of the ministry's aerospace and defense industry division. Like GE in 1941, Japanese companies have relevant technology—even if they have limited or no experience in making onboard systems. Application of new electric technology to aircraft is seen as one opportunity. It was listed alongside high-rate, low-cost composites manufacturing and automation in the agreement that the ministry signed with Boeing in January.

Japanese companies and researchers in particular have technological offerings in batteries and high-density motors, Hatada says. Following meetings between companies and Boeing in July, the ministry granted about ¥700 million ($6.4 million) for research and development in electrification. In one such project, GS Yuasa will work on extending aeronautical applications of its battery know-how. The expertise in battery technology has been focused on automotive and industrial applications, though GS Yuasa has also made batteries for satellites and Boeing 787s; it is not a complete newcomer. In another funded project, a consortium of Kyushu University and the ministry's own National Institute for Advanced Industrial Science and Technology (AIST) will focus on superconductivity.

Other companies—such as Murata Manufacturing, Toshiba and Sekisui Chemical—have battery technology that could be applied to aircraft. For motors, one source would be Tamagawa Seiki, Hatada says. Others are two partnerships: one of Sinfonia Technology and Nagoya University; and another of AIST, Fujikura, Fuji Electric and Toshiba Infrastructure.

The ministry is introducing Boeing to nonaerospace suppliers with promising technology, and it can grant government funding as well as subsidies. From the ministry's point of view, Hatada says, Boeing helps when it shows interest in a specific technology. By doing so, it indicates that a project has solid prospects, reassuring government officials as they consider how to allocate funds.

Electrification could extend to propulsion, though for commercial aircraft that prospect is decades away. The ministry sees application of better electric technology to actuation in aircraft systems as a nearer-term possibility, Hatada says.

GS YUASA

GS Yuasa, a maker of automotive and industrial batteries, has a sideline in satellite energy storage.

The use of new techniques for making composites more quickly and more cheaply is also close; low costs can follow from fast production rates. Toray Industries, Kanazawa Institute of Technology and Tohoku University are working toward this goal, specifically on making parts that combine thermoplastic materials with traditional thermosets. (When heated, thermoplastics temporarily soften and thermosets permanently harden.)

A third area of technology in the Boeing agreement is greater automation in aircraft manufacturing, which brings value to increasing production rates. This is more an area for the ministry's encouragement rather than financial support, says Hatada, since Japan already has well-established capabilities in robotics. So the issue is applying this know-how to making aircraft.

The ministry made a similar agreement on cooperation with Airbus in 2017 and with Safran this year at the Paris Air Show in June. In both cases, the agreements cover artificial intelligence, the Internet of Things and aviation electrification. Work with Safran also focuses on engine technology, while composites work is to be done with Airbus.

Technology Seen as Bridge to Space Vehicle Integration

> IMPROVEMENTS ARE SOUGHT IN OCEANIC AIRSPACE

> ALPA RELEASES SPACE INTEGRATION WHITE PAPER

Bill Carey Washington

There is a "strong connection" between technology the FAA can employ to better manage oceanic air traffic and technology that can reduce the impact of commercial space launches on airline operations, an Air Line Pilots Association (ALPA) white paper finds.

FAA

The Challenger Space Operations Room at the FAA Air Traffic Control Command Center in Warrenton, Virginia.

The new study by the influential pilots' union focuses on orbital space vehicle launches over suborbital flights associated with the future space tourism market. Orbital launches enter oceanic airspace from sites in Florida, Virginia, California and Alaska and generally require larger airspace restrictions.

Once they increase as expected, orbital launches may be more difficult to merge with conventional air traffic, ALPA says. "When looking at the challenge presented by the orbital launch facilities in the United States, they are all located on the coast and launch with trajectories over the ocean," the white paper notes.

"Ironically, it is the oceanic areas which currently have the least air traffic management infrastructure (e.g., communications, surveillance and air traffic control automation), and therefore have the least ability to tactically manage airspace," it says.

In the new document, ALPA calls for continued development of the Space Data Integrator (SDI) to provide air traffic controllers with real-time data on space vehicles as they move through shared airspace.

The association recommends that the FAA incorporate space-based automatic dependent surveillance-broadcast (ADS-B) to track aircraft and space vehicles in oceanic airspace and pursue "more timely" voice and data communications with pilots by satellite, and possibly next-generation high-frequency radio, to reduce separation buffers.

ALPA released the white paper on Oct. 31, the same day it hosted a conference with the Commercial Spaceflight Federation. During that event, the need for technology to better manage commercial space and airline traffic featured prominently in panel discussions.

Often mentioned were the SDI and an aircraft hazard area (AHA) generator—decision support software that rapidly calculates the volume of airspace that should be segregated in the event a space vehicle breaks apart.

The SDI ingests telemetry data provided by space vehicle operators during their missions and feeds it into the FAA's Traffic Flow Management System for display to traffic management coordinators. The system merges space vehicle missions in real time with traditional air traffic flows, increasing "situational awareness" and supporting dynamic management of the airspace.

The integrated SDI and AHA generator would help the FAA reduce the amount of airspace closed and time reserved for launch events.

"We're probably all aligned to what we need," Blue Origin Deputy General Counsel Audrey Powers told the conference. "The information that we need [to get] to the pilots is, what is the hazard area in real time as launch or reentry vehicles are moving through the National Airspace System?"

Dynamic hazard-area data is more important than information the SDI will provide about a spacecraft's position and velocity as it ascends, Powers suggested. "At the end of the day, what's important is, if something goes wrong, what is the hazard area that I have to avoid—the [airspace] box around that operation?" she said.

Jim Ulmann, National Air Traffic Controllers Association director of safety and technology, concurred with Powers that the capability to calculate hazard areas dynamically as a space vehicle moves along its trajectory is a priority. He mentioned a prototype AHA generator called the Hazard Risk Assessment Management (HRAM) system.

"We need controller decision support tools. SDI is nice; it's certainly better than what we've had in the past, which is next to nothing," Ulmann told the conference. "But

it's still just an awareness tool. I'm talking about a decision support tool—something that goes on the controller's scope, something more like an HRAM kind of thing."

The FAA has said for the past year that the SDI at least is moving through its acquisition process. Also speaking at the ALPA event, Duane Freer, space operations manager at the FAA's Air Traffic Control System Command Center in Warrenton, Virginia, said the process has been accelerated.

"I hope by next year, we're going to be using SDI to make operational decisions. We're going to be making real-time, dynamic decisions based on information from SDI," Freer said. "We're not there until we can get something on a controller's glass, and the controller can start managing that airspace based on real-time data."

The FAA has evaluated space-based ADS-B and automatic dependent surveillance-contract (ADS-C) to improve its surveillance capability in oceanic airspace, the Government Accountability Office (GAO) reported in July. The FAA opted to use ADS-C in the near term and to continue studying space-based ADS-B, the GAO said.

A component with controller-pilot data link communications of the Future Air Navigation System used in oceanic airspace to keep track of aircraft, ADS-C is a system that transmits position reports via satellite at defined time intervals. Space-based ADS-B, a system offered by the Aireon joint venture, captures continuous position reports from aircraft using ADS-B receivers on Iridium Next satellites.

The FAA is expected to conduct a one-year evaluation of enhanced surveillance in the Caribbean region using Aireon's system starting in March. ALPA would like to see it used more broadly.

"Space-based ADS-B is already a reality and is being used to separate traffic today, with the same performance as domestic en route radars," says the ALPA white paper. "ALPA recommends that the FAA incorporate space-based ADS-B in their infrastructure plans for oceanic airspace."

Editor's note: This article is reprinted in full here due to a production error in the Nov. 25-Dec. 8 issue.

Lawmakers Urge FAA To Speed Airspace Integration Technology

Bill Carey Washington

LAWMAKERS IN THE U.S. HOUSE OF REPRESENTATIVES ARE CALLING ON THE FAA to expedite the deployment of new air traffic management technology as the agency develops a regulation to simplify launch and reentry requirements for commercial space operators.

In a Nov. 22 letter to FAA Administrator Stephen Dickson, the bipartisan leadership of the House Transportation and Infrastructure Committee weighed in as the agency promulgates the Streamlined Launch and Reentry Licensing Requirements regulation. The agency was reviewing responses to a notice of proposed rulemaking it issued in April.

The lawmakers express concern that technology the FAA could deploy to better coordinate commercial space launches with airline and other aircraft operations is lagging in development.

The FAA has been working for years on the Space Data Integrator and an associated hazard area generator—systems that ingest telemetry data and calculate hazard zones around space vehicles as they ascend.

CAMDEN COUNTY BOARD OF COMMISSIONERS

Proposed Spaceport Camden in Georgia.

"While the FAA is working to reduce the amount and duration of each airspace closure during a launch or reentry, the technology necessary to achieve that objective is still in the development and testing stages," the lawmakers write.

"Without this technology in place, the segregation of commercial space operations can disrupt the rest of the airspace system, leading to flight delays and cancellations, longer flight times over increased distances and added fuel burn," the letter continues.

In addition, the FAA has approved launch site licenses without adequately considering the potential effects on surrounding flight operations, particularly on those of nearby airports, the lawmakers say.

"[W]e want to ensure that prospective launch site operators, launch providers, existing airspace users and the general public have realistic expectations about what kind of commercial space transportation activity can safely take place at a given location," the letter states.

The FAA has granted 12 commercial launch site licenses. In early November, the agency informed the proponents of another launch site—in Camden County, Georgia—that it planned to release a final environmental impact statement (EIS) by Dec. 16. The county expects the agency will make a final decision to approve or deny the spaceport site "no earlier than 30 days" after the release of the EIS.

The letter to Dickson was signed by House Transportation Committee Chairman Peter DeFazio (D-Ore.) and Ranking Member Sam Graves (R-Mo.) as well as aviation subcommittee Chairman Rick Larsen (D-Wash.) and Ranking Member Garret Graves (R-La.).

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Evan Peers
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The grand finale of the Wednesday evening air show at the Experimental Aircraft Association's AirVenture 2019 in Oshkosh featured a mushroom-cloud-like fireball named "Dun-Diehl SuperNuke" by creator Dion Diehl, president of DTG Pyrotechnics. Extra Aircraft's just-released Extra NG next-generation aerobatic aircraft sits in the foreground.

COMMERCIAL First Place

Santiago Borja
Quito, Ecuador

A storm cleansed the atmosphere over Jose Joaquin de Olmedo International Airport in Guayaquil, Ecuador, providing this unusually clear view of the city merging with the lights of the Airbus A319 cockpit.

COMMERCIAL Second Place

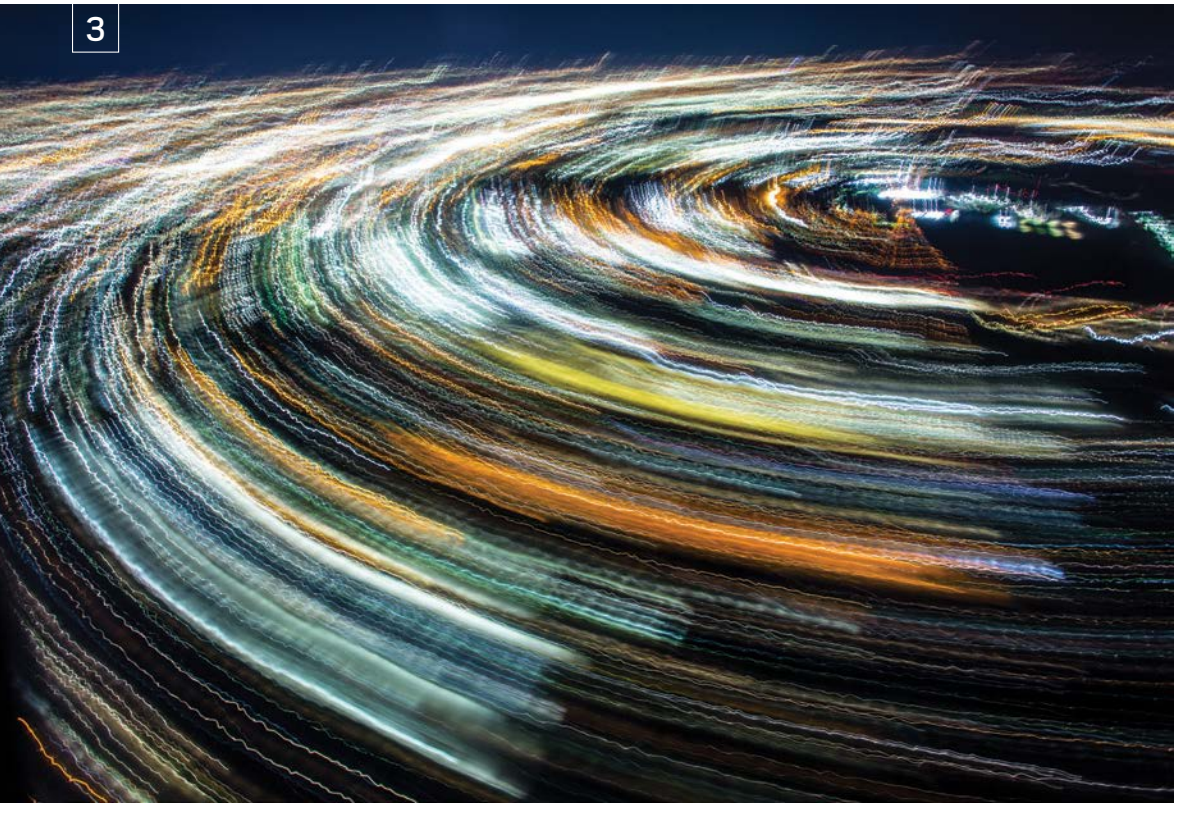
Maciej Hatta
Cold Lake, Alberta

A Boeing 787 lined up for final approach to Runway 24R at Los Angeles International Airport ahead of an autumn full Moon.

COMMERCIAL Third Place

Art Harman
Fairfax, Virginia

Chasing the sunset to California, the pilot flew between two layers of clouds, giving the Sun an easel on which to create its spectacular artwork.



COMMERCIAL Editor's Picks

1. Jacob Rutledge
Louisville, Kentucky

A two-image stack depicts a Boeing 757-200PF departing Louisville, Kentucky, as UPS Flight 1450 on Dec. 19, 2018, destined for Cleveland during the peak holiday season.

2. Vladimir Voronov
Moscow

For many flight attendants, flying is more than a job; it is a dream fulfilled. This crew member definitely has her eye on flying.

3. Jeremy Dwyer-Lindgren
Seattle

The world spins below as an Alaska Airlines Boeing 737-900 departs George Bush Intercontinental Airport in Houston in January.

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4. Jin Nakashima
Ardmore, Oklahoma

When this British Airways Boeing 747-400 was approaching London Heathrow Airport's Runway 27L, the "Queen of the Sky" created what could have been the world's largest heart. It could be seen as the warm heart of Joe Sutter, who designed and built what many consider one of the greatest aircraft, ever.

5. Santiago Borja
Quito, Ecuador

City lights from Venezuela merge with the glow of far-off Amazonian oil wells, and the clear Milky Way glows above them, as seen from 34,000 ft. onboard a Boeing 767 flying from Europe to Ecuador.

SPACE First Place

Michael Seeley
Melbourne, Florida

When this United Launch Alliance Atlas 551 AEHF-5 communications satellite launched at 6:13 a.m., 35 min. before sunrise, the downrange plume caught the rising sunlight perfectly, with just a hint of crepuscular rays emanating from the horizon. This 251-sec. exposure was captured from Palm Shores, Florida, looking across the Indian River Lagoon.

SPACE Third Place

Alexis Bechtel
Chatsworth, California

Smoke and fire from a launch abort engine rocket hot-fire test lights up the Mojave Desert at sunset. Four of these Aerojet Rocketdyne engines provide the thrust for the crew-escape system that is designed to carry astronauts to safety in the event of a launch anomaly on Boeing's CST-100 Starliner spacecraft.

SPACE Second Place

Walter Scriptunas II
Charleston, West Virginia

A United Launch Alliance Delta IV Heavy lifts off from Space Launch Complex 6 at Vandenberg AFB, California, with the NROL-71 mission for the National Reconnaissance Office.

SPACE Editor's Picks

1. Ben Cooper
Orlando, Florida

Twenty-seven Merlin engines lift a Falcon Heavy off Pad 39A at the John F. Kennedy Space Center and into orbit with Arabsat 6A onboard.

2. Jack Beyer
Los Angeles

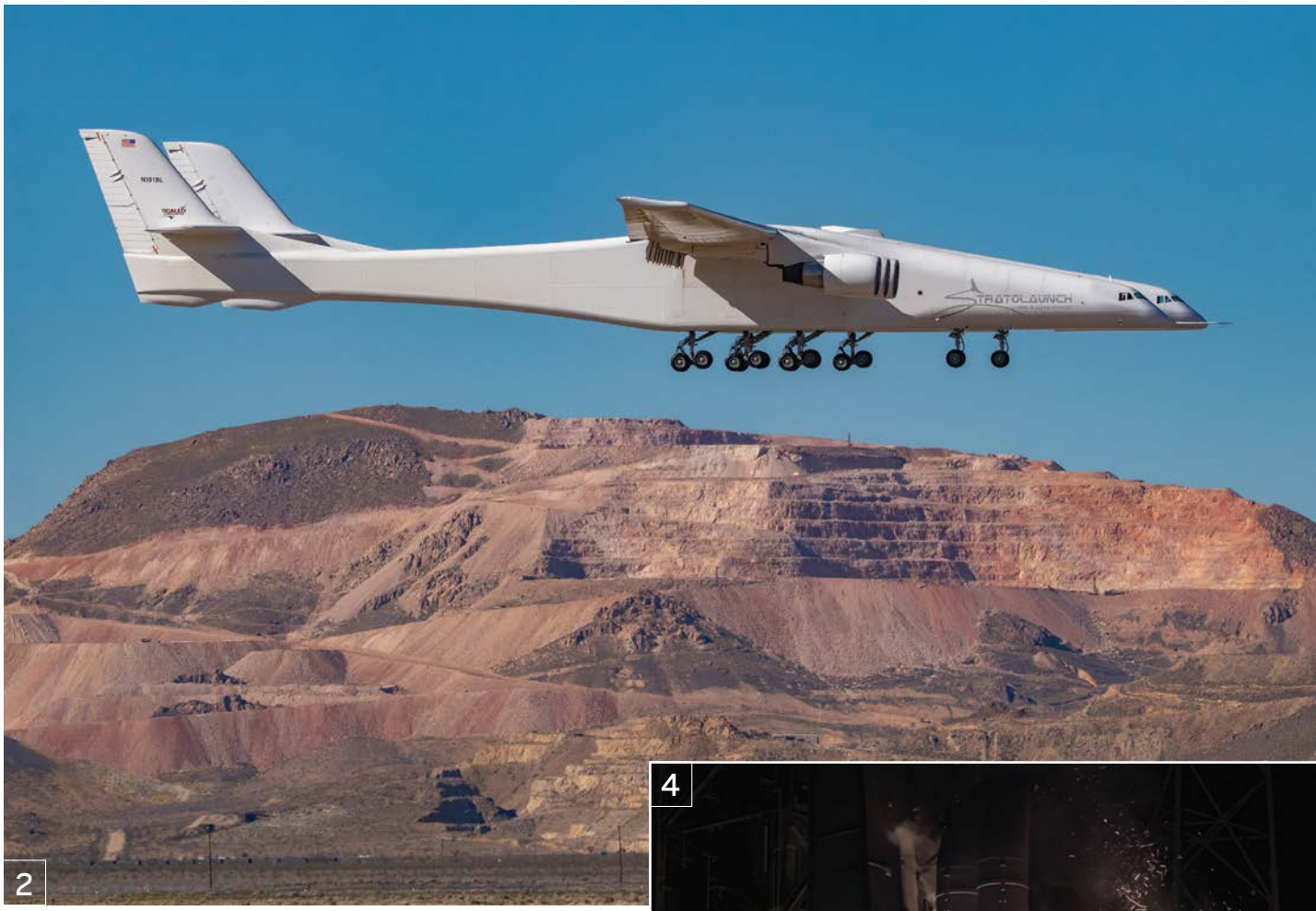
Stratolaunch's "Roc," the largest aircraft in the world by wingspan, took flight for the first time on April 13. After a test flight lasting more than 2 hr., pilot Evan Thomas did this low approach before coming back around for a picture-perfect landing.

3. Walter Scriptunas II
Charleston, West Virginia

The Mobile Assembly Shelter rolls back to its launch position at Space Launch Complex 6 at Vandenberg AFB, California, revealing the United Launch Alliance Delta IV Heavy.

4. John Kraus
Satellite Beach, Florida

The fury of United Launch Alliance's Atlas V rocket is evident in this close-up photograph of the vehicle's single RD-180 engine and five Aerojet Rocketdyne AJ-60A solid rocket motors, which powered the AEHF-5 satellite to orbit on Aug. 8.



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DEFENSE First Place

Avgar Idan
Rehovot, Israel

The afterburner of an Israeli Air Force Lockheed Martin F-35i Adir kicks in over the desert at sunset.

DEFENSE Second Place

Avichai Socher
Givat Shmuel, Israel

Symmetric in all aspects, this Israeli Air Force McDonnell Douglas F-15I "Thunder" is having its exhaust plates inspected by two technicians—one in each engine exhaust. Everything checks OK.

DEFENSE

Editor's Picks

1. Avichai Socher

Givat Shmuel, Israel

The engine exhaust and the rotor's prop wash from an Israeli Air Force Boeing AH-64A Apache "Peten" creates art in the sky as the aircraft drops flares during the blue hour in the desert.

2. Peter Lewis

Bruetten, Switzerland

A McDonnell Douglas F/A-18C flown by Capt. Andreas "Menkster" Menk from the Swiss Air Force's Sqdn. 11 banks with its position lamps glowing shortly after sunset over central southern Switzerland.

3. Avgar Idan

Rehovot, Israel

An F-15 turns above the Israeli desert.

DEFENSE Third Place

Andreas Zeitler
Manching, Germany

Two German Luftwaffe Eurofighter Typhoons sit ready for takeoff before a night mission.

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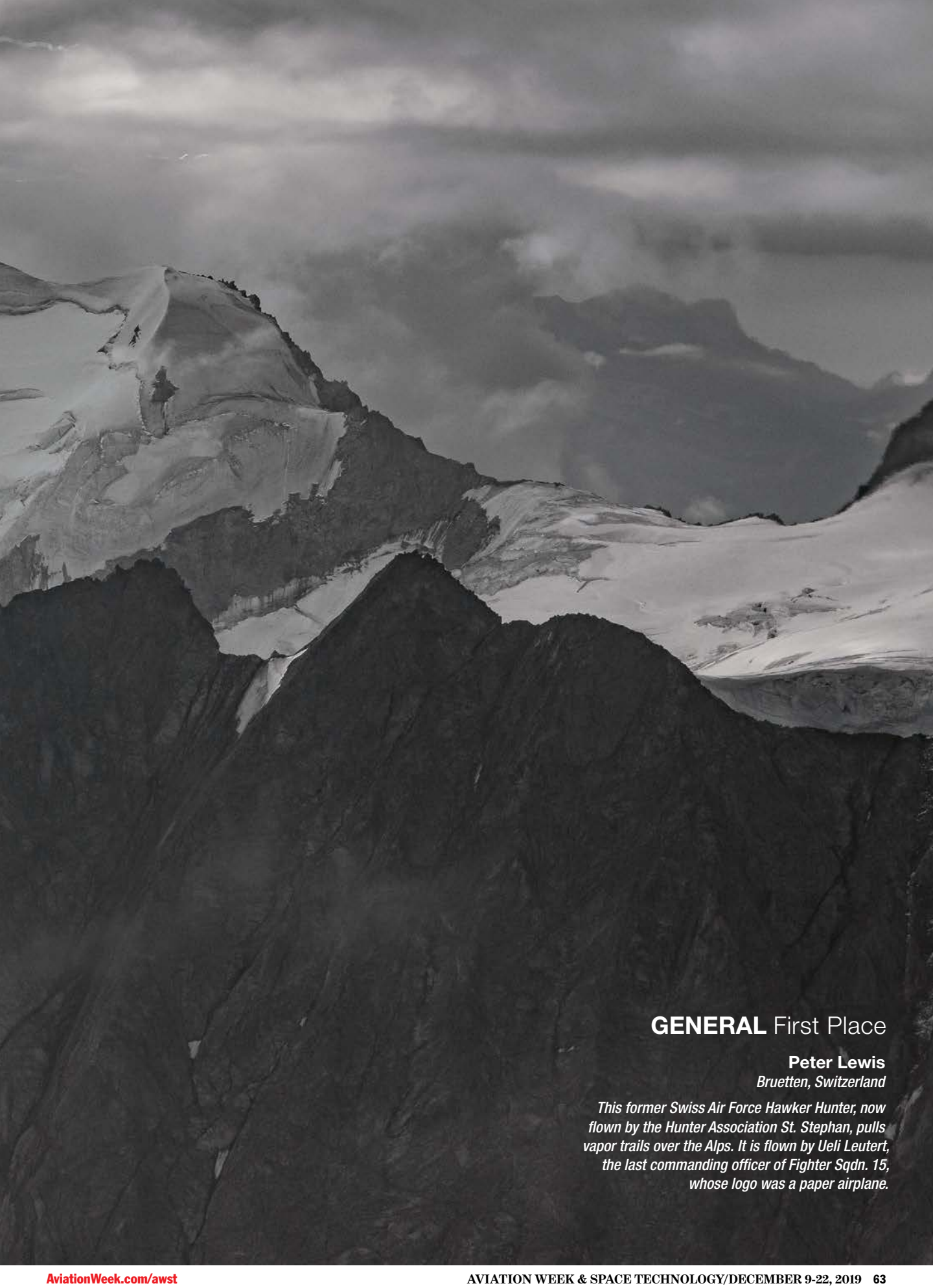

GENERAL First Place

Peter Lewis
Bruetten, Switzerland

This former Swiss Air Force Hawker Hunter, now flown by the Hunter Association St. Stephan, pulls vapor trails over the Alps. It is flown by Ueli Leutert, the last commanding officer of Fighter Sqdn. 15, whose logo was a paper airplane.

GENERAL Second Place

Peter Lewis
Bruetten, Switzerland

A Mathys Aviation C-47 is en route to St. Stephan Airfield in Switzerland, just ahead of a major storm front.


9X

GENERAL

Editor's Picks

Jessica Ambats
Malibu, California

1. *This Learjet was transformed into a rainbow to give rides to kids with serious illnesses in the Make-A-Wish program.*

2. *TxJet's fleet of Cessna Citations are used to transport life-saving organs to recipients in need.*

3. Nathan Gingles
Omaha, Nebraska

A Goodyear FG-1D Corsair folds its wings in this composite image.

GENERAL Third Place

Johnson Barros
Brasilia, Brazil

As the stars circle the south celestial pole, creating a beautiful shape in the sky, an RV-8 from the Fox Sqdn. awaits dawn for its next flight.

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GENERAL

Editor's Picks

4. Phil Taylor
Pascoe Vale, Australia

Frank Parker flies a Bristol Scout at the Classic Fighters Airshow 2019 in Omaka, New Zealand.

5. Rain Brooks
Sacramento, California

A transforming dinosaur robot named Robosaurus appears to be eating the U.S. Navy Blue Angels at the California International Air Show in Salinas.

6. Mark Usciak
Lancaster, Pennsylvania

A dawn launch at the Lancaster Balloon Festival in Bird-in-Hand, Pennsylvania.

7. Ben Ullings
Alphen aan den Rijn, Netherlands

A farmer spraying very dry land added an extra rainbow dimension to the farewell of a Catalina PBY-5A departing the Netherlands on May 29 to join the Collings Foundation fleet. It was accompanied by four Fokker S-11 "Instructor" aircraft and a Dutch-based AT-6 Texan.

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GENERAL

Editor's Picks

8. Derrick Stamos
Santa Maria, California

High-pressure waterjets blasting from a firefighting vessel frame a demonstration of a Jetpack Aviation JB10 turbojet-powered jetpack over the Pacific Ocean near Huntington Beach, California.

9. Julia Apfelbaum
Erie, Colorado

Mother Nature provided quite a backdrop during this stunning sunrise photo shoot. Several minutes into the flight, the rainbow appeared and added another dynamic dimension to the landscape as Allen Floyd piloted his Rutan Model 61 Long-EZ, which he has named "Excalibur," along the Front Range of the Rocky Mountains.

9

The Judges

James R. Asker retired as Aviation Week executive editor in 2017. He studied photography, among other subjects, at Rice University before becoming a reporter and occasional photographer for *The Houston Post*. Asker joined Aviation Week in 1989, covering space technology and science prior to becoming Washington bureau chief and managing editor. His photographs have appeared in numerous newspapers and magazines.

Dana Bell has written 34 books on aviation history and is now a full-time author after a 30-year career with the U.S. government. Starting as a photo researcher with the U.S. Air Force in 1976, he moved to the Smithsonian Institution's National Air and Space Museum in Washington in 1982.

Mitchell Koppelman has been a professional news photographer, editor and manager for more than 40 years. After a decade with United Press International, he joined Gannett as the founding director of photography for *USA Today*. In 1984, he joined Reuters as a founder of the Reuters News Pictures Service, taking a post as assistant news pictures editor for North America. He helped develop its online global news photo service, the first web-based digital picture and video archives, and directed development and deployment of the first digital broadcast satellite delivery of still photos in the Americas. He now manages Reuters' relationships with broadcasters in the Western Hemisphere.

Tony Osborne, Aviation Week's London bureau chief since 2012, covers European defense programs, avionics and unmanned vehicles. He is also an accomplished aviation photographer.

Lisa Caputo, Aviation Week's award-winning director of content design, has worked at the magazine since 1990. Her responsibilities have evolved to include digital as well as print design. Previously, she worked as a graphic artist at *Business Week* and as a layout artist at *Time* magazine. Caputo is a graduate of the Fashion Institute of Technology in New York.

Photo Contest Director

Michael O. Lavitt is director of editorial content production for the Aviation Week Network. He guided the transition of the contest to digital photography and online entry, which quadrupled entries and drew a more international field. He joined Aviation Week in 1988 as a news editor and played a key role in the organization's transition to a multimedia provider of aerospace news, analysis, data and intelligence.

The Winners

Best of the Best

Evan Peers is an aviation media producer, video editor, photo/videographer and journalist based out of Northern California. He has been fascinated with flight and aircraft since an early age, when he started attending air shows and watching airlines from airport fences. His company, Airspace Media, provides creative media services for aviation and aerospace. Peers' work has been seen in publications ranging from local newspapers to *National Geographic*. He has been the chief photographer for the International Aerobatic Club since 2016 and served as the editor of its flagship magazine, *Sport Aerobatics*, for more than two years He previously won Best of the Best in 2014 and Third Place in the General Aviation category in 2012.

First Place, Commercial

Santiago Borja was born and raised in Quito, Ecuador, where he still lives. He is a pilot for a major airline in the region, flying Boeing 767-300ERs between the Americas and Europe. His work has been published by *The Washington Post*, the BBC, *Time* and CNN. He has won numerous awards, including *National Geographic* Nature Photographer of the Year in 2016. His website is santiagoborja.com.

Second Place, Commercial

Maciej Hatta has logged nearly 3,000 hr. as a fighter pilot and instructor with the Canadian Armed Forces, including a four-year tour with the Snowbirds, the nation's demonstration squadron. Inspired to pursue aviation by a pivotal video he saw as a youngster, he has strived to "pay it forward" as an award-winning filmmaker and photographer based in the Canadian prairies. He was instrumental in helping the Snowbirds become the first jet team in North America to adopt 360-deg. camera technology, providing a truly interactive experience for fans.

Third Place, Commercial

Art Harman is a fine arts photographer and has covered many rocket launches. He can be seen on flights with his camera glued to the window as the world drifts by. He is the founder and president of the Coalition to Save Manned Space Exploration, which advised the White House to return to the Moon by 2024 and land on Mars in the 2030s. His photography website is WritingWithDark.com.

First Place, Space

Michael Seeley lives on the Space Coast of Florida and is a co-founder of WeReportSpace.com. When not photographing rockets or other aerospace things, he works as the chief development officer for Health First Inc. and the Health First Foundation in Melbourne, Florida.

Second Place, Space

Walter Scriptunas II is a professional photographer who has covered the U.S. space program since 2010. He has worked for Spaceflight Now and officially for launch providers at Vandenberg AFB, California, and Cape Canaveral. More of his work can be found at scriptunasimages.com.

Third Place, Space

Alexis Bechtel is an aerospace engineer and landscape astrophotography enthusiast based in Los Angeles. Working for a major rocket engine company since 1997, she has had the opportunity to photograph development testing of rocket engines at remote desert facilities by day and capture the Milky Way at night. She was awarded the grand prize in the 2010 *Popular Photography* photo contest. Her website is alexisbphotography.com.

First Place, Defense

Avgar Idan is an Israel-based self-taught photographer. Recently retired from the field of finance, he now spends his time with his true passion—photography. He mainly focuses on wildlife and aviation photography, flying all over the world to participate in air-to-air photography sessions and air shows.

Second Place, Defense

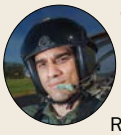
Avichai Socher was trained as an aerospace engineer. He has photographed a wide range of subjects, including aviation, wildlife and landscapes. He specializes in macro and night photography. He won First Place in the Defense category in 2014 and 2016 and Second Place in the Commercial category in 2018.

Third Place, Defense

Andreas Zeitler works as an aerospace engineer and travels the world pursuing aviation photography subjects and exotic photo opportunities. He won First Place in the General Aviation category in 2010 and 2012. His work is featured at flying-wings.com.

First Place and Second Place, General

Peter Lewis is a Zurich-based aviation photographer and owner of an aerospace company. He has published articles worldwide on the Swiss Air Force. *Swiss Tiger Parallel Flight* is his latest and fourth book. Specializing in air-to-air photography with both military airplanes and commercial types over the Swiss Alps, Lewis' pictures have graced the covers of numerous aircraft magazines. His aviation knowledge, specialized writing and photography have received global acclaim.



Third Place, General

Johnson Barros is a self-taught photographer who has studied his craft since childhood by poring through aviation magazines and books about the history of Renaissance art, especially paintings by Caravaggio. He is the Brazilian Air Force's photographer and also works on historical reinterpretation projects and social awareness through photo essays. He won Third Place in the Defense category in 2015.

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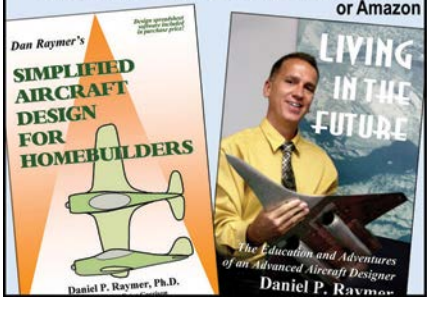

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Aerospace Calendar

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email: aero.calendar@aviationweek.com

Dec. 17-19—RTCA Plenary Sessions. Various locations. See rtca.org/content/upcoming-committee-meetings

Dec. 18-20—AeroDef India. Manpho Convention Center. Bengaluru, India. See aerodefindia.com

Dec. 29-30—International Conference on Robotics, Aeronautics, Mechanics and Mechatronics. Hotel Novotel Montreal Aeroport. Montreal. See 10times.com/icramm-montreal

Jan. 6-10—American Institute of Aeronautics and Astronautics (AIAA) SciTech Forum. Hyatt Regency Orlando. Orlando, Florida. See aiaa.org/home/events-learning/event/2020/01/06/default-calendar/SciTech2020

Jan. 14-16—2nd International Academy of Astronautics (IAA). Conference on Space Situational Awareness. Hilton Arlington. Arlington, Virginia. See reg.conferences.dce.ufl.edu/ICSSA

Jan. 19-21—Airline Economics Growth Frontiers Dublin. The Shelbourne Hotel. Dublin. See aviationnews-online.com/conferences/dublin

Jan. 21-23—Transformative Vertical Flight 2020. Doubletree Hilton. San Jose, California. See vtol.org/events/2020-transformative-vertical-flight

Jan. 27-30—HAI Heli-Expo 2020. Anaheim Convention Center. Anaheim, California. See rotor.org/home/heli-expo

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Jan. 22-23—MRO Latin America. Cartagena, Colombia.

Feb. 4-5—Aero-Engines Americas. Miami.

Feb. 4-6—Routes Americas 2020. Indianapolis.

Feb. 24-26—MRO Middle East Summit & Expo. Dubai.

March 8-10—Routes Asia 2020. Chiang Mai, Thailand.

March 11-12—MRO Australasia. Brisbane, Australia.

March 12—Aviation Week Laureates Awards. Washington.

Apr. 27-28—Urban Air Mobility Americas. Dallas.

Apr. 27-29—Routes Europe 2020. Bergen, Norway.

Apr. 28-30—MRO Americas. Dallas.

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A Risky Business

President Donald Trump appears to be getting his wish that U.S. allies pay more for their own defense, which begs the question: Is the victory worth the cost?

Pushing allies to spend at least 2% of their GDP on defense is not a new concept. Trump's predecessors George W. Bush and Barack Obama both argued for greater burden sharing, and Russia's 2014 invasion of Ukraine's Crimea region had allies starting to move toward that benchmark. Arguably, Trump's "America First" drumbeat is getting NATO allies to pay a bigger share of the cost of their defense three decades after the end of the Cold War. Military spending by European NATO nations and Canada has risen 4.6% this year, and the majority of allies have plans to spend at least 2% of their GDP on defense by 2024, according to NATO General Secretary Jens Stoltenberg (pictured with Trump).

NATO/GETTY IMAGES

Meanwhile, the U.S. is on a path to dial back its contribution from 22% of NATO's total funding to 16%. "This is a direct result of President Trump making clear our expectations that these Europeans would step up to help secure their own people," says U.S. Secretary of State Mike Pompeo.

Unfortunately, Trump has not stopped there, openly expressing disdain for an organization established to guard against the kind of territorial expansion undertaken by the former Soviet Union. He has hurled sophomoric barbs at steadfast allies such as the UK, Germany and Canada, while refusing to criticize Russian strongman Vladimir Putin, the architect of both the Crimea invasion and Moscow's campaign to interfere in U.S. elections. For the first phase of the Trump presidency, his cabinet tried to temper those go-it-alone impulses. Then-Defense Secretary James Mattis sought to reassure allies of U.S. support for their security. But more recent White House appointees have been less willing to cross their boss.

Even more damaging was Trump's abrupt decision to withdraw most U.S. forces from Syria, disgracefully abandoning America's Kurdish allies to the benefit of Turkey, Russia and Iran and leaving Europe more exposed to attacks from Islamic extremists. "What we are currently experiencing is the brain death of NATO," French President Emmanuel Macron told *The Economist*. Trump sees NATO in a transactional way, "as a project in which the United States acts as a sort of geopolitical umbrella, but the trade-off is that there has to be commercial exclusivity," he added. "It's an arrangement for buying American."

While Macron is calling for a reconsideration of what NATO means in light of reduced American commitment, European nations are not waiting. They are building up their own defense industrial base. In 2017, the EU created the Permanent Structured Cooperation initiative, which is pursuing research toward new missiles, aircraft, missile defense and electronic attack capabilities. U.S. efforts to have its companies included in the work have so far been brushed off.

Trump's hardball approach also is being applied to key allies in Asia that have long served as a bulwark against a rising China. The U.S. alliance with South Korea is now reviewed annually, instead of every four years. And after signing a deal in February that calls for South Korea to pay nearly $1 billion to maintain the U.S. military presence there, Washington is now demanding that Seoul pay $4.7 billion annually. Before an agreement was reached, the U.S. walked out of the talks. The Trump administration also is looking for more cash from Japan, calling for more than triple Tokyo's $1.7 billion contribution toward hosting U.S. troops in its country.

"THE MORE OUR ALLIANCES FRAY, THE LESS INTEREST PEOPLE HAVE IN BUYING U.S. DEFENSE GOODS AND SERVICES."

These requests are straining longstanding alliances. South Korea is edging closer to China, while Japan, which has a strong industrial base, might partner with the UK on its Tempest fighter program (see page 24).

To be sure, U.S. defense exports remain near an all-time high. The Defense Security Cooperation Agency announced $55.4 billion in potential Foreign Military Sales in fiscal 2019, about the same as the prior year. But there are indications that Trump's pay-up-now methods may lead to an erosion in future sales.

Asking allies to contribute more for their own defense certainly has merit, but the wider risks to U.S. global interests cannot be ignored. Can 70-year-old alliances survive if the leading partner vocally questions their value? And if the alliances crack, what would that mean for the U.S. military industrial base?

"The more our alliances fray," says Eric Edelman, a former U.S. undersecretary of defense, "the less interest people have in buying U.S. defense goods and services."

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