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ON THE COVER

Uncertainty about how quickly passenger demand will return amid the novel coronavirus pandemic has airlines hedging bets with their fleet strategies, blurring the lines between which aircraft are in service, parked or being stored. Our report by France Bureau Chief Thierry Dubois and Air Transport and Safety Editor Sean Broderick begins on page 20. Andy Luten photo.

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AVIATIONWEEK & SPACE TECHNOLOGY

Editor-In-Chief
Joseph C. Anselmo joe.anselmo@aviationweek.com

Executive Editors
Jen DiMascio (Defense and Space) jen.dimascio@aviationweek.com
Jens Flottau (Commercial Aviation) jens.flottau@aviationweek.com
Graham Warwick (Technology) warwick@aviationweek.com

Editors Lindsay Bjerregaard, Sean Broderick, Michael Bruno, Bill Carey, Thierry Dubois, William Garvey, Ben Goldstein, Lee Hudson, Irene Klotz, Helen Massy-Beresford, Jefferson Morris, Guy Norris, Tony Osborne, Bradley Perrett, James Pozzi, Adrian Schofield, Lee Ann Shay, Steve Trimble

Chief Aircraft Evaluation Editor Fred George

Director, Editorial and Online Production Michael O. Lavitt

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

Production Editors Audra Avizienis, Theresa Petruso

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Director, Digital Content Strategy Rupa Haria

Content Marketing Manager Rija Tariq

Data & Analytics

Director, Forecasts and Aerospace Insights Brian Kough

Senior Manager, Data Operations/Production Terra Deskins

Manager, Military Data Operations Michael Tint

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

Bureau Chiefs

Auckland
Adrian Schofield avweekscho@gmail.com

Beijing
Bradley Perrett bradley.perrett@aviationweek.co.uk

Cape Canaveral
Irene Klotz irene.klotz@aviationweek.com

Chicago
Lee Ann Shay leeann.shay@aviationweek.com

Frankfurt
Jens Flottau jens.flottau@aviationweek.co.uk

Houston
Mark Carreau mark.carreau@gmail.com

London
Tony Osborne tony.osborne@aviationweek.co.uk

Los Angeles
Guy Norris guy.norris@aviationweek.com

Lyon
Thierry Dubois thierry.dubois@aviationweek.com

Moscow
Maxim Pyadushkin mpyadushkin@gmail.com

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

Washington
Jen DiMascio jen.dimascio@aviationweek.com

Wichita
Molly McMillin molly.mcmillin@aviationweek.com

President, Aviation Week Network
Gregory Hamilton

Managing Director, Intelligence & Data Services
Anne McMahon

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FEEDBACK

HAND-FLYING SKILLS

In reply to "Manual Proficiency" *(March 23-April 5, p. 6)*, the evolution of automation on modern aircraft requires a process that enables pilots to practice and maintain their skills to manually fly the aircraft.

As a former line check airline pilot, I have concluded that few pilots get or take the opportunity to practice basic flying skills. Nearly absent in our training and also during normal line operations, is hand-flying. During normal operations, hand-flying the aircraft should be encouraged. To provide this opportunity, air traffic control (ATC) could, when absent a traffic conflict, offer a cruise climb or descent. This will provide an opportunity to hand-fly without being subject to an altitude bust. Cruise allows for intermediate level-offs without notifying ATC.

All pilots should be encouraged during climb or descent to manually follow the movement of the throttles with their hand when the auto throttles are engaged. During check rides, this should be required, or at least debriefed, to ensure that this is being accomplished. When auto throttles were placarded or failed, several accidents have occurred. Pilots have become overconfident and too reliant on automation and have fallen behind the aircraft.

Automation on modern aircraft can exceed most pilots' hand-flying skills. This promotes its use as a safer and easier mode of operation; however, when automation fails, pilots must be able to safely hand-fly the aircraft while addressing any other issues that may have developed.

Most Airbus aircraft now use the sidestick controller instead of the yoke. Although the handling skills are not compromised, the pilot not flying has no idea what the other pilot is commanding. The pilot not flying should have the ability to view a pictorial screen to determine what the other pilot is doing. Air France Flight 447 might have had a better outcome if this had been available.

Robert Bertrand, Jupiter, Florida

THE SHORT OF IT

The photo of the Breguet 941 in "Short-Field Short-Haul" *(April 20-May 3, p. 12)* brought back many memories of McDonnell Aircraft efforts in the late 1960s to sell the concept of city-center-to-city-center short-takeoff-and-landing (STOL) operations to major U.S. airlines. I was part of the flight-test team that configured the aircraft in airline livery for both Eastern Airlines and American Airlines. Aircraft were flown by senior line pilots with a French co-pilot. For Eastern, we flew simulated commercial flights from Washington to New York City (using a simulated downtown STOL runway along the piers on the Hudson River). And for American, we flew from St. Louis to Chicago Midway and Meigs Field.

We flew loads of up to 18 VIP passengers to collect data on passenger acceptance and market potential for the city-center operations concept. In one amusing incident, the antinoise coalition in Chicago gathered around Midway to record the noise signature of the potential new noise threat, and they were unable to distinguish any noise signature from the Breguet versus the truck traffic on streets surrounding Midway. The reason for the lack of noise signature was that the aircraft was so maneuverable we were able to climb to 8,000 ft. without ever overflying the airport boundaries. That made for a fun flight.

So more than 50 years ago, there were actual flight demonstrations on the now-in-vogue concept of short-field short-haul. The economics didn't work then, and I doubt they will now, but it was sure fun to try.

Brad Gale, Fort Worth

DIGITAL EXTRAS

One of the unintended consequences of the COVID-19 aviation shutdown has been the inability to "land" my printed copy of *AW&ST* in my hometown of Sydney in Australia. International airmail is not reliable now that no one is flying regularly. But I am staying up to date with my timely digital copy. I can now see all the additional material that is available to me by this means. Even though I am "old-school," I am adjusting to my new normal with some good reading from my favorite aerospace correspondents. Thank you, *AW&ST*!

Paul Simadas, Redfern, Australia

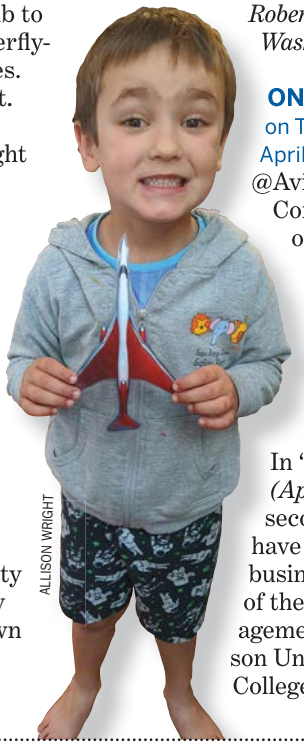
DESIGN QUESTIONS

As a veteran of the Boeing SST program, I am interested in the change of the airplane configuration referenced in the excellent article "Supersonic Evolution" *(April 20-May 3, p. 50)*. It reminds me of the Hawker Siddley Type 1011 of 1962 but with fixed wings.

The Aerion preliminary design review is six months away, and items not mentioned in the article would need answers:

- Are there thrust reversers, and are they effective? (Think prototype Boeing 737.)
- With the small tailplane, are deep stall issues addressed?
- Is tire-burst analysis complete?

Robert Ridgwell, Kirkland, Washington



ALLISON WRIGHT

ONLINE, Allison Wright writes on Twitter in response to the April 20-May 3 cover: @AviationWeek and @Aerion Corp thank you for the cover of this magazine! My 4.5 year old LOVES Supersonic Airplanes! I cut it out and laminated it so he can fly it around!

CLARIFICATION

In "Balanced Capitalism" *(April 20-May 3, p. 6)*, the second paragraph should have begun: "In the first business law course as part of the graduate industrial management curriculum at Clarkson University (then Clarkson College of Technology). . . ."

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

WHO'S WHERE

Amy Gowder has been hired by *Aerojet Rocketdyne* as chief operating officer. She succeeds Mark Tucker, who is retiring. Gowder also will serve as an officer of parent Aerojet Rocketdyne Holdings. She was Lockheed Martin vice president and general manager for training and logistics within the rotary and mission systems unit.

Thales has appointed **Alex Cresswell** CEO and chairman of Thales UK. **Christophe Salomon** succeeds him as executive vice president for land and air systems and joins the executive committee. Salomon was chief information officer at EDF.

Akima has hired **Duncan Greene** as president of mission systems for engineering and technology. He will oversee group companies providing mission support, IT and analytic services to the Defense Department and the intelligence community. Greene, a former CIA officer, was BAE Systems vice president and general manager for space intelligence and global analysis.

James R. Clapper has joined the *University of Pennsylvania's Center for Ethics and the Rule of Law* executive board. He was director of national intelligence, undersecretary of defense for intelligence, and director of defense intelligence, respectively, for several administrations. After the Sept. 11, 2001, terrorist attacks, he came out of retirement to become the first civilian director of the National Imagery and Mapping Agency, transforming it into the National Geospatial-Intelligence Agency.

Carol Tome has been named CEO of *UPS*. She succeeds David Abney, who will retire from the board in September. Tome has served on the UPS board since 2003, and was chief financial officer for Home Depot.

Keystone Aviation has hired **J. Dan Govatos** as director of operations for its private jet charter, aircraft management and maintenance services. He has captained on Airbus, Boeing, Falcon, Gulfstream and other aircraft types for airline and corporate operations.

Jennifer Upton has been named director of acquisition at the *NATO Communications and Information Agency*. Upton's Defense Department contracting experience includes service with the U.S. Naval Special Warfare Command and U.S. Special Operations Forces.

Allianz Global Corporate & Specialty (AGCS) has named **Chuck Couch** North America head of aviation programs and product development. He was AGCS product lead for aviation workers' compensation in the U.S. and manager for a group of national aviation specialty programs, including Allianz Drone.

Kaman Corp. has promoted **Rebecca Stath** to vice president of accounting and principal accounting officer from internal audit manager and **Lisa Barry** to vice president of financial planning and analysis from finance manager.

Robert Ulibarri has been named general manager of *Saab's* $37 million aerospace facility for high-tech commercial aerospace systems development at Purdue University's Discovery Park District. He was industrial automation general manager at Eckhart USA and held leadership positions at Lennox International and Oshkosh Corp.

North American Aerospace Industries, an aircraft recycling company, has hired **Janos Virag** as director of innovation. He was an aviation manufacturing instructor and manager of Airbus A350XWB fabrication with Lenoir Community College/Spirit AeroSystems in Kinston, North Carolina.

APOC Aviation has promoted **Jim Nypels** to its new engine trading division. He will facilitate engine-part sales and evaluate engine stock for trading, leasing or teardown. Nypels was project manager for airframe teardowns.

Inflite Group Jet Centre has appointed **Steve Hughes** general manager of Excellence Aviation Services Ltd., located at London Stansted Airport, as well general manager of its continuing airworthiness management organization (CAMO) activity. Hughes was general manager of CAMO and UK Civil Aviation Authority nominated post holder at Luxaviation.

Markus Haggeney has been named secretary general of the *World Air Sports Federation* from acting secretary general.

Wisk, the urban air mobility company behind the world's first autonomous, all-electric air taxi, has hired **Dan Dalton** as vice president of global partnerships. Dalton was Airspace Systems' executive vice president of strategic partnerships and a visiting scientist at Lawrence Livermore National Laboratory.

Racquel Asa has been hired as chief marketing officer for *Beep*, a startup in the autonomous mobility communications sector for future robotic vehicular passenger transport systems in low-speed environments. Asa was a transportation journalist for WFTV in Orlando.

HONORS AND ELECTIONS

Veteran Smithsonian National Air and Space Museum curator **Dorothy Cochrane** has been chosen by the National Aeronautic Association to receive the 2020 *Katharine Wright Trophy*, awarded for long-term advancement of "the art, sport and science of aviation and spaceflight."

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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COVID Relief Dwarfs Defense Spending

Global Defense Spending in 2019 (trillions)

Government Stimulus Spending in 2020 (trillions)

"Who is going to pay the piper?" asks John Dowdy, global aerospace and defense leader at McKinsey & Co., as worldwide costs to combat the novel coronavirus pandemic far outstrip defense spending.

Source: McKinsey & Co.

COMMERCIAL AVIATION

Mitsubishi Heavy Industries has suspended development of the M100 version of the SpaceJet to stanch losses on the regional jet program that drove the industrial group into the red for the fiscal year that ended March 31 (page 30).

Avianca Holdings, one of Latin America's largest airlines, has filed for Chapter 11 bankruptcy protection after failing to secure a government bailout before the deadline for a $66 million bond repayment.

Italy plans to invest at least €3 billion ($3.2 billion) in relaunching Alitalia, which is to be renationalized, and is eyeing the long-haul market, according to Economic Development Minister Stefano Patuanelli.

An ICAO-led task force has issued initial guidance for travel procedures amid the COVID-19 pandemic—covering cargo flight crews—and plans to have comprehensive protocols drafted by the end of May (page 25).

The U.S. Transportation Department has offered airlines further relief from minimum flying levels set in the CARES Act aid package, as concerns over the financial harm caused by the COVID-19 pandemic continue to grow (page 28).

Having formally decoupled restarting production of the 737 MAX from recertification on the grounded narrowbody, Boeing and leading supplier Spirit AeroSystems have begun making new aircraft.

JetBlue Airways reached an agreement with Airbus to restructure its aircraft deliveries, pushing out several dozen A321neos past 2022.

Mitsubishi's acquisition of Bombardier's CRJ regional jet program is to close on June 1, netting the Canadian manufacturer $550 million.

VIEW FROM WASHINGTON

F-35's Challenges Continue

A program intended to deliver new capabilities for the Lockheed Martin F-35 more quickly has been extended by two years because of development delays, says the U.S. Government Accountability Office (GAO).

The original schedule called for completing the Block 4 modernization program in 2024, but this timeline has been extended to 2026, the watchdog agency says in its annual review of the F-35 program. The delay will add $1.5 billion to the cost of developing all 66 new capabilities in Block 4, taking the price tag to $12.1 billion. Another $3.4 billion is budgeted to procure and insert the capabilities into future U.S. F-35s, the GAO says.

Lockheed planned to deliver the first eight Block 4 capabilities last year, but only one—the Automatic Ground-Collision Avoidance System—entered service, the GAO says.

As new Block 4 capabilities have entered testing, operational testers have noted some "caused issues" with existing F-35 functions that previously worked, the watchdog says, adding: "The contractor had not performed adequate testing of the software before delivering it to the test fleet."

Lockheed has acknowledged the issues, the GAO says, and will conduct additional laboratory testing before releasing future software blocks.

CASC

SPACE

Three days after being launched by Long March 5B on an unpiloted test flight, the reentry capsule for a new manned Chinese spacecraft returned to Earth successfully on May 8. China also has

confirmed plans to send a probe to Mars and the Chang'e 5 mission to the Moon by the end of 2020 (page 18).

In case of delays to SpaceX beginning commercial service with its Crew Dragon transportation system, NASA has bought a $90 million seat on the next scheduled Russian Soyuz flight to the International Space Station in October.

SpaceX conducted a static test fire of a full-size, second-stage Starship prototype on May 5, briefly firing the test vehicle's single methane-fueled Raptor engine.

DEFENSE

Boeing on May 7 rolled out the first of two test aircraft for the F/A-18E/F Block III program. The two aircraft will be delivered to the U.S. Navy's flight-test squadron in the "coming weeks."

Switzerland has given bidders in its CHF8 billion ($8.22 billion) fighter and ground-based air defense competition three more months, to November, to submit proposals due to the COVID-19 pandemic.

Lockheed Martin, Northrop Grumman and Australia's CEA Technologies will compete to replace the U.S. Air Force's TPS-75 long-range surveillance radar, after a contract with Raytheon was canceled last year.

South Korea has test-flown a new type of short-range ballistic missile, the Hyunmoo 4, making one successful and one unsuccessful shot in March, local media say (page 37).

Leonardo's M-345 light jet trainer has secured certification from Italian military airworthiness authorities, a major milestone toward service entry with the Italian Air Force.

Airbus is developing a removable refueling boom for its A330 MRTT aircraft to save weight when the eight-strong European Multinational Multi-Role Tanker Transport Fleet is flying transport and other missions.

Greece is to lease two Israeli Aerospace Industries Heron medium-altitude, long-endurance unmanned aircraft for three years to patrol the country's maritime borders.

QUOTED

"THERE'S A LOT OF PAIN TO COME YET,
AND A LOT OF
VERY TOUGH DECISIONS
[ON] PRODUCTION VOLUMES."

—CEO GREG HAYES, warning that Raytheon Technologies' commercial aircraft and aftermarket sales could each decline by 50%.

GENERAL AVIATION

Daher's 2020 model year TBM 940 turboprop will come equipped with HomeSafe. The emergency autoland system is available as part of Garmin's G3000 integrated flight deck.

As Gulfstream cuts jobs across its operations, including 700 at its Savannah, Georgia, headquarters, a second and third aircraft have joined the test program for its flagship G700 large business jet.

PROMOTED

United Airlines is holding course on a leadership transition plan initiated late last year, even as it fights to recover from the effects of the COVID-19 pandemic. On May 20, Scott Kirby will be elevated to CEO and replaced as president by Brett Hart, who is now executive vice president and chief administrative officer. Current CEO Oscar Munoz will become executive chair of the board.

OBITUARY

Rudy Frasca, founder of simulator manufacturer Frasca International, died of natural causes on May 11 at age 89. A former U.S. Navy flight instructor who taught pilots on early Link Aviation training devices, Frasca founded the company in 1958. He assembled the first simulator in his garage. Frasca also collected antique and replica aircraft, loaning several to the EAA Aviation Museum in Oshkosh, Wisconsin.

55 YEARS AGO IN AVIATION WEEK

Our cover from May 17, 1965, showed the first production Dassault Mystere 20 being flown on a demonstration flight for officials from Pan Am shortly before the cutting-edge executive jet was certified. Commissioned by Marcel Dassault, the Mystere 20 could carry two pilots and 10 passengers, with a maximum cruising speed of Mach 0.8 and a range of more than 2,000 km (1,080 nm). Its engines were mounted on lateral struts. Company history says Dassault repurposed technologies it had used on French military aircraft for the design, such as three-axis servo controls, fine-tuned aerodynamics and "conical wing cambers." The Mystere 20 proved to be the ideal platform to launch Pan Am's diversification into executive aircraft distribution. The U.S. airline sent famed aviator Charles Lindbergh to France in 1963 to witness its first flight. "I've found the bird," he proclaimed. Pan Am soon placed orders for 40 aircraft powered by General

Electric CF700 turbofans, with options for 120 more. Renamed the Fan Jet Falcon and later the Falcon 20 for U.S. customers, the aircraft went on to great success as the original workhorse for Federal Express. The U.S. Coast Guard bought a fleet as well. Production finally ended in 1988.

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

UP FRONT
BYRON CALLAN

THE 2020 U.S. PRESIDENTIAL election will be competitive and probably will be decided by the electoral college votes of 6-8 states. Although COVID-19 has dominated thinking about defense, it is a good time for defense planners, analysts and management to start considering what the administration of presumptive Democratic nominee Joe Biden could mean for the sector in 2021-24.

A Biden presidency and Democratic control of Congress is not likely to be a negative for defense, but it would introduce some new factors and issues. If Biden wins in November, Democrats could also regain a majority in the Senate and retain the House majority. If that happens, the 2022 midterm election will be the next major marker, because midterm elections typically are seen as a public verdict on how the president is doing.

As can be expected based on the vast majority of major election campaigns, Biden's team has not put forth much hard budget data or program specifics yet. Biden's campaign website under "Defend Our Vital Interests" states: "We have the strongest military in the world—and as president, Biden will ensure it stays that way. The Biden administration will make the investments necessary to equip our forces for the challenges of the next century, not the last one." He will also "end forever wars" in Afghanistan and the Middle East, it states.

Biden's advisors are largely centrists who served in the Obama administration. These include Tony Blinken, Jake Sullivan, Brian McKeon, Jeffrey Prescott, Julianne Smith and other former Pentagon officials. Some policies conceived when Biden was vice president—the "pivot" to the Asia-Pacific region, the "third offset strategy" and a refocus on Europe after the Russian seizure of Crimea—have been sustained, though relabeled, by the Trump administration. Other current policies are likely to be altered, including "maximum pressure" on Iran, the transactional view of alliances, overall absence of U.S. leadership on core global issues and movement away from current arms control agreements.

China also will remain a critical defense factor, particularly if a Biden administration leans more heavily on human rights issues, and U.S.-Russia relations could be more contentious.

Under Biden, significant cuts to the Pentagon's current plan for fiscal 2022-25 would be unlikely because it will attempt to assert U.S. leadership in ways that could continue to rile China and Russia. However, the administration would have to balance defense needs against post-COVID-19 spending needs, and there is a strong likelihood that the magnitude of federal debt will light new fires in Washington over total U.S. federal spending.

There could be other factors to weigh for defense. More debate may occur over U.S. strategic and nuclear forces modernization programs—specifically the Ground-Based Strategic Deterrent and Long-Range Standoff Weapon. Artificial intelligence, space and autonomous systems have been championed in the Trump administration, but their priority may be further elevated in 2021-24 and beyond.

Arms control could come back into sharper focus, as Biden is very unlikely to exit the New START treaty. His administration may seek other measures to limit the risk of crisis and counter the potentially destabilizing effects of hypersonic weapons, cyberattacks on critical infrastructure and conflict in space.

The Pentagon's interaction with contractors could change as well. Under Biden, there probably would not be as many senior Pentagon civilian officials who formerly worked for contractors as is now the case. There may be initiatives to shift risk to contractors from the Pentagon and to incentivize development. Efforts to reintegrate defense with commercial technology and manufacturing could be expected and accelerated. The Pentagon may again reassert guidance on red lines for mergers and acquisitions, too.

The Middle East will remain complex, including the potential of significant problems in Iraq and Iran. A Biden administration is likely to distance itself from Saudi Arabia, but this may not affect major defensive weapons sales, unless the Saudis turn to China or Russia. COVID-19 impacts on poorer countries also will create new security challenges that may dilute some of the central tenets of the current National Defense Strategy and notions of "Great Power" competition.

Biden's age, 78, may affect his second-term prospects and heightens the importance of running-mate selection—the VP candidate might provide another indication of how U.S. defense could evolve in the 2020s.

Change of Guard?
What **Biden** would mean **for defense**

AIRMAN 1ST CLASS CARLIN LESLIE/U.S. AIR FORCE

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

GOING CONCERNS
MICHAEL BRUNO

ALONG WITH THE COMMERCIAL air traffic numbers that fuel the Zeitgeist, mergers and acquisitions in aerospace and defense have ground to a halt. But don't believe for a minute that dealmakers are sitting at home twiddling their thumbs—the indications are they are working as hard as ever.

"There's not a week passes that we don't get some sort of early warning of people trading out of assets and things like that," KBR CEO and President Stuart Bradie said on the major NASA and Defense Department services provider's April 29 quarterly earnings call. The company will be just as selective as before the pandemic wreaked havoc, "but certainly those opportunities are there," he noted.

Gathering Kindling

Frozen for now, the **bonfire of A&D consolidation** will roar again

In the pre-COVID-19 world, aerospace and defense (A&D) and government services mergers and acquisitions (M&A) were expected to reach near-record levels this year, just off the 2018-19 peaks of around $132 billion that bookended the most active and expensive decade in A&D history. Although that will not be the case after the novel coronavirus pandemic, at least not in the immediate future, the proverbial kindling of a bonfire of M&A is being laid as A&D manufacturers and service providers go from record business activity to record cuts.

According to A&D M&A advisor Mesirow Financial, the second half of 2019 was the busiest period of dealmaking in the past decade, including a strong showing from increasingly active private equity investors. While 2020 never was expected to set records, the expectation was for a different kind of robust M&A activity, shifting from megamergers such as Raytheon Technologies and L3Harris Technologies to supply chain and technology-related consolidation, consultancy AlixPartners notes.

Not anymore: Anecdotal evidence points to a chilling effect on M&A as widespread liquidity concerns, OEM production cuts and shelter-at-home mandates rewrite the industry's prospects practically overnight.

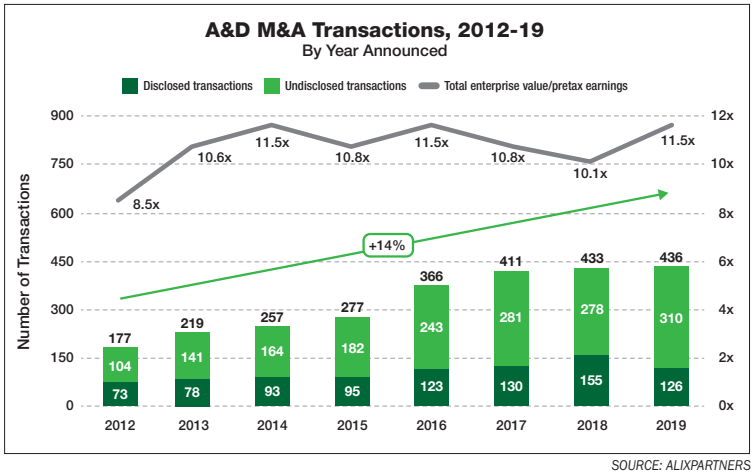
"It's like asking someone in the middle of a tornado which direction they are going," says Greg Van Beuren, managing director of advisor Houlihan Lokey. "There is really no new credit available for strategic activity like an acquisition. It is primarily being used to shore up balance sheets and see how long this will last."

Indeed, before M&A can pick up, it may have to fall apart some more. April brought a trio of cancellations: The merger of suppliers Woodward and Hexcel was called off just months after being announced, Senior plc said it was pulling its aerostructures assets off the market, and Boeing walked away from a two-year negotiation over its proposed $4.2 billion acquisition of most of Embraer's commercial aircraft division.

Attention now is turning to which other deals could fall victim. Jefferies analysts Sheila Kahyaoglu and Greg Konrad list aerostructure giant Spirit AeroSystems' bids for Bombardier's commercial aerostructures assets and the Asco aircraft parts maker.

Next, watch for hostile takeovers. Several A&D companies in recent weeks have adopted so-called poison pills to try to ward off such proposals. Among them are Spirit, Hexcel, Woodward and AAR. Other recent adoptees included Maxar Technologies for different reasons. But some corporate boards might welcome an approach.

Finally, prepare for a wave of distressed assets to emerge later this year or in early 2021. Private equity investors are scrubbing their portfolios of companies, assessing their cash situations and their potential for creating liquidity, says Eric Bernardini, global co-leader of the AlixPartners aerospace, defense and aviation practice.



SOURCE: ALIXPARTNERS

"In the near term, many downmarket suppliers may find themselves in troubled waters due to both OEM rate reductions and the collapse of the aftermarket driven by COVID-19 demand impacts," Bernardini's team says. "Ultimately, this may trigger a reconfiguration of the Tier 2 and Tier 3 supply chain landscape, with a need for consolidation and capital injection."

Despite their own troubles, well-funded serial acquirers and top industry players remain ready to pounce. "I don't want to necessarily be buying off of 2019 comps—I don't think that makes a lot of sense," Honeywell International Chairman, CEO and President Darius Adamczyk said on May 1, as he waits to see what becomes available. "But given our balance sheet, which is in great position, yes, I think that this is an area which could be an opportunity in the second half of the year," he continued.

"I think the valuations should and will change," Adamczyk said. "That's pretty obvious."

LEADING EDGE
GRAHAM WARWICK

WAS THE DECISION BY AIRBUS and Rolls-Royce to end the E-Fan X research program without flying the hybrid-electric demonstrator a sign that electric propulsion has hit a dead end? Or was it a tap on the brakes for a technology trend that probably was moving a bit too fast anyway?

The project to modify a regional jet with a 2-megawatt, 3-kilovolt serial hybrid-electric powerplant certainly was the poster child for electric propulsion. That industry giants Airbus and Rolls would take on such a project, supported by European and UK government funding, was widely viewed as an endorsement of electrified aircraft propulsion as the most promising future direction for the decarbonization of aviation. It still is a promising direction, but it might just take a bit longer to get there by another route.

Electric Reset

Can electric propulsion **survive a setback?**

When Airbus launched the E-Fan X project in 2017, it entered territory occupied by startups. New entrants such as Ampaire and Zunum Aero were taking a bottom-up approach by introducing hybrid-electric propulsion first to smaller aircraft, with 11 passengers or fewer; Airbus took aim at the top of the regional market and aircraft with up to 100 seats.

That meant tackling the technical challenges of generating, converting, storing, distributing, controlling and consuming electrical power on a megawatt scale, at kilovolt levels, in an aircraft able to fly at the speeds and altitudes of a regional jet. Airbus brought in the expertise of Siemens' eAircraft unit, which was later acquired by Rolls, its other partner on the E-Fan X.

The result was a power train that comprised an AE2100 gas turbine driving a 2.5-megawatt generator "the size of a beer keg" and supplying power to both a 2-metric-ton battery pack and a 2-megawatt electric motor driving the fan from an AE3007 turbofan. This was to replace one of the four Honeywell LF507 turbofans powering the Avro RJ testbed chosen for E-Fan X.

That testbed will now never fly, a victim of cost cuts amid the COVID-19 crisis, but Rolls plans to complete ground testing of the power-generation system to demonstrate the technology and capture the lessons. This study will include the generator, now on test in Trondheim, Norway, as well as the control and thermal-management systems developed in the UK and U.S., respectively. This power generation system "can and will be" used in future hybrid-electric aircraft, says Rolls.

The novel coronavirus pandemic exposed the E-Fan X's biggest vulnerability: that it was always destined to be only a demonstrator and never a product in service. There is a well-documented history of such projects never making it to flight, someone deciding at some point that enough has been learned from ground testing that there is no need to waste money getting into the air.

Rolls saw it happen to a key precursor of the E-Fan X, Aurora Flight Sciences' XV-24A LightningStrike. This was a hybrid-electric, high-speed vertical-takeoff-and-landing demonstrator powered by a Rolls AE1100. Aurora flew a subscale demonstrator which, after Honeywell hit problems developing the 1-megawatt generators, enabled DARPA to claim enough had been achieved to terminate the program.

In announcing that the E-Fan X was ending without the demonstrator flying, Airbus indicated it had taken the decision to refocus its research and technology efforts and "take an even bolder approach to reduce

AIRBUS

CO_2 emissions." What that approach might be was not revealed, but hybrid-electric propulsion remains one potential pathway, and Airbus says it will continue to mature the technology in its E-Aircraft System Test House.

Another pathway is hydrogen, which is gaining traction in Europe. Airbus says hydrogen propulsion "is equal parts as huge an opportunity as it is a new challenge." Here the European giant could again find itself in territory that for now is occupied only by startups—such as ZeroAvia, which is developing a hydrogen fuel-cell power train for regional aircraft.

With the demise of the E-Fan X, leadership in the drive for electric propulsion reverts to the startups. These new entrants face their own COVID-19-induced funding challenge. That may slow them down by a year or two but is unlikely to derail them as they are not targeting a traditional aviation market, one that is struggling to recover. By using electric propulsion to dramatically reduce the operating cost of aircraft, they are instead aiming to compete with automobiles to provide regional mobility.

There is a risk that governments could take their foot off the pedal when it comes to supporting electric propulsion R&D. Instead, they should see it as an opportunity to help the industry as a whole catch up with the technology leaders and get ready to move into the fast lane when the time comes.

THE LAUNCHPAD
IRENE KLOTZ

Pinning Hopes on Mars

Pandemic creates **logistics nightmare** for UAE

IT HAS BEEN A CHALLENGING RIDE for the United Arab Emirates' debut Mars mission—and it hasn't even launched yet.

The engineering and science hurdles were not surprising. After all, the UAE's previous experience building spacecraft consisted of a single small Earth-observation satellite, DubaiSat-2, launched in 2013.

To learn the trade, the Mohammed bin Rashid Space Centre, a government of Dubai entity, dispatched teams of engineers and scientists to South Korea's Satrec Initiative to build a precursor spacecraft as a teaching tool. DubaiSat-1 launched in 2009.

The next initiative, announced in 2014, was the Emirates Mars Mission (EMM), with the goal of reaching Mars in time to mark the 50th anniversary of the founding of the UAE in 2021. That meant launching during a three-week window that opens in mid-July when Earth and Mars are favorably aligned for interplanetary flight, an opportunity that arises every 26 months.

"We had only six years to develop the mission," says EMM Project Director Omran Sharaf. "You're talking about a nation that didn't have capability at that point and experience building outer-space exploration missions. . . . We had to come up with means and ways in six years, which is quite tight."

Unlike other space exploration initiatives, the overriding goal of the EMM, also known as Hope, is not primarily science but to serve as a catalyst to develop the country's science and technology sector, particularly among Emirati youth.

"It's an example of collaboration and an example of coexistence, in which we have the team in the UAE working with partners in different parts of the world," Sharaf says. "All this has to be done through novel and unique science that serves the international science community."

Hope is outfitted with three science instruments for detailed studies of the Martian atmosphere. The UAE partnered with the University of Colorado at Boulder, Arizona State University and the University of California at Berkeley in developing the science instruments.

Heading into 2020, the project was in good shape, but then the COVID-19 pandemic struck. International travel bans and workplace shutdowns stemming from efforts to contain the novel coronavirus complicated logistics to get engineering and science teams from the U.S. and the UAE to accompany the probe to its launch site in Japan. "It was a logistical nightmare," Sharaf says.

Project managers cut short the spacecraft's testing in Dubai to accommodate additional time needed in Japan for technicians to fulfill two-week quarantine requirements before being able to work. That was preceded by two-week quarantines for U.S. and other international travelers arriving in Dubai to assist with spacecraft assembly and testing.

"Because of the COVID-19 situation, we had to expedite the activities in Dubai to focus only on the critical testing and remove the additional testing we wanted to do," Sharaf says. "The decision was made early on that basically we need to ship the spacecraft as soon as possible to the launch site, given the restrictions that came up with regards to traveling and having teams get to the launch site in time.

MOHAMMED BIN RASHID SPACE CENTRE

"We asked our colleagues in the U.S. to send some team members to the UAE so they could go into our quarantine for 14 days," Sharaf says. "In the meantime, the team based in Dubai was preparing the spacecraft for shipment. Once that team, which was in quarantine, got out, the other team that was working in Dubai was sent to Japan, and they went into quarantine."

That team's quarantine was timed to end when Hope arrived in Japan so it could take over launch preparations from the group that traveled with the spacecraft. The spacecraft escorts then quarantined for two weeks while their colleagues picked up prelaunch processing at Japan's Tanegashima Space Center.

"We were able to get the critical team into Japan . . . and we managed to get all the approvals [to fly] because UAE airports are closed. We were able to get some exemptions from the UAE government and also from the Japanese government," which has imposed extra visa requirements for UAE and U.S. citizens, Sharaf says.

NASA has embarked on a similar, though less complicated, endeavor in an effort to meet the July interplanetary launch window for its Mars 2020 rover mission. China also is aiming to fly an orbiter and a rover to Mars this summer. Europe's planned ExoMars rover mission, already challenged to complete parachute testing before the pandemic struck, will miss its 2020 launch slot.

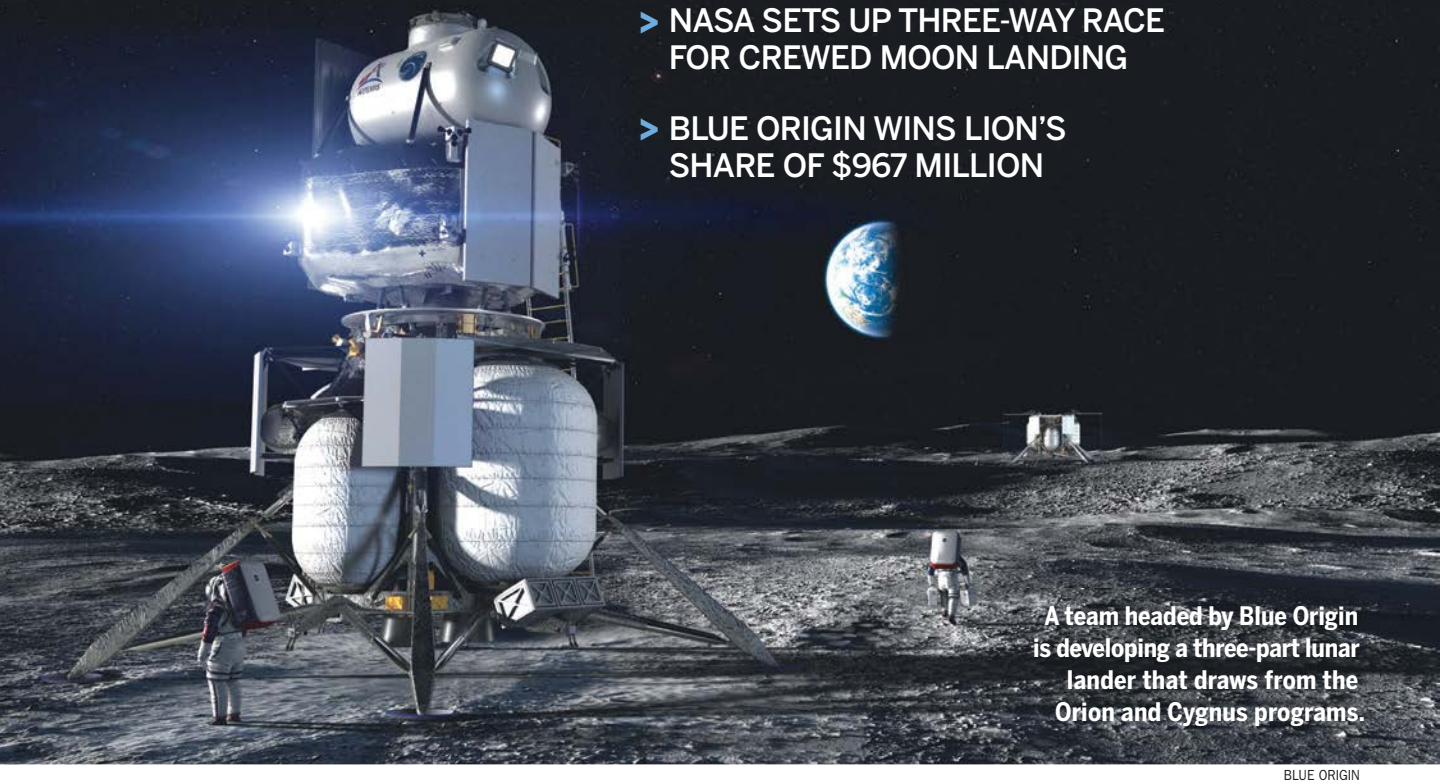
Hope is not out of the woods yet. "COVID-19 is still around, and there's always that risk that things might get postponed," Sharaf says. "I'm quite anxious about it." Hope's launch opportunity opens July 14.

SPACE > Chinese manned space program's new phase p. 18

LUNAR LANDERS

> NASA SETS UP THREE-WAY RACE FOR CREWED MOON LANDING

> BLUE ORIGIN WINS LION'S SHARE OF $967 MILLION



A team headed by Blue Origin is developing a three-part lunar lander that draws from the Orion and Cygnus programs.

BLUE ORIGIN

Irene Klotz Cape Canaveral

Hedging its bets in hopes of meeting the Trump administration's goal of landing astronauts on the Moon in 2024, NASA will spend nearly $1 billion over the next 10 months helping teams led by Blue Origin, Dynetics and SpaceX parlay their commercially developed technologies into transportation systems for lunar-surface sorties.

"One thing we were striving for with these solicitations and announcements is to see what U.S. industry could bring us with respect to innovation, and boy did they deliver," says Lisa Watson-Morgan, Human Landing System (HLS) program manager at NASA's Marshall Space Flight Center in Huntsville, Alabama.

"We have three notably different architectures—a one-stage, a two-stage, and a three-stage architecture—[which] achieves the innovation and the dissimilar redundancy of approaches we wanted," she says.

The lion's share of $967 million that NASA plans to spend on HLS offerings through February 2021 will go to Blue Origin, which heads a team of heritage aerospace companies including Lockheed Martin, Northrop Grumman and Draper.

Blue Origin proposed a three-stage HLS that includes: a descent element powered by the company's BE-7 cryogenic engines, an ascent element provided by Lockheed and based on the Orion deep-space capsules it is manufacturing for NASA under a related program, and a transfer element built by Northrop and based on its Cygnus spacecraft used for International Space Station cargo runs.

Draper will provide cross-cutting support in guidance, navigation and control and will also provide avionics and software systems.

"This teaming approach, which strategically draws upon the unique capabilities of each team member [and] relies upon heritage hardware and systems, provides confidence that the team can complete the design, development, test and evaluation of an HLS that meets NASA's requirements for the 2024 demonstration mission," NASA Associate Administrator Stephen Jurczyk, who served as the HLS source selection authority, wrote in an April 28 Source Selection Statement posted on the agency's website.

Privately owned Blue Origin, founded and funded by Amazon CEO Jeff Bezos, has been quietly lobbying NASA for three years to support commercial lunar transportation services, an idea developed as part of the company's Blue Moon program.

The procurement panel that vetted the HLS proposals liked Blue Origin's "human-centric approach" for its rendezvous, proximity operations, docking and undocking systems. "Blue Origin's unique design . . . will reduce crew workload during these critical operations and improve safety by al-

lowing the crew to monitor overall vehicle performance," Jurczyk wrote.

Blue Origin's HLS design also exceeds NASA's baseline requirement for initial habitation capability and landing accuracy, offering benefits for the initial 2024 mission and missions to follow "in a manner that is feasible and does not compromise other elements of Blue Origin's technical approach," he added.

NASA also liked that the company's plan includes an uncrewed flight test in 2023 to the same landing site selected for crewed landing a year later, significantly reducing schedule and technical risk, NASA said.

The biggest technical concern with Blue Origin's HLS is its power and propulsion system, which includes "multiple, relatively low technology-readiness-level systems that will be challenging to manufacture, integrate and test," Jurczyk wrote. The design introduces "significant risk to the program," he added.

"This design can only come to fruition as a result of a very significant amount of development work that must proceed precisely according to Blue Origin's plan, including occurring on what appears to be an aggressive timeline," he added.

Still, the design is well-thought-out and Blue Origin has conducted significant system modeling that increases the credibility of its approach, the Source Selection Statement said.

Blue Origin was awarded a $579 million fixed-price contract under the solicitation, which is more than half of the $967 million set aside in NASA's fiscal 2020 budget for HLS development.

Blue dropped its price by more than $300 million for the 10-month base performance period following negotiations with NASA, the Source Selection Statement noted.

Major NASA Programs

	Amount of Cost Overrun (U.S. $ billion)	Latest Cost Estimate (U.S. $ billion)	Schedule Delay (months)
Orion Crew Capsule	$0.9	$12.2	24
Mars 2020	0.4	2.7	0
Space Launch System	1.7	11.4	28
James Webb Space Telescope	4.4	9.7	81

Source: Government Accountability Office

While NASA still aims to land astronauts on the Moon in 2024, it is struggling to contain the cost of several major programs.

DYNETICS PLUS-25

Of NASA's three HLS partners, Dynetics, a wholly owned subsidiary of Leidos, ranked highest in the agency's technical and management assessments of the proposal, receiving rankings of "very good" in both categories. Blue Origin's technical rating was "acceptable" and its management "very good," while SpaceX received "acceptable" ratings in both categories.

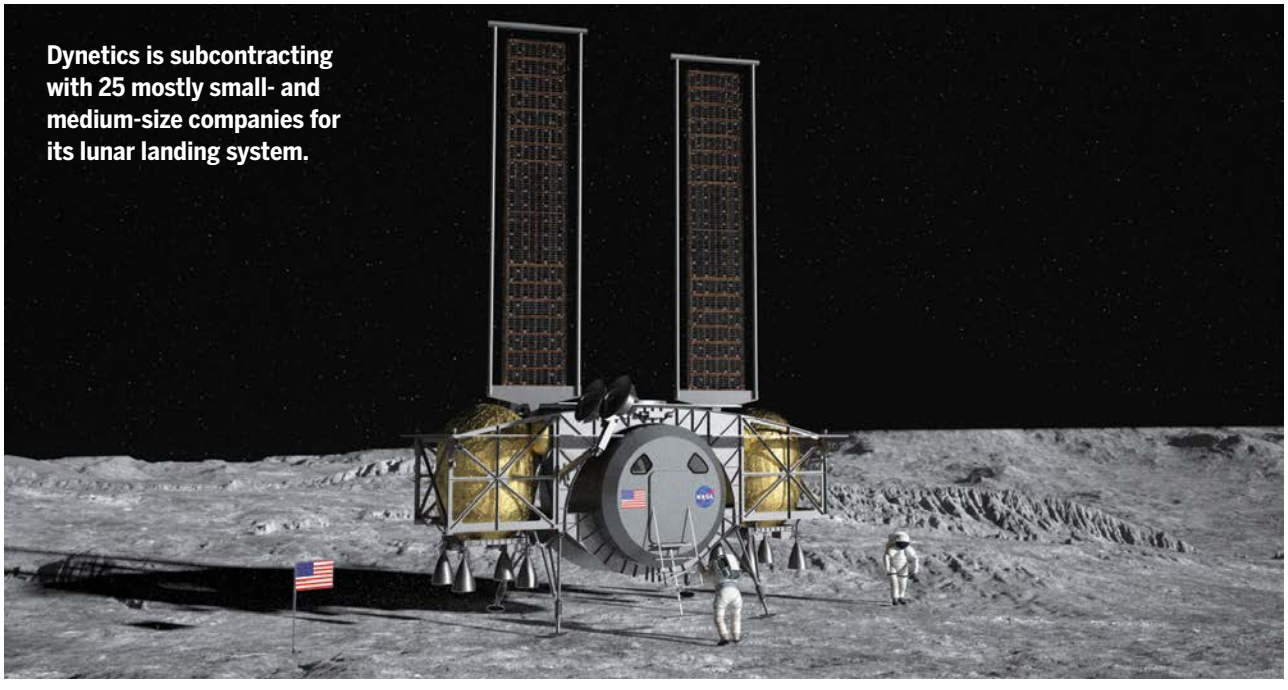
Dynetics' concept is to build a single element for lunar ascent and descent capabilities, coupled with multiple modular propellant vehicles prepositioned to fuel the engines at different points in the mission. The proposal exceeds NASA's baseline requirements for how much mass the lander can carry to the lunar surface, the number of spacewalks it can support and the vehicle's operational lifetime in lunar orbit.

NASA also likes that Dynetics' crew cabin sits low to the lunar surface, enabling a short and safer climb for astronauts entering and exiting the vehicle. "This design reduces the risk of crew injury due to falls and simplifies the offloading and loading of equipment required for EVA [extravehicular activity] missions," Jurczyk wrote.

"I find it similarly noteworthy that Dynetics' HLS design overall is crew-centric and likely to have a positive impact on successful contract performance as a result," he added.

For example, Dynetics has proposed optimal locations for its flight controls and windows to enable effective crew visibility during landing and on the lunar surface and during proximity, docking and undocking operations. Other notable features include a predictable translation path and a dust barrier, he wrote.

Another technical strength is Dynetics' integrated horizontal drop tank descent/ascent element archi-



Dynetics is subcontracting with 25 mostly small- and medium-size companies for its lunar landing system.

DYNETICS

tecture, which requires just two primary development efforts: a complex one for the crewed spacecraft and a moderately complex effort for the fuel element, NASA said.

"This architecture reduces the number of highly complex element developments to one, and thus inherently minimizes the number of required interfaces and verification steps. Overall, this design choice by Dynetics will meaningfully reduce the amount of time needed for design, development, test and evaluation of its HLS," NASA said.

Like Blue Origin, the Dynetics team will be challenged in the power and propulsion system arena, which "introduces an appreciable risk of unsuccessful contract performance from both a technical and development schedule standpoint," Jurczyk wrote.

"This system is complex and relies upon technologies that are at relatively low maturity levels or that have yet to be developed for Dynetics' proposed application, but would need to be developed at an unprecedented pace," he said.

"Many of its individual subsystems will have to be developed at a speed that does not align with historical experience for the development of analogous systems that perform similar functions," he added.

Though risky, the design concept thoroughly addresses NASA's stated requirements for propellant considerations, including storability, safety, maintainability and future adaptation to an in-space refueling capability.

If successfully developed and implemented, the proposed propellant storage solution will "result in a more mass-efficient system, which will in turn increase overall performance margin for Dynetics' HLS capability. Thus, while I agree that Dynetics' power and propulsion system overall presents substantial technical and schedule risk, it is also the case that its approach is exactly the kind of innovative solution that NASA sought through the HLS solicitation," Jurczyk wrote.

Dynetics also proposed a novel commercial approach, addressing a goal of NASA's HLS program to set the stage for the agency to become one customer among many for lunar flight services. Two of the 25 subcontractors on Dynetics' team are NASA Commercial Lunar Payload Services contractors focused on providing flight services for experiments and other research, scientific and commercial hardware to the Moon or lunar orbit.

NASA views Dynetics' subcontracting structure, primarily with small- and medium-size businesses, as another strength. "This commitment . . . will meaningfully contribute to the continued development of the small business technology base, and has the potential to reduce risk due to increased access to diverse technical solutions and capabilities within the small business community," Jurczyk wrote.

Dynetics was awarded $253 million for initial design and development of its HLS. The Huntsville-based company will serve as prime contractor and system integrator for a team that includes: Thales Alenia Space, Draper, Sierra Nevada Corp., Oceaneering International, Paragon Space Development, United Launch Alliance (ULA), Dynamic Concepts, Maxar Technologies, Creare, Craig Technologies, L3Harris Technologies, ILC Dover, Sierra Lobo, JBS Solutions, All Points, Cepeda Systems & Software Analysis, Victory Solutions, Astrobotic Technology, ATA Engineering, Ecliptic Enterprises, Bionetics, APT Research, Space Exploration Engineering, Osare Space Consulting Group and Tuskegee University.

STARSHIP ON THE RADAR

The last time SpaceX bid Starship to address U.S. government launch technology development, the Air Force turned it down, saying the company's planned fully reusable, two-stage, deep space transport was riskier than other heavy-lift launch options presented by ULA, Blue Origin and Northrop Grumman. In response to a follow-on solicitation for launch services, currently under evaluation, SpaceX dropped Starship from its offering, focusing instead on its proven Falcon 9 and Falcon Heavy boosters.

But Starship is far from forgotten. SpaceX founder, CEO and chief engineer Elon Musk has been personally overseeing prototype construction and testing near Boca Chica Beach, Texas, with an eye on achieving an orbital flight test of the second stage before year-end.

The effort has been bankrolled by SpaceX itself, along with a sizable deposit by Japanese billionaire entrepreneur Yusaku Maezawa, who in 2018 chartered a Starship mission for a flight around the Moon.

NASA is adding $135 million to the development effort, specifically to flesh out a Starship variant that would ferry astronauts to and from lunar orbit to the surface of the Moon.

NASA plans to use its own Space Launch System (SLS) rocket, still in development, and an Orion capsule to fly the crew to lunar orbit, where they will transfer to an HLS either via the planned Gateway or, more likely, directly from the Orion.

"The Gateway is critically important for what NASA is trying to achieve . . . to make the Artemis program sustainable," says NASA Administrator Jim Bridenstine, referring to NASA's deep-space human exploration program. "We would like to see private companies build landers that can go back and forth to the surface of the Moon, over and over and over again with reusable landers. That's how we drive down cost and increase access. . . . The Gateway also is important for maneuverability . . . to get to the poles

SpaceX's Starship has won its first big U.S. government development contract.

and equatorial regions of the Moon.

"It is also important to note that we have the priority to get to the Moon by 2024 and . . . we believe that does not require the Gateway," Bridenstine adds. "In fact, I would go as far as to say that it's not likely that we will use the Gateway for the 2024 mission."

The full Starship system, designed with an initial lift capacity of more than 220,000 lb. (100,000 kg) into orbit, could provide an alternative to NASA's SLS, but Bridenstine and his leadership team are clear that transporting astronauts for a 2024 Moon landing is completely dependent on the SLS and Orion. "That's the only rocket that is going to be human-rated by 2024 that will take humans to the Moon," Bridenstine says.

The HLS, along with Gateway components, will likely fly on commercial rockets.

SpaceX's HLS concept is to launch several Starships, each tailored for a specific part of the mission. A propellant storage Starship would park in low Earth orbit and be fueled by tanker Starships. A human-rated Starship would launch to the storage unit in Earth orbit, fuel up and continue to lunar orbit.

SPACEX

Musk says SpaceX will try to land the Starship on the Moon with enough propellant to return to Earth, a demonstration that would further nibble away the technological high ground of the SLS-Orion architecture.

As an HLS, NASA likes Starship's dual airlocks, each capable of supporting two astronauts to simultaneously don and doff EVA suits, with the ability to support four suited crewmembers if needed. Another strength of its proposal is the company's plan to leverage HLS development from the extensive heritage hardware and software used on existing flight programs, including cargo and crew Dragon capsules and Falcon 9 rockets.

"This methodology reduces technical, schedule and safety risk, as well as bolsters SpaceX's credibility for meeting the solicitation's primary objective of rapid HLS development to support a 2024 demonstration mission," NASA wrote.

The HLS Starship plan, however, includes a proposed propulsion system that is complex and composed of likewise complex individual subsystems—such as the reaction control system—that have yet to be developed, tested and certified, with little schedule margin to accommodate delays, the agency added.

NASA also found significant risk associated with successful development of SpaceX's integrated propulsion system for HLS given the proposed approach for integrating and testing the individual elements of the system.

"SpaceX has proposed a robust and aggressive plan for early systems demonstrations, which lends credibility to its proposed execution, [but] this plan does not adequately address the risk of [a] potential delay in development, as well as [a] concomitant delay to SpaceX's demonstration mission," Jurczyk wrote.

SpaceX's overall architecture and concept of operations pose another challenge. "Similar to the risks presented by SpaceX's propulsion system, this aspect of SpaceX's proposal presents other development schedule challenges—principally, those associated with its Starship variants and Super Heavy Booster—and requires numerous, highly complex launch, rendezvous and fueling operations, which all must succeed in quick succession in order to successfully execute on its approach," Jurczyk said.

"These development and operational risks, in the aggregate, threaten the schedule viability of a successful 2024 demonstration mission," he added.

Any problems, however, may crop up early, thanks to SpaceX's emphasis on early and numerous ground and flight demonstrations, which will reduce schedule and technical risk. "Because the base Starship design serves both HLS and SpaceX's commercial launch purposes, SpaceX asserts that many of its HLS systems will be demonstrated many times on operational missions prior to the 2024 HLS mission," Jurczyk wrote.

Examples include a low-Earth orbital flight of the Starship with a demonstration of SpaceX's Super Heavy launch vehicle, a reflight of the Starship, a long-duration orbital flight, a flight beyond low Earth orbit and a lunar landing demonstration mission scheduled for 2022.

"This comprehensive demonstration plan will meaningfully facilitate the maturation of critical technologies and demonstrably reduce schedule and technical risk, thereby greatly enhancing the potential for successful contract performance," NASA said.

NASA plans to embed personnel—virtually for now, due to ongoing closures from the coronavirus COVID-19 crisis—with the companies for three months to deepen its understanding of how the teams plan to certify their systems for human spaceflight.

"This first base period is so critical," says Douglas Loverro, NASA associate administrator for human exploration and operations. "We have got to make sure we have the requirements for the system right. An extra month that we take in the very beginning . . . will save us a year on the back end of having to change things."

In addition to bids by Blue Origin, Dynetics and SpaceX for its second Next Space Technologies for Exploration Partnerships Broad Agency Announcement, NASA reviewed and eliminated proposals by Boeing and Vivace. During the 10-month contracts, NASA will evaluate which of the HLS contractors will move on to perform demonstration missions.

Launch Opens Chinese Space Station Phase

- A 2017 LAUNCHER FAILURE THREW THE STATION CONSTRUCTION SCHEDULE AWRY
- MARS AND MOON MISSIONS CAN PROCEED NOW

Bradley Perrett Beijing

China is moving toward completing its space station in about two years, following a first launch of the facility's associated manned spacecraft by the new rocket that the project needs. The launch opens the manned space program's third phase, 28 years after it was sketched out.

It also ends a 3.5-year mission gap that resulted, at least in part, from a launcher failure in 2017. Another launcher failure this March seems less likely to affect progress, however.

Following the successful launch of the new spacecraft by a Long March 5B on May 5, China confirmed plans to send probes to Mars and the Moon this year using another version of the launcher type. For the Mars mission, the statement dispelled doubts that any COVID-19 disruption could push the shot beyond a July-August launch window.

The new spacecraft, which has not been named, is designed to carry six or seven people and can be used for freight. Beyond serving the space station, it is also intended for deep space missions, including those to the Moon. Its reentry capsule is reusable.

BRADLEY PERRETT/AW&ST

The first Long March 5B lofted the new manned spacecraft to orbit from the Wenchang base on Hainan.

Also on the ride to low Earth orbit (LEO) was a reusable cargo reentry capsule of a "flexible inflatable type," according to the Xinhua News Agency. This appears to mean that the metal capsule has an inflatable, drag-inducing device similar to those that NASA is developing under the Low-Density Supersonic Decelerator project.

Both payloads were test items. No one was aboard.

The manned spacecraft's mass is 21.6 metric tons; that of the core module of the space station is 22.5 metric tons. So China must use the Long March 5, which entered service in 2016 as the country's most powerful space launcher, to get them to orbit. The Long March 5B, lacking the second stage of the type's original version, is designed specifically for the job: its payload to LEO is "more than 22 metric tons," Xinhua says.

The 2017 failure of the Long March 5's second flight therefore threw awry the schedule for the manned space program and indeed those for sending a probe to Mars and the next one to the Moon, both of which also required the big launcher. It returned to flight in December 2019, thus the resumption of activity.

The space station is now due for completion around 2022. The core module is already at the Wenchang space base.

The manned space program has been following a scheme outlined in 1992. The first spacecraft of the original design was test-flown in 1999 and first took an astronaut to orbit in the Shenzhou 5 mission of 2003. A second manned flight, in 2005, wrapped up the first phase, demonstrating an ability to get people into orbit. The second phase, lasting until the manned Shenzhou 11 mission of October 2016, verified more advanced techniques, such as docking and spacewalking.

The 3.5-year flight hiatus followed. And even now it is not clear when the next manned mission will occur, presumably using the new spacecraft. Shenzhou spacecraft were sent to orbit four times before their first manned flight.

The launch on May 5 followed rigorous quality checks prompted by failures of a Long March 7A in March and a Long March 3B in April. The Long March 7A flight was the first for that version, which has a third stage. The flop also raised questions about the reliability of the original, two-stage version, simply called the Long March 7; this is the launcher for the manned space program's cargo-delivery spacecraft, the 13-metric-ton Tianzhou, which is also a tanker.

Still, the Long March 7 will not need to perform a resupply mission to the space station until the facility is in orbit, so engineers have years to sort out what is wrong. A Long March 3B, of long-established design, failed in April because of a fault in its third stage—which happens to be the third-stage module used by the Long March 7A.

The Mars mission will proceed in the second half of the year, says Xinhua. This must mean it will happen between July 17 and Aug. 5—a launch window that is determined by the relative positions of the Earth and Mars. NASA's Perseverance rover and the United Arab Emirates' Hope orbiter are also due to go to Mars then.

Space scientist Ouyang Ziyuan, considered the founder of the Chinese lunar exploration program, said in July 2019 that China's Mars mission would be launched in July 2020. The probe is to comprise an orbiter, lander and rover. A second Mars mission is planned for around 2028, with the aim of bringing a sample from the surface back to Earth.

The Moon mission will be Chang'e 5, intended to bring back samples. This mission is running three years later than planned three years ago. Before the Long March 5 flight failure then, Chang'e 5 was scheduled for late 2017; three new targets followed, the latest being some time in 2020. Now it is "before the end" of 2020.

The lunar mission has evidently not enjoyed the highest priority as officials have reshuffled missions for the Long March 5.

The 2020 Mars and Moon missions will use the launcher in its two-stage version.

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Thierry Dubois Lyon and **Sean Broderick** Washington

As passenger demand evaporated in just a few weeks, airlines scrambled to park or store most of their aircraft. Not only were operators forced to move fast, without the long-term planning usually associated with such actions, but they also must now cope with the volatility of the situation. One key: having aircraft ready to return into service at short notice in case an opportunity emerges.

Yet given the differences between the costs of short-term parking and longer-term storage, airlines must perform a careful balancing act.

The uncertainty about how quickly passenger demand will return means airlines are hedging bets with their fleet strategies, blurring the lines between what is in service and what is parked. A snapshot of recent activity from the Aviation Week Network Fleet Discovery database shows just 36% of the global fleet of Western-built narrowbodies, widebodies and regional jets was in service as of April 21 (see pie chart, page 22). But another 9.5%, or 2,670 aircraft, were in a parked/reserve status, defined as having flown either one or two of the previous seven days. That figure is only slightly lower than the total number of stored aircraft—generally defined as having been out of service for at least 90 days.

In Airbus' definition, "parking" usually means the aircraft is taken out of operation for up to six months. "Storage" generally applies when a rapid or unexpected return to service is unlikely; the planned out-of-service period in such cases is up to two years.

These two definitions are the basis for more nuanced situations. And depending on the carrier and the national authority, the maximum duration of "parking" may vary.

Nonetheless, parking an aircraft for any length of time is a significant commitment. To park an Embraer regional jet for three months, for example, Portugal's TAP Express plans 25 work-hours for initial storage, four work-hours for a seven-day periodic check, 12 work-hours for a 30-day periodic check and 30 work-hours for a return to service. For this last phase, 15 work-hours should be added for those scheduled calendar items that will come due during the parking period.

These time frames vary with aircraft size. Preparing a Boeing 777-300ER for a 30-day stint on the ground takes about 350 work-hours, says Paul Longhurst, Haeco Group's general manager of light maintenance. Besides being useless to an operation—no charter flights, pilot-proficiency checks or cargo-only sojourns—a parked aircraft cannot simply be powered on, taxied out and put back in service. Longhurst estimates

Airlines are using any available airport space they can find until they determine when aircraft will be needed again.

Mitsubishi SpaceJet M100 suspension **p. 30**

PRIORITY

that getting a 777-300ER back out of 30-day parking will take 600-650 work-hours.

The ramifications of sidelining aircraft has airlines exploring all options. Cathay Pacific started out by parking its aircraft for 30 days at a time. "That was the easiest one to start with, giving them both flexibility and breathing space to see what is around the corner," Longhurst says. The airline, acknowledging that it will not need many of its 130-strong fleet of widebody passenger jets for some time, is now looking at longer-term parking. Since most maintenance manuals do not cover short-term storage, airlines and OEMs are crafting strategies as they go.

"Some of the parking procedures have been altered with temporary revisions to make them more workable, and I think that will go on," Longhurst says. "We're looking at the 60-day parking procedures now, and we're asking the OEM what we must do and what we can mitigate. It's an ongoing process, and we're not through with it yet."

In the context of the COVID-19 crisis, Airbus is providing technical justifications and solutions to reduce the maintenance burden. These include extending calendar intervals for scheduled maintenance tasks and halving the frequency of periodic ground checks to every two weeks.

American Airlines has taken a similar approach to Cathay, bolstered by having multiple locations where it can conveniently service aircraft. The carrier has aircraft parked in Tulsa, Oklahoma, and Pittsburgh, where it has heavy maintenance operations, as well as in Mobile, Alabama, and Roswell, New Mexico, where it has long-term relationships with third-party providers. The approach gives American flexibility to keep aircraft on standby or prepare them for longer storage stints with little change in workforce needs.

"Parking at remote locations makes traditional preservation tougher" because of a lack of on-site staff, says Erik Olund, American's managing director of base maintenance. "We strategically use locations where we already have a footprint."

Aircraft sitting on the ground face multiple threats. Proper protection is key, so both parking and storage must be approached like a planned maintenance check.

Weather can cause problems. "If rain, snow, salty air, dust or sand enter air ducts, they can degrade or contaminate the mechanical parts they come into contact with," Christian Niederst, an Airbus field service representative, and Christoph Maier, a customer manager at Airbus' customer services engineering department, wrote recently in a company technical publication. "High humidity, lightning strikes and volcanic ash also require special consideration."

"We use anticorrosive fluid in the engines' lubrication systems and some components that are not covered with paint, such as landing gear parts," says Gery Mortreux, executive vice president at Air France Industries.

To prevent a tire structure from losing its shape, wheels must be rotated regularly. Air France Industries technicians rotate them by one-third of a round at fixed intervals. They use jacks to lift up the landing gear and take the wheel off the ground.

Apertures and openings—such as pitot tubes—have to be wrapped up and made watertight, says Ahmed Safa, Emirates' divisional senior vice president of engineering.

Covering and sealing should be thorough to prevent unwelcome "passengers" from finding a way into the cabin. "It only takes weeks for rodents, birds and insects to cause serious damage to a previously pristine cabin with seats, carpets and wiring all vulnerable, particularly if a nest

MICHAEL CIAGLO/GETTYIMAGES

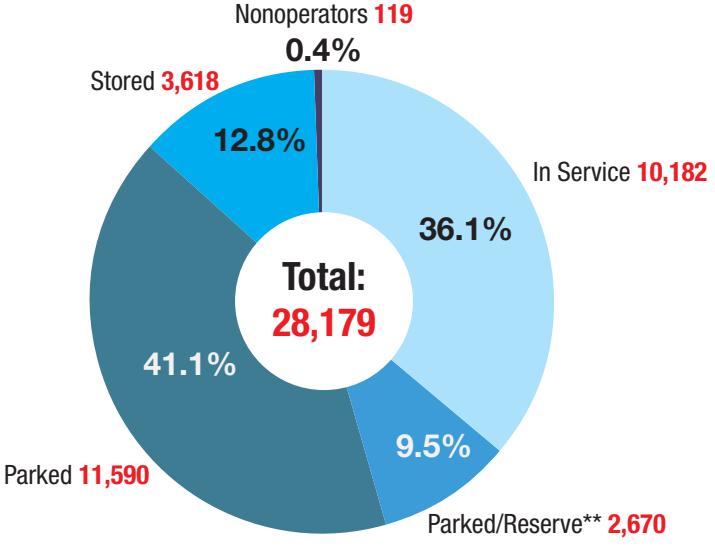
is established," Niederst and Maier emphasize. Emirates also protects the elements of the cabin interior—monuments, seats and inflight entertainment equipment.

The threats can vary depending on the region. Generally speaking, aircraft should be parked with the nose pointing in the direction of the prevailing winds to limit the effect of wind and gusts on the aircraft. In Japan, typhoons involving strong winds call for mooring as well as filling fuel tanks to add weight.

In the Middle East, to protect against locust swarms, extra caution is required when sealing ducts. Moving aircraft to hangars, where possible, may therefore be a good idea.

Airbus says that in Asia and Northern Europe particularly, humidity can be difficult to handle. In heavy rain, there is a risk of cabin flooding without careful sealing. Yet evaporation needs to be enabled, to prevent mold.

Air Transport Jet Fleet Status*



*As of April 30, 2020.
**Aircraft operated 1-2 of previous 7 days.

Includes Western-built narrowbodies, widebodies, regional jets in scheduled, nonscheduled operations.

Source: Aviation Week Network Fleet Discovery

Coronavirus Pandemic Prompts U.S. Big Four To Shuffle Their Fleets

- THE LARGEST U.S. CARRIERS ARE PERMANENTLY PARKING AT LEAST 300 AIRCRAFT
- AMERICAN'S CHANGES REMOVE FIVE ENTIRE SUBLETS

Ben Goldstein and **Sean Broderick** Washington

American will speed up the retirement of its Boeing 757 fleet as part of its response to the novel coronavirus and related decline in passenger demand.

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With the global recovery in air traffic demand expected to last 2-5 years, airlines that survive will emerge from the novel coronavirus pandemic as smaller businesses operating more efficient fleets. Moreover, several of the largest U.S. airlines have taken significant steps in preparation for the world after the COVID-19 crisis.

U.S. carriers had 3,317 aircraft parked as of the week ending April 28, totaling roughly half of the U.S. commercial fleet, according to data from Airlines for America. The Aviation Week Network's Fleet Discovery database info shows that many of the aircraft listed as in service are flying no more than two days per week as airlines prioritize flexibility until they have reliable demand trend data.

While many parked aircraft will return, a significant percentage—particularly older airframes—are not likely to see scheduled passenger service again. An early wave of retirements, led by three of the four largest U.S. carriers, has been confirmed. And more will come, necessitated by very sluggish demand growth (see graph, page 24) and continued new deliveries, albeit at a reduced pace. Negotiations with OEMs to postpone deliveries are ongoing, but U.S. carriers have not revealed

Anticipation is essential. Sufficient fuel should remain in the tanks to run the engines and operate the auxiliary power unit (APU). Air France, for instance, maintains a 10-20% level.

"We use Airbus' and Boeing's recommendations to create our procedures, which we submit to the French civil aviation authority, DGAC. The recommendations from the two airframers are close," Mortreux says.

When choosing between parking and storage, some important criteria should be considered. Parking involves less effort initially and at the end of the period. But workforce needs and costs will be significantly higher on the periodic checks, such as engine runs, a TAP Air Portugal spokesperson says. Conversely, return to service after storage involves much more work than after parking, he adds.

Another criterion is the prospect of removing parts. In stored aircraft, it is common for major components to be removed. Engines, APUs, flaps and computers can be transferred to in-service aircraft.

Parked aircraft should be flight-ready. Batteries can be removed to preserve them, because they can be quickly reinstalled.

The number of work-hours involved in either parking or storage operations depends on whether the aircraft is in a hangar, with all equipment handy, or on the ramp. And social distancing makes transportation even more complicated. "We move our technicians in vans but never more than two at a time," a Volotea spokesman says. Air France Industries employees now work in shifts, as opposed to their previous simultaneous presence on-site.

For TAP Air Portugal, initial parking or storage can take 20-200 work-hours depending on working conditions, the spokesperson says. As of late April, the carrier had 80% of its 86-aircraft fleet in storage or parking. The remaining aircraft were not all flying, because some were undergoing heavy maintenance checks.

Some operators have elected not to prepare any aircraft for a long period of storage. "We are looking to be flying again at some point in the summer," the Volotea spokesman says. Air France, too, has chosen to park its aircraft for 1-3 months, which means they can return to service with minimal anticipation. Of Air France's 224 aircraft, 180 are on the ground.

There may be a silver lining to the current predicament. Thanks to the unprecedented number of aircraft currently parked or stored, airframers will receive new feedback on their storage instructions. For instance, operators found that the aluminum blinds being used to prevent fabric fading inside the cabin were causing paint discoloration around the windows, wrote Airbus' Maier and Niederst. A new technique was developed to address that.

any major order cancellations despite the massive first-quarter losses suffered across the industry because of the coronavirus crisis.

Southwest Airlines went a step further, reiterating its preference for the still-grounded Boeing 737 MAX, even if lightly used 737NGs become available. "Our preference is to get new airplanes from Boeing," Southwest Chief Financial Officer (CFO) Tammy Romo told analysts on a recent earnings call.

But they will come in slowly—so slowly, in fact, that the airline probably will not take a MAX fresh from the factory until well into 2021. The Dallas-based carrier has reached a deal with Boeing according to which it will take "no more than" 48 MAX deliveries between now and 2022. The change removes 59 planned Boeing deliveries from the next two calendar years. Another 16 MAXs ordered from lessors remain in the carrier's fleet plan—at least for now.

Romo said the carrier's prepandemic plan had it taking delivery of 27 MAXs in 2020, assuming the grounded model gained regulatory approval to return to service. That number will now be less than 27 no matter when the MAX is cleared to fly again and deliveries resume.

The figure is notable because Southwest has 27 MAXs among the 450 in Boeing's backlog of built but undelivered MAX aircraft. Southwest's revised delivery schedule means the airline will not need an aircraft from Boeing's 737 production line until sometime next year. Manufacturing is just restarting after a three-month pause related to the MAX's March 2019 grounding and related delivery halt.

Even with fuel prices sitting comfortably at multiyear lows, Romo said the 14% fuel-cost savings offered by the MAX will amount to "very meaningful and significant" operating cost reductions in the future. "[We want] to do our fleet planning in a way that delivers good economics on an operating basis and also delivers low ownership costs for years and years to come," Romo said.

Southwest had been holding back on retirements prior to the pandemic, in part due to the continued delay in MAX deliveries. Now management intends to speed up retirements of older 737s. The plan hinges on the airline sticking to its commitment to make the MAX a key subfleet going forward. Southwest has taken delivery of 34 MAXs and has 265 on order. The carrier ended March with 742 aircraft in its fleet, including the 34 grounded MAXs and 350 aircraft sidelined to cut capacity as a result of the pandemic. Even factoring in about 100 737-700s that are prime candidates for permanent removal, Southwest has significant flexibility.

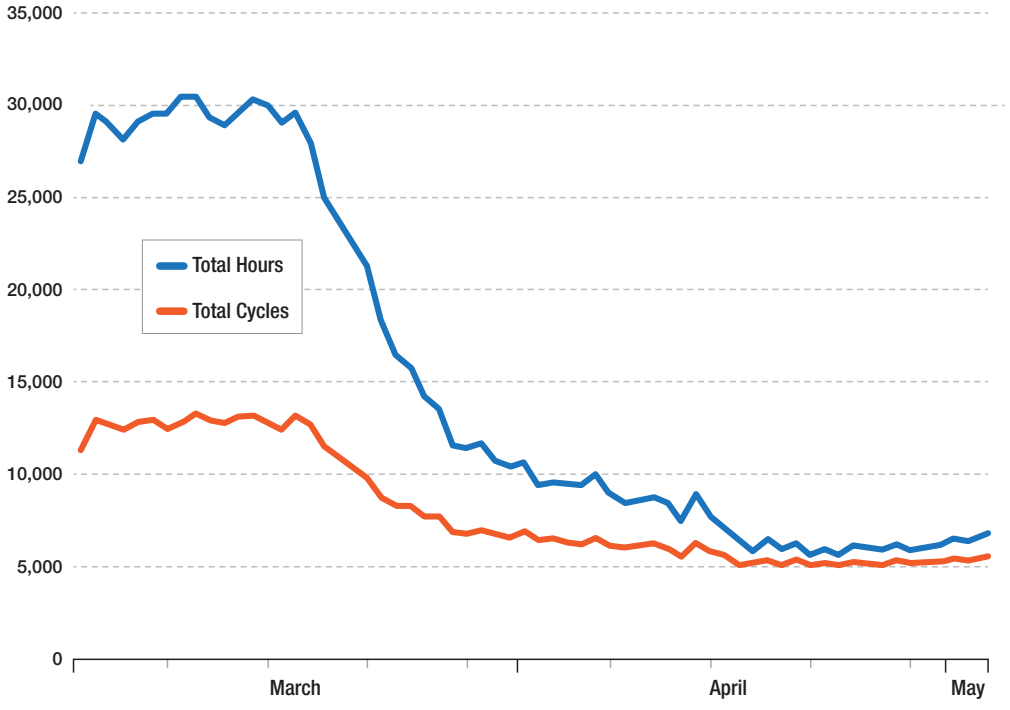
"The industry is going to rebound, and we're ultimately going to need airplanes to fly in the fleet," Southwest Chief Operating Officer Michael Van de Ven said. "We do want to bring the MAX into the fleet, and if we need to early-retire or manage the fleet by taking older airplanes out, I think that's the best position for us to be in."

American Airlines, which ended the first quarter with an industry high of 1,484 aircraft in its combined mainline and regional fleets, has accelerated removal of its least efficient assets. The company took the unusual step of announcing the immediate retirement of five separate aircraft types totaling more than 120 aircraft, the majority of which have been in service for 20 years or more and were earmarked to be parked in the coming years.

Removing the Airbus A330-300, Boeing 757 and 767, Bombardier CRJ-200 and Embraer 190 fleets amounts to a substantial simplification of the carrier's cost structure, lower maintenance expenses and greatly reduced operating complexity. The airline in early March said 17 767-300ERs and

U.S. Top Four Airlines Mainline Fleet Activity*

March 1-May 3



*Includes total hours and cycles for mainline aircraft flown by American Airlines, Delta Air Lines, Southwest Airlines and United Airlines

Source: Daniel Williams/Aviation Week Network Fleet Discovery

34 757-200s would be parked by mid-2021 due to lower demand. The A330s and regional jets were added to the list, and the entire group was moved to immediate retirement status. They may not be the last.

American is eyeing 42 older 737-800s, its 15 A330-200s and an unspecified number of older A320ceos and other regional jets as additional retirement candidates. The Fort Worth-based carrier still plans to take delivery of $1.7 billion worth of new aircraft during the year, with the bulk arriving in the back half due to the extended MAX grounding.

"These savings include reduced aircraft sparing, reduced parts inventories and crew scheduling efficiencies, all of which will have a significant effect on our cost structure going forward," American CFO Derek Kerr said of the retirements. "Even with these changes, we retain the flexibility to pursue efficient growth through increased utilization or further reduce our fleet to match demand across our system and hubs."

Delta Air Lines, which reported 677 active aircraft in its mainline fleet as of March 31—a figure that excludes about 200 that are parked—is also retiring its most inefficient jetliners ahead of schedule. The company has announced that its MD-88 and MD-90 workhorses will end their decades-long careers in June. The Atlanta-based carrier has indicated its 757s and 767s are next on the chopping block, along with more smaller regional jets. Deliveries were put on hold this year as the company assesses the path of recovery and its future fleet needs.

"Anything that was scheduled to retire over the next five years has an accelerated path toward retirement—just to be very straightforward," Delta CEO Ed Bastian said. "We'll be taking the time to accelerate into the future and fast-forwarding many of these decisions with simplification and streamlining of our entire business model at the core of the new normal for Delta."

United Airlines will continue receiving new deliveries for this year and next at a slowed pace, taking delivery of 40 MAXs through 2021. This figure is less than half the number initially expected. If all 40 of those jets are delivered, United CFO Gerald Laderman said the company has an additional 131 MAX aircraft scheduled for delivery in 2022 and beyond. "We are discussing the timing of these deliveries with Boeing," he said. "However, one thing is certain: I do not anticipate taking any of those aircraft unless and until we need them."

The Chicago-based carrier has not yet announced any aircraft retirements, but a review of Aviation Week's fleet data shows its 1,488-strong mainline and regional fleet includes 103 aircraft in long-term storage. Excluding the 14 grounded MAXs, that figure includes a host of aging 737NGs, 757s and 767s as well as some older A320ceos.

"We have a lot of parked aircraft," Laderman said. "Those are, in our view right now, temporarily parked. And until we see what's needed to run the operation, we're not going to make any firm decisions."

Restart—But How?

SKYNEXT/GETTYIMAGES

> MYRIAD RULES THREATEN AIR TRAVEL REBOUND

> ICAO TRIES TO HARMONIZE AIRLINE GUIDELINES

Helen Massy-Beresford Paris, **Sean Broderick, Bill Carey** and **Ben Goldstein** Washington, **Adrian Schofield** Auckland and **Jens Flottau** Frankfurt

As more countries consider slowly lifting travel restrictions over the coming weeks, they and the airline industry face the daunting task of finding ways to reopen air travel that ensure health protection while keeping any new rules operationally manageable. Airline lobby groups are pushing for harmonized standards, but the debate has only just begun in large markets such as the U.S. and the EU about necessary preconditions.

The International Civil Aviation Organization (ICAO)—which has no legal rulemaking power and whose deadlines typically span years, not weeks—is emerging as aviation's best hope for creating feasible, consistent standards to get aircraft flying again. A task force, working under the Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation, set up in 2006 following the SARS epidemic, is developing the Public Health Corridors (PHC) concept.

The group's starting point is evaluating piles of guidance material issued by states, agencies, operators, aircraft manufacturers and others. Its goal: Issue guidance on creating and maintaining "clean" modules that, linked together, span the commercial aviation travel process for passengers and employees.

The initial guidance document, covering cargo flight crews, was developed over the past several weeks and released May 11. It covers recommended procedures at each stage of a trip, from preflight arrivals at the airport through inflight procedures and layovers.

The ICAO-led Aviation Recovery Task Force aims to have baseline draft guidance for each commercial aviation segment by June, says Ansa Jordaan, chief of the ICAO Air Navigation Bureau's Aviation Medicine Section. Representatives include global aviation organizations, regulatory bodies and state health agencies. Each of the five modules—crew, aircraft, airport facilities, passengers and cargo—has a subset of task force members with subject expertise.

"We need to be aligned with what the public experts are saying. We also have a unique operating environment," Jordaan says. "At the moment, it is just haywire everywhere. We need to have some sort of order."

The range of issues is immense, stretching from how passengers should be screened to what cleaning agents are suitable for wiping down cabins. A survey in April of ICAO member states generated responses from 87 countries that underscored the global disparity and highlighted unintended consequences of lockdown orders.

The ICAO survey showed that pilots from one-third of the responding airlines reported not having access to food or adequate rest facilities at a destination because of restrictions placed by local authorities. Also reported: several cases where flight crews, told to remain onboard their aircraft to conduct quick turnarounds

Airlines are hoping empty check-in desks will be history very soon.

while avoiding quarantines, were not permitted onto the ramp for preflight walk-arounds. "That has serious safety considerations," Jordaan says.

The PHC concept will develop guidance and possible "certifications" for each module, Jordaan says, while ensuring all protocols align with aviation's safety management approach to operations. For instance, an aircraft that has been disinfected could have a placard placed in the cabin or flight deck. Similar approvals such as "immunity passports" will be much harder for passengers to obtain, at least until screening improves.

"Given the lack of a vaccine and definitive treatment, and the limitations on testing and resources, the risk of contracting COVID-19 during air travel cannot be completely eliminated, but the risk to crew and passengers can be mitigated significantly by these measures," the initial guidance document says.

Alexandre de Juniac, secretary general and CEO of the International Air Transport Association (IATA) says: "Impacts of the crisis on long-haul travel will be much more severe and of a longer duration than what is expected in domestic markets. This makes globally agreed and implemented biosecurity standards for the travel process all the more critical. We have a small window to avoid the consequences of uncoordinated uni-

lateral measures that marked the post-9/11 period."

In addition to its concerns over a lack of coordination, IATA is mainly opposed to two measures currently discussed or implemented in some countries: quarantine for incoming passengers and requiring empty middle seats. "Quarantine is useless if we do not implement a robust [protection] system," de Juniac says. "International travel cannot restart under such conditions."

Social distancing on board would "challenge the viability of airlines," IATA Chief Economist Brian Pearce asserts. On narrowbodies such measures would allow for a maximum load factor of 66% and, when widebodies and regional jets are taken into account, only 62% of seats could be filled. Precrisis breakeven load factors were 75% for North America, 81% for the Asia-Pacific region and 79% for Europe. To cover the cost of leaving seats empty, fares would have to rise by up to 54%, Pearce says.

IATA instead proposes measures such as health declarations ahead of departure, temperature checks, mandatory masks and redesigned catering processes on board. Asymptomatic passengers infected with the coronavirus would not be caught by the temperature controls or through health declarations, but IATA still contends that wearing face masks in combination with the onboard air ventilation systems and virus filters reduces the risk of infection greatly.

Regional approaches differ considerably. Absent binding guidance from the FAA, U.S. airlines are coming up with their own rules and processes for the time being. In Europe, some member states are pressing ahead while detailed new rules on an EU level are still being worked on.

U.S. airlines want the Transportation Security Administration (TSA) to begin checking the temperatures of all passengers and customer-facing employees "as long as necessary" throughout the COVID-19 pandemic. While Denver-based Frontier Airlines will begin screening temperatures at the gate on its own, Airlines for America (A4A) warns such an approach could risk creating a confusing patchwork of rules across the industry.

A4A's member carriers have voluntarily taken the step of requiring all passengers and crew to wear facial coverings throughout each stage of their journeys, in the absence of such a mandate from the federal government. But while the group accepts letting airlines oversee mask-wearing, it remains firm that medical screenings are the responsibility of the government, not airlines.

In an effort to accommodate social-distancing concerns, some airlines are setting internal capacity limits in the cabin. Delta Air Lines is capping seating at 50% in first class and 60% in the main cabin through June 30, encompassing virtually all middle seats and some window and aisle seats in cabins configured with 1-2, 2-2 and 2-3 seating. American Airlines is also limiting the number of passengers on each aircraft, blocking off 50% of main-cabin middle seats and seats near flight attendant jump seats.

Executives at low-cost carriers such as Frontier, however, have asserted that capping capacity in the cabin is not viable for their low-fare business models. They estimate that sealing off one-third of seats would force the company to raise fares by up to 50%.

Despite large capacity cuts across the industry, A4A's members are currently averaging just 17 passengers per domestic flight and 29 per international flight. Net bookings are now essentially nonexistent, and carriers are burning through nearly $10 billion each month. The outflows come despite the grounding of 3,188 aircraft as of May 12, totaling 52% of the combined commercial fleet.

The FAA has eased some regulatory requirements affecting airports, carriers and pilots to relieve the economic and health impact of the pandemic. Responding to a request by A4A on behalf of its member airlines, the agency on April 8 granted an exemption that allows flight attendants to relocate from the jump seats they would normally occupy on an aircraft to observe social-distancing requirements.

Effective through June 30, the exemption also excuses flight attendants from demonstrating the use of life vests and oxygen masks to passengers before each flight.

As of mid-May, however, the FAA had resisted calls to mandate—rather than just recommend—that airlines comply with federal public health guidelines aimed at protecting flight crews and passengers from exposure to the coronavirus.

The FAA insists it does not hold the statutory authority to issue health-related mandates. But a 2014 memorandum of understanding with the Occupational Safety and Health Administration (OSHA) suggests otherwise. The agreement gave OSHA jurisdiction over three specific issues in cabins: hazard communication, noise, and blood-borne pathogen exposure. OSHA's aircraft-cabin rules could not cover any other issues, nor would they apply to pilots.

"FAA will continue to exercise its statutory authority over all other working conditions of aircraft cabin crewmembers while they are on aircraft in operation, and to fully occupy and exhaust the field of flight deck crew occupational safety and health while they are on aircraft in operation," the agreement says.

Updated guidance the agency issued in a Safety Alerts for Operators dated May 11 states that the FAA and the Centers for Disease Control and Prevention (CDC) "recommend and expect" that airlines apply their company-developed COVID-19 preparedness plans in conjunction with the federal guidance.

Nevertheless, the Air Line Pilots Association (ALPA) in early May issued a report based on "deidentified firsthand accounts" from ALPA members at 17 airlines indicating that carriers were not uniformly following federal guidelines. The union, which represents pilots at 35 U.S. and Canadian airlines, reports that 300 of its members have tested positive for COVID-19.

"In order to restore public confidence, the government needs to do its job," says ALPA National Safety Coordinator Bob Fox, a United Airlines Airbus A320 captain. "It needs to mandate that all carriers comply with the CDC guidelines. That's the job of the FAA, but they're not doing their job. And airline lobbyists in Washington are not being honest with Congress or the flying public."

In addition to demanding that the FAA enforce CDC guidelines, ALPA has called on Congress to require that all airline crews and passengers wear face masks, ensure carriers provide pilots with personal protective equipment on flight decks, and clarify that airline pilots, as essential workers, have access to priority COVID-19 testing.

The TSA, responsible for manning airport security lanes, announced on May 7 that its screeners are required to wear facial protection.

The European Centre for Disease

Prevention and Control (ECDC) and the European Union Aviation Safety Agency (EASA) are set to put forward operational guidelines for airlines in the coming weeks.

The two agencies are due to map out a baseline aviation health safety protocol, proposed for application across the EU, which the European Commission (EC) says would cover procedures to limit contamination risks throughout the travel process: avoiding concentration of passengers, limiting interaction on board, exploring the most appropriate allocation of seats based on technical constraints, and prioritizing electronic documents and means of payment.

The EASA/ECDC guidelines should include strengthening ventilation, hospital-grade air filtering and vertical airflow, says the EC. The protocol will set out how to reduce movement in the cabin, such as through limiting cabin baggage and interaction with crew.

Adequately managing passenger flow will also form a part of the protocol, covering aspects such as: early arrival at the airport; prioritizing electronic or self-check-in; ensuring distancing and minimizing contact at baggage drop-off, security and border control points, at boarding and during baggage collection; and providing passengers with information on airport processes in advance.

The EC says the EASA/ECDC protocol would specify additional mitigation measures "in close coordination with national competent authorities, with the aim of deploying measures for the operation of flights coherently across the EU."

The EU transport guidelines were part of a broader framework aimed at getting tourism, a sector that accounts for almost 10% of EU GDP, moving again—and allowing EU citizens to be able to travel safely for work, family reasons or vacations.

But individual member states are at different stages of the pandemic, some of them tentatively easing out of strict lockdown measures into the next stage of controlling the virus, and differing regulations will complicate the situation for airlines attempting to offer progressively more flights.

Spain is imposing a 14-day quarantine for international travelers starting May 15. In the UK, similar plans to impose a 14-day quarantine on passengers arriving from abroad have already drawn criticism from the aviation sector, with Willie Walsh, CEO of British Airways and Iberia parent International Airlines Group, saying the move would force it to rethink its planned post-COVID-19 ramp-up in flight capacity.

"If a generalized lifting of restrictions is not justified by the health situation, the commission proposes a phased and coordinated approach that starts by lifting restrictions between areas or member states with sufficiently similar epidemiological situations," says the EC. The approach must also be flexible, including the possibility to reintroduce certain measures if the epidemiological situation requires."

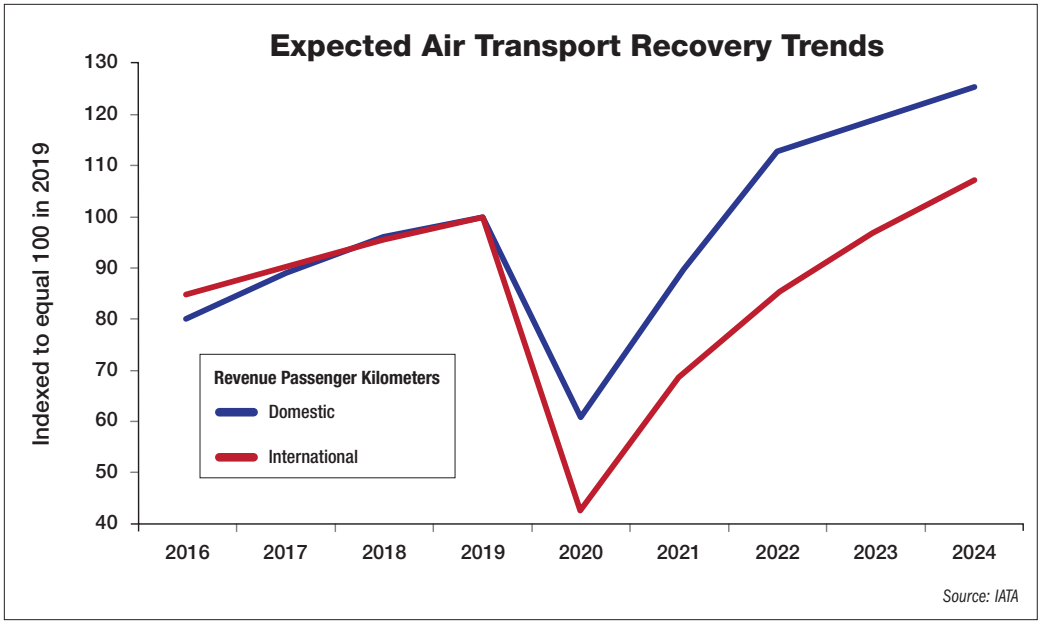
While airlines await the more detailed guidelines, they are implementing their own health measures. Air France began progressively implementing temperature checks, using a contactless infrared thermometer, on departures for all flights as of May 11. Passengers are also required to wear face masks on all the carrier's flights, tying in with a French requirement for masks on public transport. Lufthansa made face masks mandatory but is not doing temperature checks.

Many Asia-Pacific airlines are leaving seats empty to maintain passenger distance. Other airlines have gone further by requiring all passengers to wear masks. Cathay Pacific says passengers must wear masks when separation of 2 m (7 ft.) cannot be maintained, both preboarding and during flight.

The governments of Australia and New Zealand have held high-level discussions regarding establishment of a "COVID-safe travel zone" between the countries with no quarantine requirements. Such an arrangement could be introduced as early as July and would represent the first restoration of regular international service for both countries. Qantas CEO Alan Joyce says this could be the model for later restoring flights to other countries on a case-by-case basis.

Five Pacific Rim nations—Australia, Canada, New Zealand, Singapore and South Korea—signed a declaration committing to developing procedures to allow essential travel among them. They also agreed to expedite the flow of goods and facilitate cross-border supply chains.

India's government issued a draft discussion paper to airlines and airports regarding what operating procedures will be put in place when flights resume. Suggestions from industry have been received, but the final version of the operating procedures has not yet been published, says the civil aviation ministry.



CARES Act Weaknesses Cause a Flurry of Disputes

> SERVICE MANDATE FORCES CARRIERS TO BURN CASH AT AN UNSUSTAINABLE RATE

> MANAGEMENT AND LABOR QUARREL OVER PAY RATES

Ben Goldstein Washington

Given the massive scope of the CARES Act stimulus law—including up to $78 billion for U.S. commercial aviation, depending on how you slice it—it is hardly surprising that the federal agencies tasked with its implementation have had mixed results. As more and more weaknesses in the Coronavirus Aid, Relief and Economic Security (CARES) Act emerge, fast and fair solutions are needed to address the myriad problems created in its wake.

Chief among them is the law's rigid service mandate, which requires airlines receiving aid to keep flying to all domestic markets in their prepandemic schedules. Not surprisingly, this rule is forcing carriers to waste badly needed cash flying near-empty aircraft to destinations with little or no demand.

The purpose of the mandate was to ensure all communities maintain adequate connectivity through the depths of the COVID-19 pandemic. But that goal could have been achieved without imposing a stiff economic burden when airline revenue has virtually collapsed.

"Make no mistake, as the duration of this pandemic lingers, the reasonability and practicality of this requirement significantly diminishes," Airlines for America (A4A) President and CEO Nicholas Calio told lawmakers at a May 9 hearing of the Senate Commerce, Science and Transportation Committee.

"Carriers and communities alike are going to have to come together and acknowledge the footprint and frequency of service in 2019 cannot convey to the 2020 COVID-19 pandemic reality," he added.

While problematic for all airlines, the service mandate has had the most severe impact on the country's smallest carriers, many of which have appealed repeatedly to the Transportation Department for relief.

Their reasoning is straightforward: Although legacy carriers with high-frequency hub-and-spoke networks can afford to maintain connectivity, ultra-low-cost carriers and leisure airlines with lower-frequency, point-to-point networks have to retain a substantially greater proportion of their schedules to do so.

The Transportation Department has provided some wiggle room for smaller airlines but has largely kept to the letter of the law, only offering substantial flexibility in situations where small carriers look to halt flying to large hub cities. But still, airlines struggling to hold on to cash say more needs to be done.

In the meantime, carriers such as Spirit Airlines and Alaska Airlines are getting creative to meet their flying commitments, operating nearly empty aircraft on unusual triangle routes and multistop tag routes to ensure they touch every point once. Others such as Delta Air Lines and JetBlue Airways are consolidating operations at metro regions across the country, when permitted to do so.

But is there a better way? The Transportation Department has repeatedly dismissed an industry-backed proposal that would allow airlines to meet the requirement through temporary codesharing arrangements. For example, United Airlines could continue flying to T.F. Green Airport in Providence, Rhode Island, with American Airlines and Delta halting their respective operations and transferring customers onto United's flights. This would preserve connectivity without forcing airlines to operate unprofitable flights.

Carriers want relief from a federal requirement to maintain service to all domestic markets.

PAYCHECK PROBLEMS

For airline workers and the unions that represent them, the most essential element of the CARES Act is the payroll-support program, which provides $25 billion in funds for airline employee pay and benefits for the six-month period ending Sept. 30. While the law bars carriers from involuntarily furloughing workers or reducing pay rates through that period, some airlines may have discovered a workaround.

While keeping to the letter of the law, a trio of U.S. carriers have opted to cull schedules instead of pay rates, leading airline unions and members of Congress to cry foul.

The latest flash point over the employment terms erupted on May 5, when three unions representing employees at United Airlines sued the company in federal court over a plan to force thousands of frontline workers from full-time to part-time status, translating to an across-the-board 25% pay cut. As union members flooded congressional offices with complaints, lawmakers began to take notice.

"It was not the intention of Congress that recipients of this taxpayer money would then turn around and disguise pay reductions by cutting hours," Sen. Josh Hawley (R-Mo.) wrote United CEO Oscar Munoz in a May 1 letter.

As the backlash grew, United took steps to defuse tensions, partially walking back the policy, announced just days earlier, on May 6. In a letter to employees, the company said it was scrapping the hours-reduction plan,

opting instead for a voluntary leave of absence program that will allow participants to retain their full-time status and associated benefits.

The company did leave open the possibility that schedule reductions will be resumed, however, especially in the event that participation in the voluntary leave program turns out to be lower than desired.

"Without a high level of participation, we will have no choice but to reconsider a mandatory reduction to 30 hr. for our full-time employees," United President Scott Kirby told employees in a May 6 memo.

Declaring victory after United's decision to back down, the International Association of Machinists and Aerospace Workers (IAM) is looking to repeat the feat at Delta and JetBlue, both of which have instituted similar policies for their workers. IAM officials allege Delta is also forcing workers to take fewer paid hours per week, while JetBlue employees have to take 24 days of unpaid leave between now and Sept. 30.

The two airlines do not see it that way. A Delta spokesperson notes that pay rates have not come down and said the company wants employees to spend more time away from work to care for themselves and families during the pandemic. A JetBlue spokesman, meanwhile, points out that the CARES Act covers only 76% of carriers' payroll costs, stating that "with little new cash revenue coming in to JetBlue, we are taking actions that will help us preserve jobs when the payroll support funding ends."

With conflicts raging over the issue at three airlines, the Treasury Department cannot issue guidelines fast enough to clear up the confusion over what kind of payroll-reduction activities are allowed under the law. As more and more members of Congress are taking notice, such a decision may be coming soon.

AIRPORT ALLOCATIONS

Airports lauded Congress for including $10 billion in emergency grant payments in the CARES Act, money intended to assist with operational expenses and debt payments while ordinary revenue streams remain badly depressed by the coronavirus crisis. Tasked with allocating the funds, the FAA has come under fire for an administrative process that some airports have criticized as arbitrary and unfair.

The controversy concerns the agency's handling of $1.85 billion that was allocated based on an airport's ratio of unrestricted cash versus debt service. The upshot is that many smaller airports with some cash and little to no debt achieved excessively high ratios and huge payouts under the formula, while their midsize and larger counterparts with more debt on their balance sheets received only modest payments.

An example of the skewed effects caused by the ratio's application is Merrill Field Airport in Anchorage, Alaska. The small general aviation airport, with 10,000 annual enplanements, reported just $200 in unrestricted cash and nothing in the way of debt service, smashing through the cap imposed by the FAA and netting an automatic $17.5 million—enough to cover the next 9.4 years of operating expenses.

Contrast that with Ted Stevens Anchorage International Airport, Alaska's largest with 2.6 million enplanements in 2018. With $70,000 in unrestricted cash and $390,000 in debt, the airport scored only $1.5 million obtained under the ratio, a far cry from Merrill Field's allocation despite having more than 250 times as many annual enplanements.

JEFF SWENSEN/GETTY IMAGES

It is not just the country's smallest airports that won big from the cash/debt formula. In numerous regions, local competitors of roughly equivalent size and in close proximity received wildly differing award sizes. This phenomenon is illustrated by two more Alaska airports, Fairbanks International and Juneau International, the state's second- and third-largest airports by annual enplanements, respectively. Despite being roughly similar in size, Fairbanks received nothing through the formula, while Juneau realized the $17.5 million maximum award. Such local disparities, replicated in numerous regions across the country, risk throwing the sector's competitive balance into disarray.

For its part, the FAA insists that the funds were allocated as intended and in accordance with the CARES Act, arguing that the number of enplaned passengers is just one of several factors used to assess airports' financial needs under the law.

"These funds are not standard [Airport Improvement Program] grants," an FAA spokesperson explained. "The CARES Act requires funds be allocated based on a formula that reflects debt service, unrestricted airport reserves and enplanements. Some airports will receive more money than others, despite having fewer enplanements."

The agency has partially walked back some of the most exorbitant awards, informing airports all grant money must be used within four years and only for essential operating expenses. Still, many airport executives believe even four years of paid expenses for some airports is too much, warning that airports with lower operating costs have numerous levers to pull to gain an unfair advantage in the marketplace for airline customers, especially when it comes to items such as waiving fees for cash-strapped carriers.

"There were 413 airports on that list, and the moment they allocated those funds, 111 got a disproportionate share and 300 airports were dealt an unfair competitive disadvantage," says Melinda Crawford, executive director of the Charlottesville Albemarle Airport Authority in Virginia. "Was the CARES Act really ever written to float an airport for four years?"

M100 Suspension Alters Regional Jet Market Dynamics Again

> MITSUBISHI SHELVES THE M100; MORE DELAYS LOOM FOR THE M90

> EMBRAER PONDERS E175-E2 FLIGHT-TEST SCHEDULE REVISION

Bradley Perrett Beijing and **Jens Flottau** Frankfurt

The M90 was launched in 2008 as the Mitsubishi Regional Jet. It is now in flight testing.

A short three years ago, the world of regional jets consisted of four established players. Bombardier and Embraer were competing in the traditional segment up to 100 seats and adding the larger C Series and E2, respectively, at the top end of the range. They were expecting to see new competition from what was then called the Mitsubishi Regional Jet (MRJ) in the not-too-distant future. And it was competition they took quite seriously, unlike with the Chinese ARJ21 which constituted a barrier for exports to China at most.

By early 2020, the sector had changed dramatically. The C Series had become the more successful Airbus A220. Embraer Commercial Aircraft was weeks from being acquired by Boeing, a move management considered vital for its long-term survival in competition against the behemoth Airbus. Bombardier had agreed to sell the CRJ business to Mitsubishi, which looked set to become a more serious player, given the new access to a large customer base, product support business guaranteeing substantial revenues for years to come and added know-how.

Since the beginning of May, everything has changed once more. Boardroom chairs must have felt as if they were on roller coasters, particularly at Embraer. Boeing backed out of the deal to acquire its commercial aircraft business, sending Embraer into shock mode and forcing it to rethink its future strategy from the bottom up, a process that is ongoing. Then, just days after management had begun to consider its options, another announcement sent shockwaves through the industry, changing the competitive landscape again. Mitsubishi Heavy Industries (MHI) decided to suspend development of the M100 version of the SpaceJet regional jet as one measure to stanch the cash bleed from the program.

MHI CEO Seiji Izumisawa announced suspension of work on the M100 during a briefing on financial results on May 11. Plans for the version will be reconsidered during the suspension, he says. Intended for the North American market, the M100 was designed to offer an optimal combination of range and seating within the weight limits that the scope clauses of major U.S. airlines impose on aircraft operated by regional affiliates.

The SpaceJet has been under development since 2008 by Mitsubishi Aircraft, which is majority-owned by MHI. The type was at first called the MRJ. The MRJ90—seating 88 in an all-economy arrangement—became the M90 in June 2019, when the former 76-seat MRJ70 was dropped and was replaced by the 84-seat M100.

Unlike the proposed M100, Embraer's 175-E2 does not comply with U.S. scope clauses, though the first-generation E175 does. A combination of factors—a more modern competitor coming to the market much later (or never), the lack of movement on scope clauses and the current COVID-19-induced commercial pressures—could lead Embraer to conclude that it is prudent to also delay introduction of the E175-E2, which is currently in flight testing.

Following cancellation of an earlier order from SkyWest Airlines, there are no orders for the type anyway. And airlines that could operate the E175-E2, particularly in Europe, have much to consider these days. Ordering new aircraft is not on that list.

Stretching out what is left of its program is something Mitsubishi is also considering, given the circumstances. In its results announcement, MHI seemed to hint at the possibility of deliberately slowing down M90 testing. As one of its responses to the COVID-19 pandemic, it listed "continuing detailed review of the SpaceJet schedule in view of the severe market conditions facing commercial aviation and test flight-related setbacks."

MHI did not detail those setbacks, but the pandemic has interrupted work at the program's flight-testing base at Moses Lake, Washington.

MITSUBISHI

Deliveries of the first SpaceJet version—the M90—will begin in fiscal 2021 or later, the company says, repeating the wording it used three months ago when announcing the latest delay to the protracted program.

Another response to the pandemic will be "setting an appropriate budget considering challenging financial headwinds for MHI Group," says MHI.

Losses from SpaceJet development drove the whole MHI industrial group into unprofitability for the fiscal year beginning April 2019, according to its annual report. MHI expects further SpaceJet losses in fiscal 2020 will offset profits from all its other operations, which range from space launch to nuclear power to rail systems.

The company expects to lose ¥110-130 billion ($1-1.2 billion) on the SpaceJet in fiscal 2020. Since the program will be earning little or no revenue, that figure should be close to the cost of development for the year. In fiscal 2019, the loss was ¥263.3 billion, but that included impairment losses of about ¥130 billion. In the year before that, the loss was ¥85.2 billion. The company has been spending on engineering, building additional prototypes and flight testing.

The interruption of flight testing at Moses Lake came just as the program's crucial sixth prototype became available. This aircraft conforms to the new, certifiable design—the result of changes that Mitsubishi Aircraft realized in 2016 were necessary. Mitsubishi Aircraft has expected this aircraft to carry most of the burden of the remaining flight testing, with two more aircraft of the same design to be used mainly for ground testing.

These and the first five prototypes are all built to the M90 standard. The type is powered by the Pratt & Whitney PW1200G engine.

In spite of the turmoil around the SpaceJet, Mitsubishi is nonetheless pressing ahead with acquisition of Bombardier's CRJ program, which will become an MHI marketing and support unit on June 1, eventually backing the SpaceJet. Some observers have questioned whether the novel coronavirus crisis could lead the company to reconsider the deal and back out of it, as Boeing has at Embraer. Furthermore, Boeing CEO David Calhoun indicated he would be open to partnering with Mitsubishi. That would obviously help with know-how and logistics but not with access to a regional customer base.

The CRJ operation will become part of a new subsidiary called MHI RJ Aviation Group (MHIRJ). Although MHI is acquiring the type certificates for the CRJ, Bombardier will keep the facility in Mirabel, Quebec, that has been making the regional jet. Bombardier will continue to build the CRJ on behalf of MHI until sometime in the second half of 2020, when the backlog will be cleared, and the type will leave production. Bombardier says it will also continue to supply components and spare parts to MHI.

Bombardier says it expects to receive net proceeds of $550 million from the sale. MHI intends in fiscal 2020 to write down the full ¥50-70 billion value of goodwill and assets acquired and liabilities assumed with the deal, "since it is difficult to estimate the cash flow in the future for the SpaceJet business at present." The write-down will happen in fiscal 2020; the figure is presumably part of the ¥110-130 billion SpaceJet loss expected for the year.

When Bombardier and MHI announced the intended transaction in June 2019, it was clear that the prize for MHI was not the CRJ, a fading product that competed with the Japanese company's own SpaceJet, but the marketing and support infrastructure behind it—something the SpaceJet program needed. Notably, the CRJ program also has long-established relationships with regional jet operators.

MHIRJ will be based at Mirabel and will perform maintenance, refurbishment, marketing and sales, MHI says. Its servicing and support activity will be provided for "the CRJ series aircraft and, eventually, for the Mitsubishi SpaceJet family of next-generation regional jets." MHIRJ service centers, support offices and parts depots will be in important aviation hubs in the U.S., Canada and Germany.

The Japanese group says the CRJ program will be operated "under" MHIRJ, implying that it will be only part of the sales and support subsidiary, presumably alongside the equivalent operation that Mitsubishi Aircraft has already set up for the SpaceJet.

Bombardier says it delivered five CRJs in the first quarter of 2020. It also expects to close the planned sale of its aerostructure businesses in Belfast, Northern Ireland, and Morocco to Spirit AeroSystems.

Embraer handed over five commercial jets in the first quarter: three E175s, one E190-E2 and one E195-E2.

EMBRAER

The Embraer 175-E2 flew for the first time in December 2019. With no firm orders in place, the flight-test schedule is under review.

Grounded Fleet Triggers Aftermarket Hard Landing

> AFTERMARKET WILL SEE NEAR-TERM DECLINE OF MORE THAN 50%

> LONGER-TERM TRENDS HINGE ON ACTIVITY

Sean Broderick Washington and **Lindsay Bjerregaard** Chicago

The demand-sapping ripple effects of the novel coronavirus and COVID-19 pandemic have reached aviation maintenance facilities, quickly reversing one of the industry's steadiest trends.

Before the pandemic hit, most maintenance, repair and overhaul (MRO) shops were full, and the sector's full-year pace was on target to surpass mid-to-high-single-digit growth rates of recent years. This was especially true in the lucrative engine overhaul segment, which the Aviation Week Network Commercial MRO Forecast projected would make up 43% of 2020's forecast $82 billion in total MRO spend. Most engine shops were booked for months, and used parts were hard to find for many platforms—an added boost for new-parts suppliers.

Due to that momentum, the pandemic's near-term ramifications on MRO are only now beginning to come into focus. The picture is not pretty.

GE Aviation reported global shop visits for its engines were down low-double-digit figures in the first quarter of 2020, including CFM56s produced under its 50-50 CFM joint venture with Safran. While that pales in comparison to the more than 90% dip in global airline flight activity, MRO is a lagging indicator. Early second-quarter trend data has GE and CFM global shop visits, which totaled 5,400 for all of 2019, falling 60% year-over-year. The reason is simple: The less an aircraft flies, the less often it needs work. For manufacturers and many service providers alike, the result is either less cash now or waiting longer to get paid.

Engine manufacturers are fond of long-term agreements that take two basic forms: per-flight-hour and per-overhaul. Both offer predictable costs over the contract's life. The primary difference: Flight-hour deals are paid regularly, while overhauls are paid for when the work is done.

GE is projecting a 50% drop in long-term agreement revenue for the first quarter of 2020, implying fleet activity at roughly half of 2019's first-quarter levels. While that constitutes a major drop, many airlines in the current environment would welcome activity levels matching 50% of their 2019 output. GE's own figures show total CFM-powered departures have been down about 75% year-over-year for the last several weeks. Pratt & Whitney parent Raytheon Technologies' unofficial projection of a 50% drop in commercial aftermarket business in 2020 includes even more dire year-over-year figures for April and May, as customers with long-term agreements keep aircraft on the ground and repair-shop inductions plummet.

"If you look and take a snapshot of where we are today, obviously aftermarket is going to be down a lot more in April and May than the 50%," Raytheon CEO Greg Hayes says.

The newly combined mega-supplier Raytheon Technologies—composed of the former entities Raytheon Co. and United Technologies—says that repair input at its Collins Aerospace subsidiary was down 55% in April. The drop was even more severe within Pratt, as engine shop visits fell 70% after a relatively routine first quarter. Raytheon is estimating that full-year aftermarket revenues will fall roughly in line with global traffic, which the International Air Transport Association is projecting will decline 48%.

Much like everything else amid the pandemic, the commercial aftermarket recovery's pace and strength remain unpredictable. But the market will bounce back, so long as there are aircraft flying. CFM points out that more than 60% of the 30,000 CFM56s in service have not had the first of what is usually at least three scheduled lifetime shop visits. While some maintenance can be pushed out, deferring major shop visit costs by breaking up work is not seen as a cost-effective long-term approach.

"If you cut [an engine overhaul] in pieces, it's going to cost you 20% or 30% more than if you can do it all at once," says Safran CEO Philippe Petitcolin, citing costs such as labor and leases for replacement engines incurred each time an engine is removed. "You are going to do a full shop visit over a period of 18 months [to] two years, but you will have to do it. When it's time, it's time, and nobody plays with that."

While repairs must go on, a downturn that creates a pool of surplus aircraft reshapes the aftermarket landscape. A recent Aviation Week poll found that 74% of respondents—all of them airline operators or aftermarket services providers—expect airlines to start sourcing components from their parked aircraft, a daunting prospect

SAFRAN

Engine shop inductions have fallen quickly as airlines have stopped spending cash.

for both manufacturers and used serviceable materials (USM) providers.

"If you have a fleet of 100 aircraft [of the same type] and you stop flying 50, then why would you buy parts if you have those airplanes grounded?" asks Derk-Jan van Heerden, CEO of AELS, an end-of-life aircraft specialist.

While parked aircraft make an attractive source for harvesting parts, the scenario may only come into play if there are no better options for the assets.

"Airline CEOs and [chief financial officers] simply aren't going to allow that," says Jason Reed, president of the Component Solutions Group at GA Telesis. "They're going to get rid of aircraft now. They need the liquidity for that full engine and airframe. Then, they're going to go to the used [parts] market even more."

Another shift that will breathe more life into the USM market: the surging demand for cargo lift.

"What is flying is pretty much cargo only," says Steve Williamson, vice president of acquisitions and trading at Contrail Aviation Leasing. "So this is a big shot in the arm for [older platforms such as] the Boeing 767 and 747, and the engine types that power them," he adds, singling out GE CF6-80C2B powerplants in particular.

As airlines get increasingly conservative on MRO spending, from seeking out alternatives for new parts to delaying some overhaul work, opportunities will emerge for USM traders and parts manufacturer approval providers. But top-tier suppliers will not be left out.

While the used-parts world may conjure up visions of small-time suppliers working with fringe operators, the reality is much different. Not only is the practice of sourcing second-hand material a common occurrence for airlines of all sizes, but manufacturers are also some of the biggest USM consumers. As OEMs embrace long-term, fixed-price service agreements, they assume financial risk. Funneling used parts into their shops for use on customer equipment lowers the OEM's costs while allowing it to satisfy the ultimate contractual objective of keeping aircraft flying.

Buried inside the Collins Aerospace unit of Raytheon Technologies is Intertrade, one of the industry's most established USM businesses. Started in 1969 with a focus on repairing and reselling Collins avionics, the business now deals in airframe, engine and component parts for products both within and outside the Raytheon family. Intertrade is linked with a network of more than 100 shops and six former stand-alone manufacturers that were rolled up into Collins Aerospace—connections that provide a leg up on many competitors. Intertrade can source parts and have them ready to sell with minimal reliance on vendors. The end result, ideally, is lowering both internal and customer costs.

"That's something I anticipate Intertrade doing more of: funneling our repairs of used material inside instead of out to third-party repair shops," says Intertrade Director Shawn Bergquist. "We have a very diverse set of offerings. How we manage through this with customers is what they will remember."

BACK TO ORBIT

BOEING

About the X-37B

The X-37B is derived from NASA's original X-37 program, which ran from 1999 until September 2004, when it was transferred to DARPA. Initial low-speed/low-altitude tests were conducted by NASA from 1998 to 2001 using the X-40A, a subscale version of the X-37 developed by the Air Force Research Laboratory. Following the transition of the program to DARPA, a series of captive-carry and drop tests of the Boeing-built X-37A were conducted in 2005-06. The success of these demonstrations led to the U.S. Air Force's decision to launch the X-37B Orbital Test Vehicle program, which was announced in November 2006.

To date, the Air Force has flown five X-37B missions (OTV-1 through OTV-5) beginning with its first launch on April 22, 2010, from Cape Canaveral AFS. OTV-1 through OTV-3 all landed at Vandenberg AFB, California, while the most recent missions, OTV-4 and OTV-5, landed at Kennedy Space Center in Florida. The first five OTV missions have spent a total of 2,865 days on orbit.

X-37B General Characteristics

Primary Mission: Experimental test vehicle
Prime Contractor: Boeing
Height . . . . . 9 ft. 6 in. (2.9 m)
Length . . . . . 29 ft. 3 in. (8.9 m)
Wingspan . . . . . 14 ft. 11 in. (4.5 m)
Launch Weight . . . . . 11,000 lb. (4,990 kg)
Power . . . . . Gallium arsenide solar cells with lithium-ion batteries
Launch Vehicles . . . . . ULA Atlas V (501), Space X Falcon 9

Source: U.S. Air Force

> X-37B SERVICE MODULE DEBUTS

> TEST TO CONVERT, BEAM SOLAR ENERGY PLANNED

Lee Hudson Washington and **Irene Klotz** Cape Canaveral

The sixth mission of the X-37B Orbital Test Vehicle (OTV-6) is preparing to launch from Cape Canaveral.

While the U.S. aerospace industry is being hit hard by the coronavirus pandemic, the Pentagon is pushing ahead with its goal of making reusable space vehicles more affordable by launching an X-37B Orbital Test Vehicle for a sixth mission.

This will be the inaugural U.S. Space Force (USSF) launch of the X-37B, which was scheduled to lift off aboard a United Launch Alliance Atlas V from Cape Canaveral AFS on May 16. It will be only the third U.S. space launch since work sites nationwide have been shut down and travel curtailed in an effort to stem the spread of novel coronavirus COVID-19.

"I suspect we will be under some form of restriction at least through June 30," Brig. Gen. Doug Schiess, 45th Space Wing commander, tells Aviation Week. "We're doing a measured approach . . . as we continue to work with state, city and county leaders to release restrictions. These things change so fast, it's kind of hard to tell."

New Chinese trainer p. 45 USAF's Agility Prime p. 46

Previous X-37B Missions

Flight	Vehicle	Launch date	Landing date	Launcher	Mission	Duration	Notes
OTV-1	1	April 22, 2010	Dec. 3, 2010	Atlas V 501	212	224 days, 9 hr.	• First launch of Atlas V 501 configuration • First autonomous orbital runway landing in U.S. • First X-37B flight
OTV-2	2	March 5, 2011	June 16, 2012	Atlas V 501	226	468 days, 14 hr.	• First flight of second X-37B
OTV-3	1	Dec.11, 2012	Oct. 17, 2014	Atlas V 501	240	674 days, 22 hr.	• Second flight of first X-37B
OTV-4	2	May 20, 2015	May 7, 2017	Atlas V 501	261	717 days, 20 hr.	• Second flight of second X-37B
OTV-5*	Unknown	Sept. 7, 2017	Oct. 27, 2019	Falcon 9	277	779 days, 17 hr.	• First launch of an X-37B on SpaceX's Falcon 9 • Longest X-37B mission

*Believed to have been flown using vehicle No. 2

In addition to the X-37B launch, designated USSF-7, two SpaceX launches, including the Demo-2 crewed flight test to the International Space Station for NASA, are on the Eastern Range calendar for May. Those launches are expected to be followed by a GPS-3 launch on a SpaceX Falcon 9 on June 30 and another ULA Atlas V launch with NASA's Mars 2020 rover on July 17.

The X-37B mission, the sixth in a series of Orbital Test Vehicle (OTV) flights that began in April 2010, will further develop the concept of operations for reusable space vehicles, while simultaneously fine-tuning technical parameters for an affordable, reusable space vehicle, Space Force spokesman Maj. William Russell tells Aviation Week.

The Air Force's Rapid Capabilities Office is working with the Air Force Research Laboratory—and now the U.S. Space Force—to execute a mission that maximizes the X-37B's unique capabilities, Air Force Secretary Barbara Barrett said May 6 during a Space Foundation event.

For example, OTV-6 will be the first time an X-37B is outfitted with a service module to host experiments. The service module, which is attached to the aft end of the vehicle, allows additional experimental payload capability to be carried to orbit.

The Defense Department is disclosing details of three experiments the normally classified X-37B program will perform during the upcoming mission. The robotic, reusable spaceplane, manufactured by Boeing, will host two experiments for NASA and one for the Naval Research Laboratory (NRL).

The first NASA experiment will assess how the space environment affects seeds used to grow food. The second study will use a materials sample plate to determine the results of radiation and other space phenomena on various materials. The NRL wants to test the ability to transform solar power into microwave energy that would then be transmitted to the ground, Russell says.

Microwave beaming technology has implications for long-endurance unmanned aircraft systems (UAS), the NRL noted in a May 8 report referenced on The War Zone website. Additionally, the technology could allow satellites to provide reliable power to Earth and other spacecraft in orbit.

The use of microwave beaming technology would provide military installations in austere locations an alternative to relying on low-power solar energy systems or transporting generators and large amounts of fuel. Instead, military personnel could pack a rectifying antenna to capture energy beamed from orbiting satellites. Rectifying antennas, also referred to as rectennas, convert high power-density microwave energy to DC electrical power.

Lightening the load and moving away from consuming vast amounts of fuel is something the Marine Corps has targeted for years. The upcoming test is not the first time researchers have studied using power-beaming to extend the flight time of small UAS.

In 2012, Lockheed Martin kept a Stalker aloft for 48 hr. by beaming laser power to a photovoltaic array on the small electric UAS. In NRL's concept, UAS would be outfitted with rectennas to capture the microwave energy beamed from space and use it to power otherwise conventional propulsion systems.

The NRL says its experiment aboard the X-37B flying the OTV-6 mission could shift how people think about generating power as well as lay a foundation for continuous unmanned flight.

"The Space Force dedicated this [upcoming] flight to the nation's first responders and front-line professionals who keep America strong," Barrett said.

Like previous X-37B flights, the expected mission duration of OTV-6 has not been announced. The X-37B is designed for an on-orbit duration of 270 days, but longer missions have been demonstrated. To date, the Air Force's two reusable OTV spacecraft have completed a total of five missions, with a cumulative time in orbit of 2,865 days. Individual mission durations have ranged from 224 to 779 days.

Most of the details surrounding the X-37B program are classified. The Air Force has said the program is intended to demonstrate technologies for a reliable, reusable and uncrewed space test platform for the military. The Pentagon does not only want the X-37B to prove a reusable autonomous spacecraft can return to Earth, but it also wants the avionics, flight systems, guidance and navigation, thermal protection, insulation, propulsion and reentry systems to remain intact.

"A number of lessons learned have been incorporated into both refurbishment and the concept of operations for the vehicle," Russell says. "These improvements aided in the checkout of the vehicle, the expansion of launch providers, landing corridors and landing sites, and more efficient and flexible integration, launch and landing timelines."

X-37B vehicles have previously launched four times aboard ULA Atlas V rockets and once on a SpaceX Falcon 9.

MDA Revives Dormant Concept for Extended-Range THAAD

> IMPROVED THAAD FLIGHT TEST IS SET FOR 2023

> MDA OPEN TO A NEW LAUNCHER AND CANISTER

Steve Trimble Washington

A nearly 15-year-old concept to double the range and altitude performance of the Terminal High-Altitude Area Defense interceptor has reemerged as a short-term option for the U.S. Missile Defense Agency (MDA).

The revival of the Terminal High-Altitude Area Defense Extended Range (THAAD-ER) concept adds to the MDA's options for a multilayered hypersonic defense system and potentially a new weapon to intercept intercontinental ballistic missiles beyond the atmosphere. The proposed improvement, however, raises the possibility of a dramatic reinvention of Lockheed Martin's 30-year-old interceptor for intermediate-range missiles, with perhaps a new launcher and canister required to support a larger first-stage booster and a kick stage.

LEAH GARTON/MISSILE DEFENSE AGENCY

The MDA wants to double the range and altitude of the THAAD interceptor.

Lockheed started working on the technology for THAAD-ER in 2006, commissioning propulsion subcontractor Aerojet to demonstrate a new 21-in.-dia. first-stage booster, along with a new upper, or "kick," stage, with funding provided by internal research and development accounts. Barely a month after China successfully tested the experimental WU-14 hypersonic glide vehicles (HGV), Lockheed again dusted off the THAAD-ER concept in early 2015. But the company's public campaign failed to win support from the MDA to launch an estimated $1 billion development program.

Now, however, the agency's position appears to have shifted. In late April, the MDA requested feedback from industry on options for demonstrating more powerful boosters than THAAD's current 14-in.-dia. single-stage rocket.

"The intent is to provide a booster that will increase the THAAD kill vehicle (KV) velocity at booster separation with a goal of increasing the KV range and altitude by a factor of at least two from the baseline," the MDA document states.

The MDA also revealed plans to conduct the first two demonstration events for a new THAAD booster since 2006. A static fire test for a new booster would occur no later than the end of fiscal 2022. By the middle of fiscal 2023, the agency also plans to perform a flight test of the new booster paired with a real or mass-representative surrogate THAAD KV, the agency says.

One stumbling block for the MDA in Lockheed's original THAAD-ER proposal was the 21-in. diameter of the new Aerojet booster. The existing THAAD canister has a 20-in. diameter, so the extended-range version required a new container and potentially a new launching system. The MDA still prefers a new booster that fits within the existing THAAD canister, but larger rockets are "acceptable," the agency's solicitation says. The MDA also prefers a new booster that is compatible with the existing KV.

The MDA's latest long-term spending plan discloses no funding or program of record for a THAAD-ER, but it is clear the agency is seeking a more powerful interceptor. In addition to seeking feedback on a larger booster, Lockheed also awarded BAE Systems a contract in March to upgrade the infrared seeker for the KV.

Moreover, an improved THAAD has been under study by the MDA for nearly two years. In September 2018, the MDA awarded 21 concept-definition studies to multiple companies for a Hypersonic Defense Weapon System, then selected five of those for concept-refinement studies a year later. One of those five studies is based on an interceptor concept submitted by Lockheed called the Valkyrie, which company officials have confirmed is an improved version of THAAD. The concept refinement studies were due to be completed this month. Lockheed deferred questions about the new solicitation to the MDA, which did not immediately respond to emailed questions.

Although the MDA has discussed few details publicly, a picture of a multilayer hypersonic defense strategy has started to emerge. In addition to demonstrating an improved THAAD within three years, the MDA also has launched development of a new, purpose-built interceptor called the Regional Glide-Phase Weapon System (RGPWS). The latter is scheduled to be deployed in the mid-2020s or potentially 2-3 years after the improved THAAD may be available.

Industry officials have debated the merits of improving existing interceptors versus investing in a purpose-built system. Even if an improved THAAD or SM-3 is unable to directly intercept a missile, the attempt can force the HGV to maneuver and bleed off energy. By making several intercept attempts along the flight path, the HGV loses speed and becomes more vulnerable to traditional interceptors in the terminal phase.

Latest South Korean Ballistic Missile Hurls Hefty Warhead

> PAYLOAD RISE FOLLOWS AMENDED AGREEMENT WITH U.S.

> BUNKER-BUSTING CAPABILITY REPORTED

Kim Minseok Seoul and **Bradley Perrett** Beijing

A range of 800 km (500 mi.) looks pretty handy for a South Korean surface-to-surface weapon. And it happens to be the range of the country's most recently reported ballistic missile—enough to reach all targets in North Korea from positions respectfully distant from the border.

The new weapon, the Hyunmoo 4, represents a leap in South Korean capability. An earlier ballistic missile, the Hyunmoo 2C, can also fly 800 km but carries a warhead of only 500 kg (1,100 lb.) at that distance. The Hyunmoo 4 can hurl 2,000 kg that far, according to widespread media reports.

The extraordinary size of the payload also raises the possibility that South Korea can modify the Hyunmoo 4 to carry a smaller payload much farther, moving it from short to medium range (above 1,000 km), making more Chinese, Japanese or Russian targets reachable.

Two Hyunmoo 4s were test-flown on March 24, according to the media reports, obviously based on a government briefing. One shot failed.

Like all South Korean ballistic missiles, the weapon is designed to be carried by a mobile launcher, says a source who is familiar with the system but declines to give more details.

Hanwha is the manufacturing contractor for the earlier missiles and so probably for the Hyunmoo 4. The defense ministry's Agency for Defense Development leads development of the weapons, a powerful but low-profile element of South Korean military capability.

The existence of the Hyunmoo 4 first was reported in September 2017, when the *Seoul Economic Daily* quoted an unnamed military officer saying the weapon could penetrate 20 m (66 ft.) of reinforced concrete. Its development follows that of the Hyunmoo 2 series.

The March 24 tests, range, payload and identity of the new missile were reported by the newspapers *JoongAng Ilbo* and *Asia Economy Daily*, online news service Newsis and news agency Yonhap. *JoongAng Ilbo* further reported the test failure. The tests used lofted trajectories, *JoongAng Ilbo* says, meaning the missiles flew higher than they would when maximizing range. As a result, the flights covered 400 km.

South Korea limits its ballistic missile capabilities by agreement with the U.S. Until 2017, the warhead limit for a ballistic missile of 800-km range was 500 kg. U.S. President Donald Trump and South Korean President Moon Jae-in agreed in September 2017 that the throw weight limit would be removed; range still is limited to 800 km. That range has looked more useful since July 31, 2019, when South Korea said North Korea had fired two missiles over a range of 250 km. A day later, North Korea said the missiles were of the multiple-launch rocket type and guided.

This raised the possibility that North Korea had an economical way of hitting fairly precise targets—at least south of the border. An ability to shoot from deep in home territory has become more valuable to South Korea.

Whether the nominal capability of any of the South Korean weapons also is the full capability is unknown. Designers could provide room for growth, and the weapons could be sandbagged in tests. In 2012, the *Chosun Ilbo* newspaper said the Hyunmoo 2B could fly 500 km but had been restricted to 300 km to comply with a commitment to the U.S. at the time not to deploy ballistic missiles with greater range. The 500-km range of the Hyunmoo 2B was later confirmed when the agreement was loosened.

Why the Hyunmoo 4 has such a large warhead is undisclosed. Other countries use smaller warheads on short-range ballistic missiles. The Russian Iskander has a payload of 480-700 kg and range of 400-500 km, according to the Center for Strategic and International Studies in Washington. The Chinese DF-12 can throw 480 kg 280-420 km.

South Korea's first ballistic missile was the NHK-1, adapted from the MIM-14 Nike Hercules surface-to-air missile and deployed in 1973; it has been retired. The Hyunmoo 1, which entered service in the 1980s, used the Nike Hercules shape but differed internally; it is still in service. A new, larger type entered service in 2008, the Hyunmoo 2A, supplemented the following year by a lengthened version, the Hyunmoo 2B.

The Hyunmoo 2C, test-flown in 2017, evidently is another new type, despite its designation: Its launcher is longer than that of the Hyunmoo 2A and 2B, according to someone who has seen the vehicle, and a photograph suggests the missile is fatter. Its reentry vehicle has fins, implying it is maneuverable and perhaps terminally guided. Consistent with that, the government has said it has technology for ballistic missiles to perform pull-up maneuvers. An ambiguous 2015 media report suggested the Hyunmoo 2B could fly 800 km with a 500-kg warhead, but this now seems to have referred to the Hyunmoo 2C.

The Hyunmoo 3 is a cruise missile. "Hyunmoo" is also spelled "Hyunmu."

South Korean Tactical and Short-Range Ballistic Missiles

	Status	Range* km (mi.)	Payload kg (lb.)	Design
NHK-1	Retired	180 (110)	400 (880)	Based on Nike Hercules
Hyunmoo 1	EIS 1980s	180 (110)	500 (1,100)	Nike Hercules shape
Hyunmoo 2A	EIS 2008	300 (190)	1,000 (2,200)	2A and 2B are one type
Hyunmoo 2B	EIS 2009	500 (310)	1,000 (2,200)	Longer version of 2A
Hyunmoo 2C	Flown 2017	800 (500)	500 (1,100)	Larger than 2A, 2B
KTSSM**	EIS 2020	165 (102)	560 (1,200)	Unrelated to Hyunmoo series
Hyunmoo 4	Flown 2020	800 (500)	2,000 (4,400)	No details

Sources: Media reports, photos, direct observation

EIS = Entry into service.
*Range with stated payload.
**Range and payload undisclosed but similar to MGM-140 Atacms data, which is stated here.

TEAM PLAYER

> THREE PRODUCTION-REPRESENTATIVE AIRPOWER TEAMING SYSTEM AIRCRAFT ARE BEING BUILT

> REMOVABLE NOSE ENABLES RECONFIGURATION IN THE FIELD

The first completed ATS reveals a different leading-edge profile on the outer wing sections.

BOEING

BOEING CONCEPT

Graham Warwick Washington and **Bradley Perrett** Beijing

Boeing is making extensive use of digital-twin technology to achieve a level of trusted autonomy that will enable its Airpower Teaming System (ATS) unmanned aircraft to operate as a "loyal wingman" to manned combat and surveillance platforms.

The first of three ATS prototypes was rolled out in Australia on May 4 and is scheduled to fly this year ahead of an extensive test campaign in partnership with the Royal Australian Air Force (RAAF), which is backing the program with A$40 million ($25.6 million) of government funding.

Designed to be affordable enough to be purchased in quantity and flexible enough to perform multiple missions, the fighter-size unmanned aircraft is the first clean-sheet Boeing aircraft to be developed outside the U.S. and the first military aircraft to be built in Australia for more than 50 years.

For the RAAF, its Loyal Wingman Advanced Development Program is an experimentation effort to explore the concept of manned-unmanned teaming (MUM-T). For Boeing, the program is developing a product for which Australia is one possible buyer—and one possible location for production.

The RAAF is interested in operating the ATS alongside its Boeing-supplied F/A-18F Super Hornet strike fighters, electronic-attack EA-18G Growlers and commercial-derivative E-7A Wedgetail air-surveillance and P-8A Poseidon maritime patrol aircraft, as well as its Lockheed Martin F-35As.

The ATS could enter production by the middle of the decade, "maybe a little earlier," says Shane Arnott, Boeing program director. The RAAF's head of capability, Air Vice Marshal Cath Roberts, says the timing of a potential acquisition decision is consistent with Boeing's mid-2020s timeline.

Experimenting with the prototypes will reveal what the loyal wingman can be used for, says Roberts. If an ATS is working with an E-7A, it is likely to be an escort, she says. Operating with an F/A-18F, it is likely to play the role of an adversary, pretending to be target. As well as training, Boeing says the initial role is intelligence, surveillance and reconnaissance, but the RAAF expects the ATS eventually to be armed.

"We see a growing demand for increased force mass, the ability for these platforms to support expeditionary operations as well as provide range and persistence to support the evolving theater of operations," says Jared Hayes, Boeing senior director of autonomous aviation and technology. "Think of it as a core vehicle that can be tailored to any specific set of export-market requirements." The UK and U.S. are interested in the ATS, says Roberts, indicating that other countries are looking at the system.

Arnott says the Boeing Australia-led team has brought disruptive ideas to the design, engineering and manufacturing of an affordable but relatively high-capability platform. The flexible payload approach is based on a reconfigurable nose that can snap on and off. The 8.5-ft.-long nose section provides 90,000 in.^{3} of volume, all for payload as power, and cooling is provided from behind the fuselage bulkhead.

"The idea is that the nose is completely removable in

theater. So you can have [an ATS] off doing a mission and be programming a new nose on the ground for a new mission and, during that mission flow, change the nose and therefore change the role of the system," Arnott says. He adds that crews in the field will be able change noses "in a few number of hours."

The reconfigurable nose provides open-architecture payload interfaces. "We can work with customers to create their own mission systems and are able to do that in-country, so there are some industrial opportunities there," he says. A buyer can make its own noses and thus keep the innards secret.

The ATS has been designed using model-based engineering and "is one of the most comprehensive digital twins within Boeing," Arnott says. The digital twin is key to developing trust in the autonomy that will enable the loyal wingman to team safely with manned platforms.

"It enables us to derisk as we develop the system. As we're designing, we're building the simulators. And as we build pieces, we are replacing those simulated pieces with hardware. But, more importantly, we're using it to mature the autonomy," he says. "We've been flying the digital twin for some time on surrogates," and it will be important to certifying the system in an affordable fashion, he adds.

Boeing is tuning its "operator-on-the-loop" approach to ATS autonomy to minimize the manned aircraft workload.

The program is prototyping not only the ATS but also the factory. The first three aircraft are referred to as production-representative vehicles because they are being built using the automation processes planned for manufacture. The second ATS is now in fabrication.

While it is a relatively small program, ATS is able to capitalize on Boeing's "massive" investment in advanced manufacturing and automation, Arnott says. The composite wing is produced using resin infusion, a technique pioneered on the Boeing 787, and "is Boeing's biggest-ever single-piece resin-infusion composite part," he says. "It is actually two pieces: the top and the bottom that snap together."

Cost was a key parameter in design trades. Boeing is not disclosing a figure, but Hayes says the cost target is inside the price range for attritable-class airframes. Compared with Boeing's previous stealthy, tailless unmanned combat aircraft demonstrators, the X-45 and X-46, the ATS has a relatively simple airframe design.

"Flying wings can be quite expensive and very unforgiving, particularly on actuators," says Arnott. "A lot of thought went into getting that right balance of 'good enough' across the board, and signature is one aspect, but affordability is a big one, along with flexibility. So we have a relatively simple airplane from a control-surface standpoint."

The ATS program is about more than just the airframe. "The difficult bit, and the bit that's going to make a difference for the customers, is that integrated autonomy piece," says Arnott. Boeing's concept of operations, which will be explored in experimentation with the RAAF, is that a manned platform such as the F/A-18F Super Hornet would fly with three or more ATS.

"ATS teams with piloted aircraft through an 'operator-on-the-loop' approach. It is not remotely piloted. . . . So central to our development effort is getting the 'right' level of autonomy to manage the workload on the teamed manned systems to enhance, not detract from, their capabilities," he says.

Working with RAAF operators, Boeing is using the ATS digital twin "to figure out the right level of information feed and direction" between the manned and unmanned aircraft. "That's a big part of the extensive flight-test program we have in front of us. We don't have all the answers yet," Arnott says.

"Our development to date in the digital-twin labs and surrogates has confirmed a manageable workload in some of the most stressing scenarios. But we will learn more through our test program as we confirm that manned-unmanned teaming architecture," he says.

"Trustable autonomy is one of the big concepts that we need to prove out in this program," Arnott notes. "It's another reason why we've invested so heavily in the digital twin—to enable the warfighters to come in and fly the asset, including sitting in a cockpit with the switchology so we get the flows and the tactics development. We've been doing that as we've been building the airplane."

Boeing's approach to enabling manned-unmanned teaming does not require significant modifications to the manned aircraft, at least not initially. "Out of the box, we have a concept where we don't push any requirements upstream from our aircraft," Arnott says. "You can't get an affordable system and then require significant upstream changes."

More capability will be possible when the ATS is teamed with larger platforms such as the E-7 and P-8. "There are opportunities for greater MUM-T capability when you have more glass in the back seats," he says. "We see different paths for enhancing MUM-T across fighters, which have limited screen space, up to the bigger commercial derivatives."

Force protection, and the defense of high-value platforms such as the E-7 and P-8, is one of the major teaming concepts being explored by the ATS program. "Boeing has a big interest in making sure those assets continue to be effective and safe in the future battlespace. This system is seen as a key enabler to make that happen," he says.

After ground and taxi tests at an undisclosed location in Australia, Boeing and the RAAF plan to progress through unmanned-unmanned and manned-unmanned teaming experiments on various representative missions to an operational demonstration. This will help Boeing develop the ATS into "a real product that has operational utility," Arnott says.

PACAF Girds for Lighter, Leaner War

> RUMRUNNER EVENT TESTED BASE DEFENSES

> LOGISTICS-UNDER-ATTACK EFFORT PROPOSED

SR. AIRMAN MATTHEW SEEFELDT/U.S. AIR FORCE

Two F-15Cs decorated in Kadena's ZZ tail flash were refueled by a 909th Air Refueling Sqdn. KC-135 during the WestPac Rumrunner exercise.

Steve Trimble Kadena Air Base, Okinawa, and Singapore

The technological details of the U.S. Air Force's new approach to fighting an air war in the next decade are still being fine-tuned in laboratory experiments and simulation centers, but a few of the dramatic changes are already visible here on the rocky shores of Okinawa, Japan.

A local exercise held in January called WestPac Rumrunner appeared to be built around a routine counter-air scenario: Twenty-four Boeing F-15Cs scrambled from Kadena AB to a point about 100 mi. east of the island to intercept "invading" U.S. Navy Boeing F/A-18E/Fs launched from MCAS Iwakuni on Japan's mainland. Meanwhile, Special Operations Forces (SOF) aircraft attempted to infiltrate a team of commandos on the island.

Underlying that routine setup, however, was a glimpse of the future. Four Kadena-based F-15Cs refueled and rearmed during the exercise at MCAS Futenma on Okinawa. Another mainland Japan-based Navy E-2D, which supported Kadena's F-15Cs against the invading F/A-18E/Fs and SOF teams, refueled at Kadena. Although those seem like trivial logistical details, both offered a chance to test the Air Force's new Agile Combat Employment (ACE) strategy. Moreover, the Navy's Northrop Grumman E-2Ds and local MIM-104 Army Patriot batteries added layers to the defenders' battle-management tasks.

WestPac Rumrunner was not the full realization of ACE or Joint All-Domain Command and Control (JADC2), but the event was a tiny step on a pivotal base within the first island chain east of China.

"We're trying to use all of our exercises to learn something about Agile Combat Employment and base defense," Gen. Charles Brown, Jr., commander of Pacific Air Forces (PACAF), told Aviation Week in February. Brown has directed PACAF-controlled wings to start experimenting with two concepts that require a change in mindset as much as technology.

"I don't think we've got all the answers yet, but [such events provide] feedback or validate some things we've tried to do," Brown says. "And then we ask, 'How do you put that into our doctrine and change our approach?'"

Adapting base defenses and logistics lines across the sprawling PACAF region is a major focus for the Air Force. In February, Air Force leaders rolled out a budget proposal that includes a new logistics-under-attack initiative. The goal is to make bases more resilient to coordinated attacks aimed at weakening or destroying the hubs currently used to rearm and refuel combat aircraft.

"The key aspect of ACE is to be light, lean and agile," Brown says. "So your logistics do not become something that's a challenge."

Most of the details of the new initiative are classified, but Air Force leaders have acknowledged the plan involves dispersing forces to remote airstrips and building up base defenses.

Brown also favors distributing nascent technologies such as directed-energy weapons, to serve as point defenses, lest the Air Force face the cost of deploying sophisticated kinetic systems, such as Terminal High-Alti-

tude Area Defense (THAAD) or Patriot batteries to the dispersal sites around the region. Brown, who has been selected to become the next chief of staff, also has said he is interested in examining novel power sources such as a future class of small, modular nuclear fission reactors to serve as the generators for such high-power systems.

Part of the logistics initiative has already been set in motion. PACAF eventually wants to preposition weapon systems in cargo containers around the region, but that first requires host nation approval. In the meantime, the command is laying the groundwork with proposals to preposition humanitarian relief supplies.

"It really started out with [humanitarian assistance and disaster relief] capabilities that you can put in different locations," Brown says. "If you look at this region, it's full of typhoons, volcanoes, earthquakes. And we respond to a lot of those. That, to me, is a way to start the process."

The focus on lightness and agility also marks a change. One way to reduce threats to the logistics systems is to reduce the tonnage required to support an operation, thus decreasing the overall demand for airlift. That emphasis could lead to design requirements for lighter and more efficient weapon systems, but the focus now is on paring down logistics needs to essentials and using software applications to drive new decisions about what that means.

"This is where I think we start talking about data and being able to understand that better so we can forecast better," Brown says. "And we're not bringing everything just in case—you actually bring what you need."

Finally, protecting the mobility fleet that delivers the equipment to dispersed and remote bases is another priority. Air Mobility Command, for example, has funded defensive upgrades for the Boeing KC-135 and Lockheed C-130H fleets, providing those previously undefended aircraft with warning systems and countermeasures against infrared- and radio-frequency-guided missiles. Another way to defend the mobility fleet is to make it harder for an adversary to guess where such aircraft will take off and land.

"I can put [defensive aids] on a single airplane, and that's important, but I also want to look at the places we're operating from," he says. "This is why we were looking at Agile Combat Employment. So instead of dispersing on an airfield, we disperse [combat aircraft] across airfields. And then I've got to defend that."

In addition to being costly weapons systems, THAAD and Patriot batteries also require significant airlift support to relocate and sustain, Brown says. "I'm looking for things that are lighter, leaner, where you have a more unlimited magazine, and the cost curve is different, so you can reserve your very expensive interceptor against a ballistic or cruise missile or hypersonic missile. At some point, though, you can't afford it. So having a high-power microwave and directed energy gives us a lot more flexibility to go to different locations. That's the thought process. I think there's good dialog about it. We still have a ways to go."

The first steps are taking place in local exercises, such as WestPac Rumrunner. The Kadena-based 18th Wing scored the counter-air element of the event as a success. No Carrier Air Wing Five F/A-18E/F "invaders" infiltrated the 100-mi. boundary zone circling the island. An SOF team successfully landed an insertion team, but the 44th Fighter Sqdn.'s F-15Cs immediately "killed" the infiltration aircraft, says Lt. Col. Ryan Corrigan, commander of the 44th Fighter Sqdn.

The event's focus on practicing the ACE concept added another layer of complexity. Dispersed operations are not new to the Okinawan F-15Cs. A decade ago, Kadena's squadrons helped pioneer a concept called Agile Eagle, which paired enough airlifters and tankers to move a group of F-15Cs anywhere in the region at a moment's notice. The idea further evolved into the Rapid Raptor concept, which applied a similar operational model to F-22s based at Hickam AFB in Hawaii, and then into the wider ACE strategy, but it still presents a challenge to the hub-based mindset of PACAF units.

STAFF SGT. BENJAMIN RAUGHTON/U.S. AIR FORCE

A Kadena F-15C was refueled at MCAS Futenma during the exercise.

Widely dispersed high-energy lasers defending bases from saturation missile attacks still seem years into the future, although field experiments with counter-unmanned aircraft systems designed by Raytheon and the Air Force Research Laboratory have begun. In the meantime, the focus on the unit level is about making practical changes.

"What we can take care of now is training to not be an easy target," Corrigan says. "It is finding the right level of acceptable risk to right-size the support package that goes with that deployment team. So [for example], now I don't need to bring both a weapons loader and a refuel team because I have trained my weapons loader to know how to put gas in several different types of aircraft."

Finnish Fighter Needs Challenge Bidders

- ALL FIVE BIDDERS PARTICIPATED IN THE HX-CHALLENGE DURING JANUARY AND FEBRUARY
- BUDGET SET AT €10 BILLION, ALTHOUGH €700 MILLION SET ASIDE FOR INTEGRATION

Tony Osborne London

During January and February, some of the West's top fighter exports were put through their paces in the challenging environment of Finland.

Over the course of several weeks, the HX-Challenge hosted by the Finnish Air Force saw foreign fighter aircraft and their sensors pitted against their Finnish counterparts, a sign that the program to replace the country's legacy-model F/A-18 Hornets was beginning to heat up. For procurement officials, however, it was a chance to test whether the promised performance of the five aircraft would live up to reality.

Before a selection is made in 2021, the Finns plan to game out scenarios that will test the military capabilities of the bidders. Using a combination of verified data from the HX-Challenge flights as well as information gleaned from examinations focusing on the future capabilities of the aircraft, Finnish defense procurement officials will simulate a two-week war that will help them decide which aircraft will offer the best military capability: Boeing's F/A-18 Super Hornet, Dassault's Rafale, the Eurofighter Typhoon, Lockheed Martin F-35 or Saab's new JAS-39E/F Gripen.

Military capability is the most critical factor in the decision, HX-Fighter Program Director Lauri Puranen tells Aviation Week. "Finland is not an allied nation; we are entirely responsible for our national defense," Puranen says. "So we will score each of the contenders on their military capability alone."

Issues such as supply chain security, industrial participation and life-cycle costs are also important considerations, but the scoring for those factors is more black and white—a pass or a fail. Industrial participation in the HX program—investment by the winner in the Finnish industrial and technology base—is set at a minimum of 30%.

Finland's contest is seen as one of the most important fighter contests in Europe; it is certainly among the most valuable.

Eurofighter Typhoon

BAE SYSTEMS

Lockheed Martin F-35A Lightning II

LOCKHEED MARTIN

Initial budgetary range for the procurement was listed at €7-10 billion but it is now firmly set at €10 billion. Around €700 million of the budget has been earmarked to support integration of the fighter into the wider Finnish defense system and to bolster the building of new infrastructure to support them.

Finland did not originally ask for fighters per se, but rather for equipment to perform the five primary air force missions: air defense, anti-ship, ground attack, long-range strike and intelligence, and surveillance and reconnaissance.

"We gave [the bidders] a free hand in designing and building a solution to meet our scenarios," says Puranen. "They could have chose ground-based air defense systems and ground-launched missiles, or UAV and other assets. All opted to provide multirole fighters."

With fighters proposed, Helsinki tendered a contract for 64 aircraft—a number that would have replaced the existing legacy Hornet fleet on a near one-for-one basis. Some of the bids have been innovative as well: Saab's proposal for Gripen fighters also includes a pair of GlobalEye multisensor surveillance aircraft, while Boeing's Super Hornet package contains several EA-18G Growler electronic warfare platforms. But as a recent request for quotations has suggested, all of the bidders are struggling to provide a 64-strong fleet within the intended budget.

The bidders have found things challenging because Finland requires everything to be included in the tender (airframes, weapon packages, sensors, initial training, spares and maintenance capabilities).

The F/A-18 Hornet, now in the autumn of its Finnish Air Force career, will exit service by 2030.

FINNISH AIR FORCE

Saab JAS-39E Gripen

SAAB

"We have to be prepared to defend Finland by ourselves," Puranen says. "So we need sizable stocks of weapons."

Given that Finland already flies a U.S.-sourced aircraft with American weaponry, it could be argued that the selection of a U.S.-made fighter would be beneficial, as the aircraft in the fleet could make use of such weapon stocks. Puranen accepts the fact that some elements in the fighter program could benefit a U.S. platform, but he notes that weapons like the Advanced Medium-Range Air-to-Air Missile can also be used on European aircraft types such as the Eurofighter and the Gripen. Besides, many of the weapons in the Finnish defense stock will be old and running out of life by the time the new fighter begins entering service in the late 2020s.

The bidders will need to provide initial instruction, but all future training will be performed in-country with pilots first flying the BAE Systems Hawk jet trainer—some of which have been in service since 1980, although additional aircraft with low flight hours were purchased from Switzerland in 2008. There are no plans to replace the Hawks until the 2030s. Instead, Finnish industry has upgraded the aircraft extensively to keep them relevant and has introduced a live, virtual and constructive training environment linking the aircraft with simulators on the ground through a system called Hawk Link. Basic training will be carried out on secondhand Grob G 115 twin-seat trainers purchased from the UK. These, too, are being outfitted with new glass cockpits.

Puranen expects all five competitors to remain in the competition to the end, pointing out that the cost

Dassault Rafale C

DASSAULT AVIATION

of sending aircraft to the in-country evaluation was not a cheap process.

The Finnish procurement system does not call for short-listing competitors. "We are not making comparisons; we are looking at the whole system," Puranen says.

Several of the bidders have welcomed Finland's approach to transparency in the process. This has gone even further in recent weeks, after Finnish Defense Minister Antti Kaikkonen called upon the participants to refrain from using consultants. A number of the competitors had hired former senior military officers and chiefs to lobby politicians. While concerns about the economic impact of the COVID-19 coronavirus pandemic could affect defense procurements elsewhere, Finnish politicians are keeping the HX program on track—just as they did in 1992, when the F/A-18 Hornet was chosen in the midst of an economic recession. Finnish Prime Minister Sanna Marin has called for the program to remain on schedule because of the urgent need to renew defense capabilities.

Nonetheless, key meetings planned with each of the bidders for this month had to be postponed until the fall, Puranen says. They cannot be performed virtually because of security concerns, he adds.

The HX program has already issued two requests for quotations: the first in April 2018 and the second in November 2019. At the end of the year, a third request will be issued calling for the best and final offer from the bidders. Once received, the information will be collated for use in the simulations that score the military capability and help inform the final decision in 2021.

Boeing F/A-18 Super Hornet

TONY OSBORNE/AW&ST

REPLACING THE HORNET

Unlike many of the fighter contests in Europe in recent years, Finland's fighter choice is difficult to predict. Having spent decades striking a balance between East and West, with the Mikoyan MiG-21 and the Saab Draken, respectively, the end of the Cold War meant Finland could turn to the West for its future combat aircraft.

The F/A-18 Hornet had to beat out stiff competition from a group of challengers that included Dassault's Mirage 2000, the Lockheed Martin F-16 and the A/B models of Saab's Gripen. Even Russia's Mikoyan MiG-29 was considered but quickly dropped. The Hornet was selected on the basis of operating costs and suitability to air force requirements and production-line stability, Aviation Week reported in May 1992. Local Finnish firm Valmet completed final assembly of all the single-seat models.

The desire at the time was for a pure fighter, but Helsinki's wish to participate in international missions after 2000 prompted the development of an air-to-ground capability. Over the last 15 years, the Finnish Hornets have been equipped with a range of advanced weapons including the U.S.-made Raytheon AGM-154 Joint Standoff Weapon (JSOW), Joint Direct Attack Munition (JDAM) kits and the Lockheed Martin AGM-158 Joint Air-to-Surface Standoff Missile (JASSM). The Hornet has suited the Finns well, with its roots in carrier-based aviation allowing it to operate from a wide range of airfields and even from road runways—as is commonly practiced in Sweden. Finland practices road-runway capabilities at least once a year, and that need is unlikely to go away. Helsinki did examine extending the life of the Hornets but concluded that the process would have been expensive and left the country lagging behind its Nordic neighbors, not to mention unable to deal with new and increasingly capable threats.

As the victor in almost every fighter contest in which it has participated, the Lockheed Martin F-35 is likely the aircraft to beat. The Lockheed aircraft is the only fifth-generation fighter in the contest and is equipped with some of the most advanced capabilities. And while the procurement cost of the aircraft has fallen, life-cycle costs remain high. For Finland, there are questions about how independent the aircraft would be, given that the F-35 is tied into logistics systems originally designed for NATO air forces. Finland would also face additional scrutiny of its security requirements for basing of the platform.

The other U.S. competitor, the F/A-18 Super Hornet, could also be in the mix. In addition to being the incumbent, the Super Hornet package has been potentially bolstered by a fighter selection by Germany. The Luftwaffe's plan for a split buy of Eurofighters and Super Hornets means a Finnish Super Hornet fleet might not be orphaned in Europe. Notably, the Super Hornet is the only one of the five aircraft on offer that will not be equipped with the MBDA Meteor beyond-visual-range air-to-air missile.

Strengthening bilateral defense ties between Helsinki and Stockholm could help the chances of Saab's JAS-39E/F Gripen, an aircraft currently in development but due to come to market with advanced electronic warfare capabilities. A long-term program of spiral updates could help sell the Dassault Rafale: The French want to keep their Eurocanard in service until the 2060s, a timeline that could be attractive for the Finns.

Meanwhile, the Eurofighter—which would benefit from the planned long-term evolution program—is planning to offer Typhoons equipped with active, electronically scanned array radar in a similar specification to the Quadriga aircraft proposed for Germany. The Eurofighter Finland bid is being led by BAE Systems on behalf of the four national partners: Germany, Italy, Spain and the UK.

A New Chinese Naval JL-9 Appears, Possibly for Carriers

> MARKETING MATERIAL DEPICTS THE SUPERSONIC TRAINER OVER AN AIRCRAFT CARRIER

> IT MAY BE PREFERRED TO PRACTICING DECK LANDINGS WITH J-15s

Bradley Perrett Beijing

Avic Guizhou is developing what may be a shipboard version of its JL-9G supersonic trainer intended for use on Chinese aircraft carriers. Separately, the state operation says it has taken a first foreign order for the JL-9G in its export configuration, the combat-capable FTC-2000G. Myanmar appears to be the customer.

The new domestic version must be only a candidate for some requirement, not yet selected for production, because Avic Guizhou speaks of trying to win a new victory with the JL-9G. Its obvious competitor would be the JL-10 from Avic Hongdu. That requirement could be for shipboard operation, since China now trains fighter pilots to land on and take off from aircraft carriers with big and costly J-15s from Avic Shenyang, which are reportedly difficult to control.

AVIC GUIZHOU

Differences appear in the rear of the new JL-9G version.

The JL-9G, a distant derivative of the MiG-21, is already used by China's navy as a land-based trainer.

Avic Guizhou said on April 19 that its flight-test department had taken delivery of a "first aircraft"—meaning the first unit of a new type or version. Photographs of the rear fuselage and wing published four days earlier indicate that the design was based on the JL-9G. The project is proceeding rapidly to its first flight, says the company, which is formally called Guizhou Aviation Industry Corp.; it is part of Avic.

Since the new aircraft was painted in the red and white colors used by JL-9Gs in naval service, it must be intended for the navy. Representatives of the armed forces were present when final assembly was completed earlier on April 19, Avic Guizhou says.

Moreover, the appearance of the aircraft follows a March 16 statement in which Avic Guizhou said on its social media account that it is determined to win a new victory with JL-9G development. It illustrated the social media post with a generated image of a JL-9G flying over a Chinese aircraft carrier.

Designers who created the MiG-21 as a Mach-2, high-altitude interceptor in the 1950s would have been amazed by the idea that a new derivative could arrive on Chinese aircraft carriers in the 2020s. The prospect is even more surprising when one considers that China has a modern type designed from the beginning as a trainer, the JL-10, which first flew in 2006.

But Chinese internet portal Tencent reported in 2018 that U.S. "experts" had pressured Ukraine to cease supplying the JL-10's engine, the Motor Sich AI-222-25. Russia's Ivchenko-Progress has begun making the AI-222-25 (for the Yak-130 trainer), but cessation of Ukrainian supplies may have disrupted the JL-10 program and perhaps created an opening for an improved JL-9G.

Two changes in the design appear in official photographs of the first aircraft of the new JL-9G version. One is the deletion of external longitudinal structures for mounting the large ventral strakes that have long been a feature of the MiG-21, its J-7 Chinese copy and the JL-9 trainer derivative. The strakes were left off the JL-9G, presumably to increase angle of attack on takeoff and landing, but the mounting structures remained; now they have disappeared, saving weight.

A second change is at the base of the fin, under the rudder, where a new housing of triangular section is fitted; this replaces a housing of round section on the original JL-9G design.

If this version really is intended for shipboard operation, the design must have much bigger changes, including strengthening the landing gear and, probably, the airframe structure for deck impact. A suitable tailhook would be needed, too.

This implies a costly development program—and one that foreign experience suggests may be unnecessary. The U.S. Navy, keeping at least 10 aircraft carriers in service, has long used dedicated training aircraft for shipboard operation, but other navies have not.

The *South China Morning Post* reported last December that China had suspended plans to build more than four aircraft carriers, due to cost and problems in developing an electromagnetic catapult and, for the originally intended fifth and sixth ships, a nuclear powerplant. China commissioned its first aircraft carrier, Liaoning, in 2012 and a second, Shandong, in 2019. Both have ski jumps. A JL-9G has appeared in a seemingly authentic video taking off with a ski jump. The third and fourth ships will reportedly have electromagnetic catapults.

The first export order for the FTC-2000G was signed in January 2020, state media including the *Guizhou Daily* say, citing officials from Avic Guizhou. Delivery of the first batch is due next year. The customer is not identified but Chinese media speculate it is Myanmar, which uses several Chinese aircraft types, including the J-7. Another possibility would be Cambodia.

HIGH HOPES

> U.S. AIR FORCE'S AGILITY PRIME AIMS TO BOOST INVESTOR CONFIDENCE IN eVTOL MARKET

> PROTOTYPE AGREEMENTS WILL PRODUCE VEHICLE TEST REPORTS

Graham Warwick Washington

For a defense program with relatively little funding behind it, Agility Prime comes freighted with expectations.

The U.S. Air Force program to help build a domestic electric vertical-take-off-and-landing (eVTOL) industrial base is a lifeline for a nascent market as private capital dries up because of COVID-19. For the Air Force, if successful, Agility Prime could be a model of how to bring defense procurement together with commercial markets to compete with China's national drive for technology supremacy.

"For me, it's a template for how to take the military market—our entire value proposition, not just our funding—and bring it to bear on an emerging commercial market in a way that accelerates it for all of us, and not just for the military," says Air Force acquisition chief Will Roper.

Agility Prime aims to tap into existing commercial investment in eVTOL development and, through in-kind support in the form of access to test resources and technical expertise, help U.S. manufacturers along the way to FAA certification. At the same time, the program will seek out opportunities within the Air Force and other government agencies for early purchases of eVTOLs to help ramp up production.

The program has been conceived to avoid what happened in the small drone market, where the Pentagon failed to engage the emerging U.S. industry and the supply chain migrated overseas. Drones made in China by market leader DJI are now regarded as a security risk in the U.S. "Because we were not proactive, the market went in a way that was not to the benefit of our national security or industry," says Roper.

The value Agility Prime brings to the nascent eVTOL market is more than just funding, he says. It includes access to resources to help manufacturers move quickly through military certification so that the Air Force and other agencies can begin buying vehicles for missions including logistics, base defense and disaster relief, "removing the risk that the market will move overseas," he says.

"This looks like a model that could counteract the benefits a country like China gets with a nationalized industry base where you're able to pick winners and losers," says Roper. "What I like about this is it brings together our national assets—our vibrant com-

Sabrewing Aircraft's Rhaegel-A unmanned cargo aircraft prototype will be test-flown under Agility Prime.

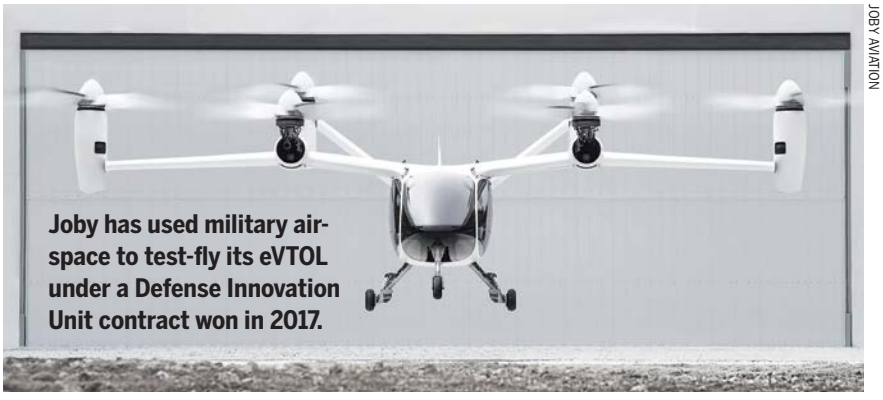
mercial ecosystem, private capital, government—but it maintains those markets that have been so amazing at keeping innovation fresh and vibrant."

"The Air Force's Agility Prime initiative comes at a critical time when many innovative eVTOL developers are beginning to fly demonstrators but need support to move forward," says Mike Hirschberg, executive director of the Vertical Flight Society. As private investment in startups and corporate spending in R&D have been hit by the novel coronavirus crisis, Agility Prime "is an endorsement of the potential of eVTOL technology that should also bolster investor confidence," he says.

The Air Force has established three "areas of interest" (AOI) under the Agility Prime "innovative capabilities opening" released in late February. The first AOI is for eVTOL air taxis carrying three to eight people, the second for one- or two-person vehicles and the third for unmanned cargo aircraft able to carry payloads of more than 500 lb.

Each AOI has three phases: submission of a proposal or "solution brief," a site visit to determine funding and testing needs and, if successful, an invitation to submit a prototype proposal. To qualify, bidders must be able to fly a full-scale prototype by Dec. 17, 2020. The program plans to award no-cost "other transaction authority for prototype" contracts to produce test reports on the vehicles.

SABREWING AIRCRAFT



JOBY AVIATION

Joby has used military airspace to test-fly its eVTOL under a Defense Innovation Unit contract won in 2017.

In return for providing access to Defense Department test resources and certification expertise, the Air Force, Marine Corps and other government agencies will get to assess the performance and capabilities of commercial eVTOLs with an eye to procuring aircraft off the shelf for military and public-use missions that have yet to be identified. The Air Force plans to field a small quantity of eVTOLs by 2023, says Lynda Rutledge, Air Force mobility and training aircraft program executive officer.

The Air Force is particularly interested in the promise of eVTOL to provide lower acquisition and support costs, reduced acoustic and infrared signatures, and simplified flight control requiring less pilot training, says Agility Prime team lead Col. Nathan Diller. The missions being studied include transporting ballistic-missile operators to remote launch control centers, perimeter security at large bases, "lateral logistics" by moving packages and personnel between squads, disaster support to civilian agencies and distributed personnel recovery by locating rescue assets closer to combat.

The $25 million provided by Congress for Agility Prime in fiscal 2020 is small compared with the cost of certifying an eVTOL. "When you look across our [vehicle] partners, just to develop an experimental aircraft is $100-150 million. To certify that aircraft is $750 million-1 billion," Mark Moore, Uber Elevate director of strategy, told the Agility Prime virtual kickoff event on April 28.

But the Air Force hopes that putting these vehicles through its trusted airworthiness program, and the data collected operating them, will accelerate FAA certification while early procurements will help scale up the supply chain. The Air Force goal is to operate 30 vehicles by 2030, says Roper, and the Marine Corps and Special Operations Command are also involved.

By fielding eVTOLs "in some substantive way" by 2023, when Uber plans to begin limited commercial service in its pilot cities, the Air Force aims to "stress-test this new capability in a way that brings acceptance by the public, as well as delivers better capability for the Defense Department, [and] ultimately for the commercial market," says Col. Scott McKeever, global mobility lead for the Air Force Warfighter Integration Capability office.

A key consideration for Agility Prime is how private investors react to the Air Force working with eVTOL startups. Investors previously devalued companies if they were engaged with the Defense Department, Roper says. But since the Air Force revamped how it interacts with technology startups, the ratio of private to government investment has risen to 3:1 from 0.75:1, bringing more than $1 billion in private money into its programs, he says. "They now raise the value of a company if it is engaged with the Air Force," he adds.

By providing a boost to emerging eVTOL manufacturers at a time when access to private capital is limited, the Air Force hopes Agility Prime will help avoid a repeat of "the cautionary tale" of the drone industry. The virtual kickoff event, which ran from April 27-May 1, "really came out strong about the need for the U.S. to invest in American eVTOL developers and discouraged U.S. companies from accepting 'adversarial capital' from countries like China," says Hirschberg.

"There are so many challenges with developing commercially compelling eVTOL systems; Agility Prime helps build momentum to overcome them," says Hirschberg. "If we get Agility Prime right, I hope that it becomes the standard for how the Pentagon engages in all areas of commercial tech," Roper says.

Fiber-Optic Sensing Could Transform Main Rotor Blade Technology

> BLADESENSE TECHNOLOGY TESTED ON AIRBUS H135 HELICOPTER IN NOVEMBER 2019

> SYSTEM COULD HELP ENGINEERS DEVELOP MORE ADVANCED BLADES

AIRBUS HELICOPTERS UK

Tony Osborne London

Trials of a fiber optic-based sensing technology fitted to helicopter rotor blades could pave the way to extended blade life and, if successful, even support future generations of rotorcraft flight control systems.

A technology that was originally conceived to speed up international communications has been adapted for this usage, which means it could now help engineers understand the complexities of blade dynamics and their shape in the harsh, challenging environment of a main rotor system, providing an enhanced capability over strain-sensing systems currently in use.

The development of the Bladesense project has been carried out with the support of Airbus Helicopters, BHR Group, Cranfield University and Helitune. The program has been funded with £2 million ($2.49 million) by the Aerospace Technology Institute and Innovate UK.

Technical aspects of the work have been led by Airbus Helicopters engineer Simone Weber, who began work on the proposals in 2016 and finally saw the concept brought to life during ground trials on an H135 twin-engine light helicopter in November 2019.

Bladesense was developed to look for deformations in the blade and assess the blade condition in flight. Normally, such deformations can be found only in controlled environments with specialist equipment.

For the trials, fiber optics were outfitted down the length of two of the helicopters' four main rotor blades. Fiber Bragg gratings, a type of reflector within the optics, were used to monitor local environmental parameters at key points along the blade length. The changes in blade shape alter the wavelength of the light emitted down the optic.

The fiber optics have significant advantages over electrical systems: They are much lighter, have a higher reliability and are durable even when subjected to the forces experienced by rotor blades.

"Strain sensing using fiber Bragg grating is not necessarily a novel system . . . but shape sensing, on the other hand, is very new," Weber says. "The project was very ambitious, given our funding and resources, but we did achieve a lot."

The process was also challenged by the need to collect data from balance positions on the aircraft that would not be influenced by vibrational loads, so Weber and the Bladesense team developed an assembly using off-the-shelf components that sits above the blades in a static position.

Inside are the interrogation devices that collect data from the sensors. The assembly also includes batteries because the system could not take power from the aircraft due to its temporary fitment, a wireless connection so that data can be collected in real time, and a power management system to prevent the system from overheating. Data was collected during a 3-hr. ground run of the H135 helicopter in Oxford, England. However, since the aircraft was not tied down, the measurements were limited by the amount of power that could be applied and the level of cyclic control the pilot could provide.

"We were very happy with the data," Weber says. "The sensors collected data on the rotor harmonics and the blade frequencies and captured all the major loads."

The Bladesense system was fitted to the top of the H135's main rotor assembly during its November 2019 ground run.

The next step could be Bladesense 2, in which the system would be developed further to support flight testing. This will require the Bladesense assembly to be scaled down compared to the current system, while the fiber optics would likely be embedded within the blade. Work on developing plans for the Bladesense 2 project began in January. But there is more to do, notes Weber, including the drafting of research proposals.

Nonetheless, the prospects for the technology are bright, Weber suggests. Airbus believes the concept could provide significant advantages for predictive maintenance of the blades if installed on customer aircraft, giving them longer installed life as well as reducing operational costs and increasing aircraft availability. The technology could also lead to the development of health- and usage-monitoring systems for blades—although there have been very few composite main rotor blade failures, unlike their metal and wood predecessors. For military helicopters, the technology could warn pilots if an aircraft's blades have been damaged by enemy fire or degraded by the environment during landings in dusty conditions.

Bladesense could also be an invaluable tool for prototyping new blades, validating aeroelastic instruments and helping helicopter engineers better understand blade dynamics, particularly as blade shapes become more complex and manufacturers introduce active blade systems. The technology's monitoring of dynamics could also help inform future flight control systems, especially for future rotorcraft using active or morphing blades, Weber suggests.

SHORT STORY

- DISTRIBUTED ELECTRIC PROPULSION REDUCES WEIGHT AND COST OF STOL
- STOL AIRCRAFT COULD FIT BETWEEN URBAN AIR TAXIS AND REGIONAL JETS

MIT's 30%-scale unmanned model showed the STOL performance potential of distributed electric propulsion.

MIT PHOTOS

Graham Warwick Washington

While many aviation startups are focusing on electric vertical takeoff and landing and urban air mobility, a small cadre believes extreme short takeoff and landing and regional services could be easier to certify and more economically viable in the near term.

It is a view that harks back to the 1970s and a vision of short-haul transportation using short-takeoff-and-landing (STOL) airliners as an answer to the growing problems of congestion and noise at major airports. Both NASA and the FAA saw quiet, clean STOL aircraft as a way to make better use of airports that were becoming hemmed in by urbanization. But with the technology available then, the economics did not work out.

Fast-forward to the 2020s, and proponents see in electric propulsion a way to enable the potential of STOL—and see in STOL a way to unlock the benefits of electric propulsion that is less technically challenging and more economically rewarding in the near term.

With electric vertical takeoff and landing (eVTOL), the opportunity is in bringing air transportation closer to the customer by enabling operations from convenient urban vertiports. The challenges are in the energy required for vertical flight and the criticality of a propulsion system that provides both lift and flight control.

With electric STOL (eSTOL), the opportunities are in lowering the energy density and airworthiness certification hurdles. But the challenge is in providing field performance sufficiently short to enable operations from the same vertiports that eVTOL urban air taxis would use. Enter distributed electric propulsion (DEP) and powered-lift STOL, where propellers and aerodynamics interact to enable high lift at low airspeed. Together, they offer the potential for extreme STOL performance with lower weight and cost.

The Breguet 941 turboprop transport of the 1960s is a good example of both the capability and complexity of powered-lift STOL aircraft using conventional propulsion. Designed to take off in 185 m (607 ft.) carrying up to 60 people, the 941 used full-span slotted flaps to deflect the slipstream from four oversize propellers.

Power came from four Turbomeca Turmo turboprops, each with a free turbine driving a master shaft running through the wing. Connected by a shaft to each propeller, this master shaft ensured power from the engines was distributed equally to the props. If an engine failed, its free turbine was isolated, but the propeller kept turning.

The 941 first flew in 1961, and in 1964 demonstrated it could fly between heliports at Issy-les-Moulineaux in Paris and Allee Verte in downtown Brussels. The 941 and production 941S conducted two U.S. tours, in 1964-65 as the McDonnell 188 and again in 1968-69 as the McDonnell Douglas 188, including demonstrations for American and Eastern Airlines.

No airline order was forthcoming, cost of operation being one factor. But research continued, and NASA in 1978 flew the Quiet Short-haul Research Aircraft (QSRA). This was a de Havilland Canada DHC-5 Buffalo transport modified with a new wing and four Avco Lycoming YF102 turbofans providing upper-surface blowing. The QSRA was retired in 1993, but it contributed to the design of the Boeing C-17.

There are electric STOL aircraft flying today. California startup Pyka is using unmanned eSTOL aircraft for crop-dusting operations in New Zealand. Powered by three 20-kW electric motors on the wing and tail, Pyka's production aircraft can take off and land in 150 ft. and carry a 625-lb. payload. The design does not use powered lift but has a sailplane-like wing with full-span flaps for high lift at low speed. With a cruise speed of 90 mph and battery swaps between flights, the aircraft can cover 85-135 acres per hour.

At the other end of the spectrum is the Metro Hop concept for a two-seat eSTOL able to take off and land in 200 ft.

A Pyka electric STOL unmanned aircraft is being used for crop dusting in New Zealand.

PYKA

and fly a 990-lb. payload 100 mi. at 250 mph. The initial application envisaged is express delivery of medical supplies from central warehouses to local hospitals, says CEO Bruno Mombrinie. Being designed for the California startup by the e-Genius electric aircraft team at the University of Stuttgart, Germany, the Metro Hop is simple in concept but has some unique features.

To take off from a flight deck atop a warehouse, electric motors in the main wheels first accelerate the aircraft to 60 mph in 4-5 sec., then active landing-gear legs push the nose up to rotate for takeoff. To land with the precision required, the aircraft measures the distance to the flight deck and extends the motorized landing gear to meet the ground when over the landing mark. Wing lift is then spoiled to put weight on the wheels and brakes used to decelerate. Cargo and battery swap would be robotic.

UK startup Faradair is taking a different approach to STOL regional transport with its Bio Electric Hybrid Aircraft (BEHA) concept. Designed to take off and land in under 985 ft., the BEHA has a triple box wing for high lift—three staggered lifting surfaces joined at the tips by vertical stabilizers. "Our modeling analysis shows the aircraft is still lifting at 40 kt., at 16-deg. angle-of-attack and a lift-to-drag ratio similar to a [Boeing] 747," says Neil Cloughley, Faradair managing director.

Propulsion is provided by a 1,600-shp turbine engine and 500-kW electric motor driving a contrarotating fan in a duct that increases thrust and reduces noise as well as providing vectored thrust for flight control. Takeoff is primarily done on batteries to reduce noise and emissions, transitioning to the turbine to cruise and recharge the batteries, which provides a reserve power capability in case of engine failure, he says.

Design cruise speed is 200 kt. At a higher speed, the drag penalty from the wings and duct would be too great. But Faradair aims to compete mainly with helicopters, flying faster, farther and more efficiently with less noise. "We see the BEHA doing 90% of the mission a large helicopter can do," Cloughley says.

The planned first member of the family is the MH1, a 55-ft.-span aircraft capable of quick change between 18 passengers, three LD3 cargo containers or 5 metric tons of payload. Faradair is completing design optimization and hopes, funding permitting, to fly a full-scale prototype by early 2024 and certify the MH1 by 2025-26. The startup has struggled to secure private funding or government support in the UK, but Cloughley says interest has picked up recently, mainly from offshore sources.

John Langford, founder and former CEO of Aurora Flight Sciences, has launched Electra.Aero to develop a super-STOL (SSTOL) hybrid-electric aircraft for regional mobility using DEP and powered lift. He is working with a team from the Massachusetts Institute of Technology (MIT) that has been studying SSTOL as an alternative to eVTOL for urban air mobility (UAM).

Using propulsion for both lift and control in an eVTOL

Faradair's BEHA transport features a triple box wing that provides high lift at low speed.

FARADAIR

raises the criticality of power failure. This requires increased redundancy and complexity, which add cost and weight to the aircraft and time to the certification process, says Christopher Courtin, a graduate student at MIT. A fixed-wing SSTOL would be comparable to existing single-engine aircraft in a failure scenario, providing an established pathway to certification, he says.

Among the benefits of SSTOL over eVTOL, Courtin lists performance and the ability to use smaller motors, leaving more weight fraction for energy storage or passenger capacity. The lower thrust-to-weight and higher lift-to-drag ratios of an SSTOL versus an eVTOL aircraft are expected to increase speed, range and payload capability.

MIT has been studying a four-seat SSTOL as an alternative to eVTOL for infrastructure-constrained UAM. "If takeoff and landing distances can be made comparable to the size of a vertiport, there may be substantial benefit to using SSTOL aircraft for many of the proposed urban air mobility missions," Courtin told the American Institute of Aeronautics and Astronautics SciTech conference in January.

Active landing-gear legs and motorized wheels provide Metro Hop's STOL performance.

METRO HOP

DEP can enable extreme short-field performance by mounting propellers along the wing leading edge so that they blow the trailing-edge flaps along most of the span. Based on wind-tunnel tests, the MIT team believes takeoff and landing ground rolls of less than 100 ft. can be achieved using DEP-powered lift, short enough to be competitive with eVTOL.

"It needs a maximum lift coefficient [$C_L$max] of 7-12 to be feasible. That is well beyond what we can get without a blown wing," says Courtin. "In the wind tunnel we saw a $C_L$max of about 9, but we were not confident we would see that in flight, so we decided to go to a subscale aircraft."

With funding from Aurora, the MIT team in 2019 flew a 30%-scale unmanned model of their conceptual SSTOL. Weighing less than 40 lb. and with a span of 13 ft., this had eight propellers on the wing leading edge, single-slotted flaps and partially blown ailerons, as well as a conventional tail.

Blown-wing aircraft such as the Breguet 941 use wing flaps to deflect the propeller slipstream. This increases lift, both by turning the propeller jet and by suppressing the separation of airflow over the wing and flaps. Compared with turboprops, DEP allows the use of many small propellers. The small jets they produce increase blowing effectiveness. This allows use of a mechanically simple single-slotted flap, reducing the weight and cost of the high-lift system compared with previous blown-lift aircraft, he says.

The goals of MIT's subscale testing were to determine if high lift could be achieved in flight, to assess the handling qualities and look at the effect of changing propeller diameter on the efficiency of turning the flow. Motors were evenly spaced along the wing leading edge. In takeoff mode, all eight were controlled together by a single throttle lever. In landing mode, the inner six motors—which provided most of the blowing—were controlled via a knob, while the outer pair were modulated by the throttle.

The team tested the aircraft with 9-in.-dia. two-blade and 7-in.-dia. five-blade propellers. Significantly slower flight speeds were achieved with the smaller props. "This was likely because the smaller jet is more effectively deflected by the flap, which enables more lift with lower power," Courtin says.

At low speeds, the aircraft's lateral handling qualities degraded, making it difficult to control. "It was hard to keep the aircraft in steady flight, which made it hard to measure C_L," he says. "But the five-blade prop gave the best high-lift performance, pretty repeatable up around a $C_L$max of 10."

The subscale aircraft took off in about twice its own length, with a nearly level liftoff attitude. "This indicates that the takeoff distance of the aircraft was limited by the rotation rate that the unblown tail is able to generate at low airspeed," Courtin says. Takeoff $C_L$max was not that high. "This suggests that the ground roll of this aircraft is limited by the control power of the horizontal tail," he says.

The aircraft was difficult to handle because of low dynamic pressure over the control surfaces. At high flap deflections and C_L, upwash from the flap ends induced the wing to stall at that location. As a result, a significant portion of each aileron was in separated flow, reducing roll control authority.

The tail was also a factor, its ability to trim the aircraft limiting the achievable lift coefficient. "Control strategies for this aircraft, both in how to generate sufficient control authority and how to translate pilot inputs into actuator movements, are an important area of research going forward," says Courtin.

Langford's Electra is working with the MIT team, led by professors Mark Drela and John Hansman, on the next steps. These will begin by flying a full-scale, two-seat concept demonstrator, within a year of COVID-19 restrictions lifting, to address control challenges and show the potential of hyper-STOL.

The team is looking at four-, nine-, 19- and 35-seaters and conducting market studies on which to launch first. Langford sees an opportunity between small urban air taxis and large regional jets for aircraft that can take off "in a couple of hundred feet" and fly 50-500-mi. stage lengths, a market now dominated by automobiles. The short-haul transportation promise of the Breguet 941 may yet be realized.

Drone Services Promoted in U.S. Pandemic Battle

> UPS FLIGHT FORWARD ANNOUNCES NEW SERVICES

> ZIPLINE FOCUSES ON CHARLOTTE, NORTH CAROLINA

Bill Carey Washington

A concerted effort to expand the ways drones can fight the COVID-19 coronavirus pandemic in the U.S. took a few steps forward and at least one step back in late April.

With reference to the "First in Flight" motto that adorns license plates in the state, the North Carolina Department of Transportation (NCDOT) is advancing initiatives to deliver COVID-19 test samples by drone from collection points to laboratories. The initiative also supports delivery of food, prescription medicines and other supplies from retail sites and warehouses to housing complexes and senior citizen communities.

Similar to many states, North Carolina has imposed social distancing measures that prohibit mass gatherings and dine-in restaurant services to contain the spread of the novel coronavirus. On May 5, Gov. Roy Cooper signed an order easing some restrictions but prohibiting gatherings of more than 10 people.

On April 24, the NCDOT hosted a webcast during which three of its industry partners under the FAA's Unmanned Aircraft Systems Integration Pilot Program (UAS IPP) described what they can do to move needed supplies during the pandemic—assuming federal regulatory approvals.

Julie White, NCDOT deputy secretary for multimodal transportation, recalled that North Carolina deployed drones to monitor road conditions and floodwaters after Hurricanes Florence in 2018 and Dorian in 2019.

"We are no stranger to using our UAS program during a crisis," White said on the webcast. "We consider ourselves a national leader in deployment of UAS in hurricanes."

Under the FAA pilot program, UPS and drone manufacturer Matternet have transported blood samples at the WakeMed Health and Hospitals campus in Raleigh, North Carolina, since March 2019. UPS created a drone subsidiary, UPS Flight Forward, last July and announced in October that it had received the nation's first FAA Part 135 Standard air carrier certificate for a drone operation.

UPS Flight Forward is now seeking waivers from the FAA to fly COVID-19 test samples by drone from a hospital to a testing facility in the Winston-Salem area of the state. The program would operate in collaboration with Wake Forest Baptist Health.

FLYTREX

A Flytrex multirotor drone delivering takeout food.

Separately, UPS has received FAA approval to use Matternet's M2 quadcopter to deliver prescription medicines from a CVS pharmacy to a landing site near The Villages retirement community in central Florida. The service, designed to support social distancing by keeping residents at home, began in May.

Another IPP partner—Flytrex of Tel Aviv—has developed a takeout delivery service connecting a shopping center with a recreational complex in Holly Springs, North Carolina. The company started delivering food packages by drone in Reykjavik, Iceland, in 2018. More recently, the company initiated operations in Israel and in Grand Forks, North Dakota—the latter through an IPP partnership.

Flytrex's service, which uses a hexacopter capable of delivering a box of food weighing up to 6.6 lb. over a distance of 3.5 mi. and back, can also support social-distancing requirements, the company contends.

"We want to help with exposure to this virus," Wes Shover, Flytrex head of U.S. operations, said on the webcast. "We know that our aircraft is highly reliable, and we just want to make an impact. As fast as possible, we're looking to deploy in high-risk areas."

Long-distance drone delivery operator Zipline, one of the participants in the NCDOT webcast, provided more details on its plan with Novant Health to launch a delivery service this year in Charlotte, North Carolina.

Deploying Zipline's fixed-wing, catapult-launched drones would require a $5 million capital investment for an operating base and warehouse situated on 10-12 acres of land, with 15 full-time employees, Joe Marshall, Zipline director of flight operations, said on the webcast.

"We're actively working to assess flight routes, which are static to maximize the level of safety related to airborne and ground hazards," said Marshall. "Prior to flying in this region and other regions, we will have an extensive outreach with the local community to drive awareness and trust."

Just as North Carolina's effort to use drones in the pandemic response appeared to advance, a pilot project that drone manufacturer Draganfly announced on April 21 with the police department of Westport, Connecticut, was canceled within days following a public outcry.

Draganfly, the University of South Australia and health care data company Vital Intelligence are developing a "pandemic drone" that combines a specialized sensor with computer vision image analysis to detect coughing, sneezing and potential infectious conditions of COVID-19 from a distance of 190 ft.

"While the development of the program is not moving forward in Westport, this was a valuable learning experience," Draganfly CEO Cameron Chell stated in a press release. "We are looking forward to evaluating lessons learned so the practice of social distancing has the right policies and procedures in place to support this life-saving technology."

TECHNOLOGY LIFT

UNILODE

> UNILODE IS INSTALLING BLUETOOTH TRACKING TECHNOLOGY

> CEVA LOGISTICS INTRODUCES AUTOMATED MOBILE ROBOTS

> SITA IS WORKING ON BLOCKCHAIN PROJECTS FOR CARGO

Helen Massy-Beresford Paris

Air cargo operators are in the spotlight as the COVID-19 pandemic rages on, and the vital role the sector plays in transporting essential medical supplies and other goods across the globe is highlighting the importance of longer-term efforts to make use of innovative technologies to boost efficiency and transparency.

Players from all segments of the air cargo supply chain have been investigating how technologies such as artificial intelligence (AI), blockchain, robotics and Bluetooth can improve the efficiency of their operations for some time. But the crisis has underlined the significance of these endeavors.

For Unilode Aviation Solutions, which owns 140,000 unit load devices (ULD), innovation does not just equate to brand-new technology at all costs.

The Zurich-based company, which serves more than 45 airlines, is seeking to improve reliability and transparency by installing Bluetooth tracking technology on its ULDs. Unilode accounts for around one-eighth of the world ULD fleet.

Bluetooth provides accurate and live data that can improve cooperation between different partners within the air cargo supply chain. In other words, the technology helps forwarders, carriers, ground handlers and ULD managers, like Unilode, to integrate their processes more seamlessly.

"In aviation, innovation is good, but it has to be reliable," explains Martijn van Geest, managing director of digital transformation at Unilode.

"That's one of the main reasons we decided to use the Bluetooth standard," he says. "It's exactly the same technology that you find in every mobile phone. This has multiple advantages—reliability and interoperability. What is innovative about the project is more around the design and how it is integrated within air cargo operations."

Improving transparency is a vital step in meeting the needs of customers, too, he adds.

Unilode is installing Bluetooth tracking technology to boost transparency.

"The shipper expects a seamless and reliable supply chain these days, especially in the air cargo industry with critical and high-value goods," van Geest says. "Shippers really expect this transparency, and if the air cargo industry cannot provide this, they will find a way to do it themselves."

That said, the Bluetooth technology has to be integrated into the ULDs in such a way that it avoids obstructing daily operations. It also needs to be well-protected against damage and loss in a rough environment.

"As well as geotracking, we also wanted to have additional sensors in place that give us information on temperature, humidity or shock exposure and a light sensor so that you can identify when a container has been opened during the supply chain process—giving more transparency [to see] if things are missing or broken," van Geest says. "The data is really at your fingertips. You can see within seconds if a container has been opened or a shipment has

CEVA LOGISTICS

Robotics have sped up operations at CEVA Logistics' Melbourne site.

missed a flight, meaning you can take corrective action to ensure that the supply chain is not disrupted."

In addition to improving the service for shippers, Unilode's tracking technology, which the company is putting in place in conjunction with its hardware, software and ULD manufacturer partners, can help improve the sustainability of the air cargo supply chain, van Geest says.

"If you are going to do something, do it right the first time," he says. "It will save you money in the long run and [help you] avoid going around in circles. From that perspective, creating a more efficient process with this technology will reduce unnecessary use of resources of any type and contribute to greater sustainability."

SITA, an air transport information technology (IT) and communications specialist, is also working with ULDs, but the Geneva-based firm is doing so through the prism of a different technology: blockchain.

In its latest blockchain project, in conjunction with trade association ULD Care, SITA is exploring how blockchain can be used to digitally track and record change of custody for airline cargo containers throughout their journey. The endeavor to weave blockchain into the fabric of air cargo operations carries with it estimated potential savings of $400 million a year for the industry.

SITA chose to focus on ULDs because that part of the supply chain is simpler than others. ULDs also offer a huge potential for savings, says Sebastien Fabre, vice president of portfolio management for airline and airports at SITA.

Although more than 1.2 million ULDs are in use by airlines, the system used to track them has been only partially digitized and relies on incomplete data sharing and record keeping, Fabre adds.

"For any given shipment, there can be up to 12 custodian companies monitoring and tracking the cargo," he says. "Many rely on paper documents, making the process cumbersome and undermined by trust and transparency issues."

However, the use of blockchain technology could revolutionize that process, Fabre asserts. "Knowing the location of all ULDs at all times, and therefore their cargo, means companies can accurately track where loss or damage occurs and recover the costs without dispute," he notes.

SITA and ULD Care are working on a proof-of-concept plan that will extend and upgrade the current ULD interlining platform to include nonairline third parties such as ground handlers through open application program interfaces. The two partners are working with four major airlines and the project is due to be delivered by the end of the third quarter of 2020, a target they are keeping despite the current coronavirus-related industry disruption.

"The platform also has the potential to provide a wide range of authentication and trust-based benefits, reducing the risk of tampering, cybercrime, trade-based money laundering, fraud and illicit trade," Fabre says.

For the air cargo industry to improve efficiency, new technologies need to be deployed at all points in the supply chain—on the ground as well as onboard aircraft.

CEVA Logistics has deployed automated mobile robots at its 250,000 m^2 Truganina super site near Melbourne, Australia.

"In the e-commerce sector, this kind of technology has been particularly efficient," says Mathieu Friedberg, CEO of CEVA Logistics. "We achieved a 400% increase in the speed of operations in less than a month from 'go live.'"

The deployment of eight robots across a 400 m^2 trial space comes at a key juncture for the e-commerce industry.

Prepandemic, e-commerce was seen as a growth driver for an industry facing obstacles in the form of trade wars and geopolitical uncertainty, with knock-on effects in sectors such as manufacturing.

Now, the COVID-19 pandemic has highlighted the value of being able to ship goods quickly and reliably across the globe. Dire economic forecasts around the world will affect consumer spending, but e-commerce operators are expected to continue to benefit from a change in shopping habits.

The increased data-processing capacity of the AI-driven robotics technology has a positive impact not only on productivity but also on workers' comfort and workload, Friedberg says.

CEVA Logistics is looking to roll out the technology to other e-commerce sites within its network and sees similar technologies continuing to gain ground within the broader industry.

"I think this crisis will have a lasting impact on consumer habits—for sure, e-commerce is one of the major beneficiaries of the crisis, and that will stay," Friedberg says. "In fulfillment on the [business-to-consumer] side, artificial intelligence, automation and robotics will be more and more important because they provide enormous computing capacities, which help us deliver the efficiency and the productivity required to provide customers with the service level they expect."

Anthony Florian, Honeywell vice president for airlines in Europe, the Middle East, Africa and India, agrees that the pandemic will drive long-term demand for e-commerce operations. "The implementation of prolonged social distancing and stay-at-home measures worldwide have a significant effect on e-commerce," he says. "Millions of people around the world who otherwise have not experimented with online purchasing are now becoming more dependent on e-commerce."

In that context, smarter cockpits for cargo and better connectivity for cargo crews will help ensure cargo

aircraft can continue to fly without downtime, Florian says. "Many cargo operators fly older flight management systems (FMS) with limited memory," he notes. "This can require them to maintain and load multiple databases for different regions. That wastes precious time, especially when aircraft are shuttling supplies to multiple regions in a single day."

Honeywell recently sold 16 Pegasus II Upgrades to a major cargo carrier. The upgrades boost the memory capacity and functionality of FMS in Boeing 757s and 767s. Meanwhile, the company is also developing cockpit retrofits on Airbus A300s for another major cargo carrier. And it has been upgrading the software of communication management units on Boeing aircraft and the air traffic services units on Airbus aircraft.

Improved predictive maintenance can also help boost cargo efficiency, Florian says. "Any downtime can be detrimental to cargo planes as shipments will be delayed, incurring a huge cost to operators," he says. "It is crucial for air cargo operators to be able to anticipate maintenance needs."

The company is introducing Honeywell Forge with several cargo operators and says the platform can help them by analyzing data streaming from aircraft components to anticipate maintenance needs. "The same system also delivers advice on routes and thrust settings to help cargo airlines fly more efficient fleets," Florian adds.

Looking beyond the coronavirus crisis to longer-term innovations, Unilode also believes blockchain may change the way the sector operates.

"Blockchain technology will play a key role in the future in improving transparency as well as boosting performance and efficiency," van Geest says. "But if you create true blockchains, you need to get to the next level of transparency within the cargo industry: sharing all relevant data with all partners. I think that still requires a substantial change of mindset toward [a] willingness to share such data. But I think it's more of a 'when' question than an 'if.'

"We need to really start working as an industry toward this mindset and getting this transparency in place," van Geest says. "Blockchain would mean all relevant information on all participants in the sector would be available. That's a huge step, but shippers are expecting it, and we have to go down that road."

SITA also sees applications for blockchain in other areas of air cargo such as developing "certificates of origin" for transported goods and enhancing financial processes (including automatic payment or delay penalties) and the cargo booking process. Further ahead, SITA believes collaboration between different technologies is crucial. "In innovative digital technology solutions, it's often the combination of multiple technologies that maximizes the delivered value," Fabre says.

"In the future of air cargo, we imagine a 'convergence' and a world where data will be captured by Internet of Things, mobile and electronic data interchange systems; managed by blockchain; and automated using artificial intelligence," Fabre adds.

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Managing Director, Global Media: Iain Blackhall (UK);
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May 19-July 23—RTCA Plenary Sessions. Virtual or Various locations (check website). See rtca.org/content/upcoming-committee-meetings

June 15-19—American Institute of Aeronautics and Astronautics (AIAA) Aviation Forum. Virtual Event. Reno, Nevada. See aiaa.org/aviation

June 25—Space Tourism Conference. The Proud Bird. Los Angeles. See spacetourismconf.com

July 16—American Institute of Aeronautics and Astronautics (AIAA) 2020 Fellows Dinner. Hilton Crystal City. Crystal City, Virginia. See aiaa.org/events-learning/event/2020/05/19/default-calendar/2020-fellows-dinner

July 17—AIAA 2020 Aerospace Spotlight Awards Gala. Ronald Reagan Building and International Trade Center. Washington. See aiaa.org/events-learning/event/2020/05/20/default-calendar/2020-aerospace-spotlight-awards-gala

July 20-21—DoD Hypersonic Capabilities Symposium. Mary M. Gates Learning Center. Alexandria, Virginia. See hypersonics.dsigroup.org

Aug. 1-6—SmallSat 2020: Space Mission Architectures. Virtual event. See smallsat.org

Aug. 4-6—Space and Missile Defense Symposium. Von Braun Center. Huntsville, Alabama. See smdsymposium.org

Aug. 9-13—AAS/AIAA Astrodynamics Specialist Conference. Lake Tahoe Resort Hotel. South Lake Tahoe, California. See space-flight.org/docs/2020_summer/2020_summer.html

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Aug. 5-6—CAPA Australia Pacific Aviation Summit 2020. Adelaide, Australia.

Aug. 25-26—Aerospace Manufacturing Conference. Charleston, South Carolina.

Sept. 1-3—MRO Americas. Dallas.

Sept. 2-3—Military Aviation Logistics & Maintenance Symposium. Dallas.

Sept. 5-8—World Routes 2020. Milan.

Sept. 14-16—Commercial Aviation Industry Suppliers Conference-Europe. Toulouse.

Sept. 16-17—Aero-Engines Europe. Stavanger, Norway.

Sept. 17-18—CAPA Latin America Aviation & LCCs Summit. Salvador, Brazil.

Sept. 22-24—MRO Asia-Pacific. Singapore.

Sept. 22-24—Aero-Engines Asia-Pacific. Singapore

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

Oct. 15-16—CAPA Americas Aviation & LCCs Summit. San Juan, Puerto Rico.

Oct. 19—Aviation Week Laureates Awards. McLean, Virginia.

Oct. 20-21—Aviation Week DefenseChain Conference. McLean, Virginia.

Oct. 20-21—Aviation Week Program Excellence Awards and Banquet. McLean, Virginia.

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VIEWPOINT

Saving the Aerospace Supply Chain

By **John Byrne**

The aerospace supply chain is unlike any other. It is broad, complex and deeply tiered, and at the bottom it depends on thousands of small suppliers, often referred to as Tier 3 and 4, many of which are privately owned. This supply chain feeds commercial production, defense programs and the aftermarket, and most suppliers support all three segments.

In the past 17 years, the commercial aerospace industry has grown to record production levels. The defense industry has benefited from the commercial boom, capitalizing on the scale and volume for lower costs and establishing pay to play approaches on new programs. Both the U.S. and Europe have the same relationships between commercial volumes and their defense industries.

Although the industry has been through many crises—economic shocks, wars, the Sept. 11, 2001, terrorist attacks, self-induced program delays—the impact of COVID-19 will be more severe and extensive than any previous downturn. Airlines have too many aircraft and have grounded most of their fleets, forcing aircraft OEMs to lower production rates and reduce capacity. Oil prices and leasing rates have plummeted, further dampening demand for new airplanes. As the pain trickles down, the lower tiers of the supply chain will be hit especially hard on both sides of the Atlantic.

INCENTIVIZE AIRCRAFT RETIREMENTS TO SPUR DEMAND FOR NEW ONES.

This is an opportunity to take an international approach to solving the problem COVID-19 is creating. A NATO-centric effort that would stabilize and protect the economic and defense security of all partners is needed, the U.S. and Europe, Airbus and Boeing working together for the common good.

There are debates about what the recovery will look like, but past experience will be of little use. The future is a guessing game. One tool is available today, though, that could hasten the industry's eventual recovery: decisive action to speed the retirement of older aircraft. Clearing fleets of older models would help bridge the disconnect between demand and supply by incentivizing airlines to order new aircraft more quickly when airline travel returns.

The U.S. and European governments are well-positioned to help the aviation industry. Stabilizing and accelerating the return of true demand to the commercial industry will stabilize and strengthen the defense capabilities for NATO. Government support for airlines and OEMs could include provisions that encourage airlines to scrap older airplanes. In exchange, they would receive funding to pay for operations and employee salaries.

How would it work? Each aircraft has a market value that has been determined by the industry. For each aircraft scrapped, a cash payment and a credit for purchasing a new airplane would be granted, and free trade would be in place: U.S. carriers could purchase from European or U.S. OEMs and vice versa. The right balance for air passenger demand, existing capacity (including parked jets) and new production could be managed until stability and a viable level of demand can be achieved.

GE AVIATION

Additional capability to scrap and recycle aircraft would be established, creating job opportunities and maintaining the workforce for the future. The remaining in-service fleets would be more fuel-efficient. That would have the added benefit of addressing climate change without burdening the industry with new regulations to reduce carbon emissions and demonstrate that Europe and the U.S. can work together on climate. Operational reliability, service and comfort levels would be improved, a positive for both airlines and their passengers.

The current approaches that the U.S. Treasury, Congress and aviation industry leaders seem to be putting forth to address the devastating economic impact of the coronavirus are worthy, but they are focused on creating a bridge to an unknown recovery date and work from the top down. That's a good start, but it will not help the supply chain anytime soon. In an industry built on long cycles, loans and a Paycheck Protection Program will not be enough to carry small suppliers through. If Europe goes with different solutions, complexity will be created, and synergies will be lost.

The aerospace industry is complex and sophisticated, especially concerning the financials around producing, buying, owning and operating commercial airplanes. We need something different to attack this challenge.

Accelerating aircraft retirements is no panacea by itself, but the COVID-19 pandemic calls for bold and innovative steps. I have worked for more than three decades in the aerospace supply chain. If our recovery is protracted, the foundation of our industry will be further weakened, endangering our long-term competitiveness and economic and national security. It is time for governments, airlines, leasing companies, financiers, OEMs and suppliers to join forces. A quicker recovery will be better for all.

John Byrne is an advisor at Pasayten Advisors. He was vice president of supplier management for aircraft materials and structures at Boeing from 2011 to 2017.

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